Computer Oral History Collection, 1969-1973, 1977

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Interviewer: Henry S. Tropp
Date: April 27, 1973
Repository: Archives Center, National Museum of American History

TROPP:

This is a discussion with Betty Holberton and Betty Jean Bartik and the date is the 27th of April 1973. We are going to start off by talking about how both of these people got involved in ENIAC in terms of their arrival at the Moore School and the War work that they were connected with.

And really, we're two of the first programmers on [an] electronic computer before the word was even coined. There wasn't even a word like program was there?

HOLBERTON:

Programmer ?

BARTIK:

I don't remember how the name got started.

HOLBERTON:

No. Our classification was called computer.

TROPP:

Computer.

BARTIK:

I was a mathematician.

HOLBERTON:

When we got to be P3s, or P2s. Our first job description is, is called computer, I looked it up just recently. [Laughter]

TROPP:

Yea, well a computer, computer in that —

HOLBERTON:

Was a person who computes.

TROPP:

Was a person who did mathematical computation. A computer was not a machine in that time era, computer was a human being.

HOLBERTON:

It was a job classification then. They had a hole. I remember that very vividly when we took that job. The first thing that Goldstine says, "Your grades won't be, won't be decreased because you are going to be working on a machine." The idea of a machine, you know, was a low-grade something or other. Because I remember asking that question.

TROPP:

Mhm. When you, when you first came to the Moore School though, it was for what purpose?

HOLBERTON:

When I first came to the Moore School, I had been working at *Farm Journal Magazine* and all of my family had joined the Service. I had two sisters in the Waves and I wanted to join the Waves but I wasn't accepted because of my eyes. I saw an ad in the, in the Philadelphia papers, they needed girls to do mathematics and they would train you. So I applied and then I got about three or four other of my friends from college and they applied and that's how I got in.

TROPP:

And you were a mathematician originally?

BARTIK:

I was a math major, which —

TROPP:

At, at where?

BARTIK:

I was just a graduate from college.

TROPP:

From, from which —

BARTIK:

Mhm.

BARTIK:

And I didn't want to teach school and I wanted to get out of Missouri. So one of my teachers came along and told me that the Government was looking for mathematicians and that she thought I might be interested in it.

And she said, "It's located at the University of Pennsylvania" and she said, "Boy, that's a good place to go because they have one differential analyzer there, and there are not very many of them, and that's an exciting place to go, and I think you should apply." So I applied and I got a telegram back saying "yes" because at that time, it was just before the end of World War II, and there weren't that many mathematicians around that weren't doing something.

So I was twenty years old and I just jumped on the Wabash and came to Philadelphia.

TROPP:

The Wabash railroad is no longer in existence. [Laughter]

BARTIK:

The Wabash, oh yes it is.

TROPP:

Is it still in existence?

BARTIK:

Sure. The Wabash rail — railroad built the town that I grew up in.

TROPP:

Which is?

BARTIK:

Stanberry, Missouri.

TROPP:

Stingray?

BARTIK:

Stanberry.

TROPP:

Oh, Stanberry.

BARTIK:

Yea, they laid out the town.

TROPP:

Well you, you had been there earlier then, Betty?

HOLBERTON:

Oh yes. I joined when they first opened to the first group that came on board and —

TROPP:

Was that in '42?

HOLBERTON:

1942, yes. The summer of '42, right.

TROPP:

And you were doing ballistics calculation?

HOLBERTON:

I took, actually we, they gave us this quick math, brush up for three months in mathematics where I had, you know, mathematics eight hours a day, six days a week. That's how I learned calculus, you know, all the way through, in, in, you know, like it was a month, I guess, of calculus. Like that.

TROPP:

Some differential equations?

HOLBERTON:

That's right. The rest of it was a review for me, but I had never had calculus so that was new.

TROPP:

Mhm.

HOLBERTON:

And so I got started with the first group.

TROPP:

Well, the first group included, I guess, about five or six of you? Do you remember who some of the people were?

HOLBERTON:

Oh, there were more than five or six. There were more like twenty.

TROPP:

Like twenty?

HOLBERTON:

More like twenty. I think that there were some who were working that you were referring to, the five or six who didn't have to take the course who already had graduate degrees in mathematics, which I was not.

TROPP:

Mhm.

HOLBERTON:

I was a journalist.

But there were at least twenty in our class and I think the other five or six became the supervisors of us who came in as, as beginners. Well, the first thing that you worked on then, were, were those the ballistics calculations that John Mauchly has told me about where each of the

HOLBERTON:

Oh yes, oh yes.

TROPP:

Individuals had sheets of calculations?

HOLBERTON:

We not only had sheets, but we also worked, we worked two shifts, from 8 to 4 and from 4 to 1. And the girl who started and sat at the desk with another one on the opposite shift worked on the same trajectory when things really got tough.

In other words, you'd stop on one line and the girl would pick up and proceed on the same, on the same trajectory computation. This was done very often when we really had a crash job to do. This kept going for sixteen hours a day.

TROPP:

Mhm. And these were strictly what? Pencil and paper or Marchant type —

HOLBERTON:

Oh, we had Marchants too, we could, you know, do that stuff in our sleep.

TROPP:

Well, when you got there this would have been —

BARTIK:

This was March 1945.

TROPP:

In 1945 that whole environment then had pretty much changed, because by '45 ENIAC was almost ready to go, wasn't it?

HOLBERTON:

Well, we didn't know about it. It was a very close kept secret. We didn't know a thing about it. Until they called for volunteers to do something, they didn't quite tell us what.

BARTIK:

That's right. In fact I came there and this group was really buzzing right along. There must have been 50 to 75 people there and I came as a very young, inexperienced worker and I saw that sitting there running a calculator wasn't going to get me anywhere and besides it was kind of dull, so when the .. request was made for people to volunteer to work on the ENIAC I didn't know what it was, didn't have any idea, but I had enough confidence in my own ability that if I could get on the ground floor in some area that I could do very well, so — [Laughter]

HOLBERTON:

I think the one reason there weren't too many volunteers at that time, because we had to say at that time, as I recall, that we would move to Aberdeen,

BARTIK:

Yes.

HOLBERTON:

And there weren't too many people who were willing to do that. [Laughter]

BARTIK:

That's right.

HOLBERTON:

I think that was one of the reasons we got so lucky, I mean there weren't that many people who wanted to do that kind of thing, go to Aberdeen.

TROPP:

Well, when you first came to the Moore School, the calculations that you were doing were under the, at least overall supervision of Mauchly weren't they?

HOLBERTON:

No.

TROPP:

No? Who was the —

HOLBERTON:

Not at all, he wasn't connected with us. He wasn't working for Aberdeen Proving Ground. We were working for Aberdeen Proving Ground.

TROPP:

Oh, I see.

HOLBERTON:

And we worked for various military officers and one of whom was, was Goldstine at one point in time.

TROPP:

Mhm. Do you remember when Goldstine arrived, because you, you were there before he was?

HOLBERTON:

I don't recall that. I know that, that I was interviewed by my future husband and whether he was in charge at that time, I believe he was not.

TROPP:

But John was at Aberdeen then? Or connected with Aberdeen?

HOLBERTON:

Oh yes, we all were connected with Aberdeen. We were what they call a filler computing unit of Aberdeen Proving Ground.

TROPP:

I see.

HOLBERTON:

We were located in a, in a house on Walnut Street

TROPP:

Mhm.

HOLBERTON:

And then we moved to a fraternity house, as I recall, at the corner of

BARTIK:

Woodland Avenue.

HOLBERTON:

Woodland Avenue and 32nd, 34th.

BARTIK:

34th, yeah.

HOLBERTON:

By the time you got there we had moved. Before that we were in a three story home.

TROPP:

So the first that you heard about some kind of a computational device was when you were asked to volunteer for something —

HOLBERTON:

I don't know whether they told us what it was at that time or not.

BARTIK:

Well, they said,

HOLBERTON:

The ENIAC

BARTIK:

We knew the word

TROPP:

You knew the word ENIAC.

BARTIK:

We knew the word, but it was just a piece of paper that was passed around to everybody that worked there,

TROPP:

Mhm.

BARTIK:

So anybody could volunteer that wanted to.

HOLBERTON:

So it was a secret project,

TROPP:

Yeah.

HOLBERTON:

So they weren't divulging what it was.

BARTIK:

In fact, I can't even remember when the first time was I saw it.

HOLBERTON:

I remember

BARTIK:

I think we saw pieces of it

HOLBERTON:

We saw —

BARTIK:

The day we were interviewed.

HOLBERTON:

We went into a dark room. There were no lights in there and there were two accumulators, side by side. They weren't even adjacent and there were lights flying back and forth and that's about all.

TROPP:

Mhm.

HOLBERTON:

Just two things in that room. I don't even remember who took me in to see it. But I do remember it was dark.

TROPP:

Well, before the ENIAC volunteer period, what had your contact been with people like Mauchly or, or Goldstine?

HOLBERTON:

I didn't know Mauchly at all.

TROPP:

You didn't know Mauchly at all?

HOLBERTON:

No. I knew Goldstine because he was connected with the computing unit.

TROPP:

And how would you describe his role in that Aberdeen computing approach?

HOLBERTON:

Well, I think at the time when he was there, he was the military head of that, of that unit.

TROPP:

Mhm. And was his job essentially as I read it, to get tables out

HOLBERTON:

Yes, oh yes.

Faster and more efficiently

HOLBERTON:

Yes, oh yes. In fact there were times when they would tell us that the tables had to go abroad in, I remember one time they were going to go abroad and in our handwriting we all wrote little letters to these soldiers who might look at this thing with our names and addresses and we never heard a word.

BH&TROPP:

[Laughter]

TROPP:

Yeah. I thought the story that you told me earlier about someone who had used it on the

HOLBERTON:

Oh yes.

TROPP:

155 Howitzer. [Laughter]

HOLBERTON:

Oh yes. My brother came back from the war and I told him I was working on these, you know, 155 Howitzer tables and he says, "We never used them, we just shot three shots and sighted on that and that was it." It really busted my balloon.

TROPP:

[Laughter]

BARTIK:

Yeah. Well, other people told me that too.

HOLBERTON:

Well many times, you know, I always felt it was a terrific thing we were doing. I really was just gung-ho on the whole thing and then, you know, long years later my husband would say, "Many times we just gave you work to do, we didn't really have work to do."

BARTIK:

Really?

HOLBERTON:

I wasn't aware of that. No, I wasn't aware of that. He says many times there really wasn't anything to do.

TROPP:

That's, that's and interesting comment because somehow as you look at the literature today you get this feeling of incredible pressure to get these tables out and a backlog of things just waiting to be done.

HOLBERTON:

Well, I think the thing was it had to do with whether there, a new gun was coming along, then the pressure really was great.

TROPP:

Mhm.

HOLBERTON:

It really was great. I remember, that was the time when, when we would be working on a, on a trajectory with someone else. Then we really knew the pressure was on

TROPP:

Mhm.

HOLBERTON:

And that happened before D-Day.

I remember the pressure then before D Day. Because we were working on something which was associated with the …. The, the, the air the air traffic across there, and we were doing sidewise firing from, from airplanes and this kind of thing.

I was aware that the terrible pressure, things had to be done by a given date and then sometime later there was D Day, or was this invasion.

TROPP:

Invasion.

HOLBERTON:

Invasion, that's right, invasion.

TROPP:

Right. This would have been before June of '44.

HOLBERTON:

Right. And there was pressure before that. I went to Pine Camp for a session. We were doing some work there in the way of hand computing and what not, but we were really not doing it for that, we were sort of camouflaging the weather forecasting that was being done in Washington. The balloons being sent up at Pine Camp were to see where they correlated.

TROPP:

Mhm.

HB:

And they were so far off, it was, it was, was amazing.

TROPP:

Mhm.

HOLBERTON:

This was all in advance of D Day also.

TROPP:

That's right because the weather was one of the big determining factors of the

HOLBERTON:

That's right.

TROPP:

Which month D-Day was going to occur. And all their planning was centered around the weather predictions and what kind of cloud cover they thought they might have and what kind of —

HOLBERTON:

That's right, that's right. And there was a lot of —

TROPP:

I know that was very critical. But you had no contact with Mauchly then until you volunteered.

HOLBERTON:

No. I didn't even know Mauchly. I didn't know Mauchly until after I volunteered.

BARTIK:

Oh, I can tell you the story of when we first met him. After we had been recruited, had gone to Aberdeen, had learned punched card equipment,

HOLBERTON:

… Yes.

BARTIK:

We came back to Philadelphia and no one really knew what to do with us, so they had no training materials or anything to tell us how to be programmers.

TROPP:

[Laughter]

We didn't know. We knew we were supposed to run the machine and set up problems for the machine, but no one had any techniques or anything. So, what they did was give us big block diagrams, and I can remember Harry Huskey's name was on most of them and Arthur Burks' was on most of them and Arthur Burks' was on some of them. And we were given these block diagrams, "study them, study them."

HOLBERTON:

Yeah, but before that, you know, Bob Shaw came and showed us how, how to read the, the accumulator diagram, because I remember in the left hand side at the bottom was where you entered this thing and he went around and what not. And he went through the accumulator diagram with us. And then Betty, Betty and I were assigned to do a function table. Do you ever forget that one?

We went upstairs in the Moore School. It was the hottest summer, the flies were terrible. We were in Reed Warren's old classroom. They were building a floor above us, they were drilling overhead, and the dust was coming in,

TROPP:

[Laughter]

HOLBERTON:

There was no place, there were right handed tables and I was left handed, and no place to put the huge function table diagramming except on the table in the front. And I will never forget that. We went through and we really got that thing down pat.

BARTIK:

Well, we would work and work and work, and having — we decided that the first thing we needed to know was to find out how this machine worked. So that's what we were doing, reading block diagrams. So one day, we were sitting there looking at this and a man entered the room looking up at the ceiling. He walked all around the room and looked at the ceiling. And we had never seen him before and he —

HOLBERTON:

Was that up in Reed Warren's old room?

BARTIK:

In the old classroom.

HOLBERTON:

Classroom, yes.

BARTIK:

And so he said, "Oh, I'm just checking to see if the ceiling's falling down."

TROPP:

[Laughter]

HOLBERTON:

Well, they were drilling over, putting that floor above us. [Laughter]

BARTIK:

.. Yeah. So, we thought that was kind of a funny thing for somebody to be saying. Well, then, it turned out that this man was John Mauchly and he really wanted to meet us and really wanted to talk to us. So that was our first meeting with John Mauchly.

HOLBERTON:

I don't remember that, I don't remember that.

BARTIK:

So then after that, of course, here was the John Mauchly, this machine that we were supposed to do something with — so then he helped us with the diagrams and we discovered where his office was. So then, when we would get hung up on figuring out how this machine worked, we used to go ask him. So very early in our training we were involved with John Mauchly.

HOLBERTON:

I remember that John Mauchly and Bob Shaw were the two people that we saw most of all.

TROPP:

But then your first thing, after you volunteered for ENIAC was to literally go through all the circuitry?

HOLBERTON:

Well, the first thing,

TROPP:

In all the units —

HOLBERTON:

The first thing we did, they sent us to Aberdeen to learn all the tab equipment because that was the input, output equipment.

TROPP:

Was that IBM tab

HOLBERTON:

Yes, yes.

TROPP:

Equipment that they were using,

HOLBERTON:

Right.

TROPP:

What, 405?

HOLBERTON:

405, 405, and we were taught that and I remember that the, I had to do a fourth order difference board and from what they had taught us, it, it was just, you know, you do it this way. It was never, is, what is going on inside, it was a, it was a sort of response kind of thing from, from the gal who was teaching us.

So I asked the little IBM maintenance man by the name of Smitty, if I could borrow his, his maintenance books and he said, "I'm not allowed to do this." But he lent them to me for a weekend and I went through and I learned how that thing really worked. And I came back and I, and I programmed a fourth order difference board and I remember the day I was doing that, was very intent on doing it. And it was in one of these huge rooms in, in the Aberdeen Proving Ground and right outside the window is this firing range.

And one of these guns went off; there was always a whistle that went first so you could be prepared for it. I didn't hear the whistle

TROPP:

[Laughter]

HOLBERTON:

And it went off and I went into hysterics, and I'll never forget that. [Laughter]

BARTIK:

Well now, wait a minute, I think that is, that isn't quite right. Because actually the old tab equipment

HOLBERTON:

Mhm.

BARTIK:

That they used at Aberdeen, we were sent down there to learn the punched cards, but, the guy that had designed that fourth difference board, and I think that was the only tabulator that did it anywhere in the country, and there was, we wanted to learn how the tabulator worked and how we could, because we were going to be using it back at Philadelphia to, as a listing device.

TROPP:

Well, so how you could set up differences, of course.

HOLBERTON:

Well, you had to, had to delay the cycle without having a card mixed in there, before there was an extra card was put in there, every four - to delay the cycle with a blank card. This one didn't have a blank card.

BARTIK:

Well, in any case, when we were there, this fourth difference board had been designed by the man that ran the punched card equipment, but he had no diagram of it. And did not, and so consequently you couldn't change the board, you couldn't make any additions to the board.

HOLBERTON:

You're right Betty. You're right. We were making a diagram of it.

BARTIK:

The punched card board was just full; it was just full of wires. So, he used to lecture to us and tell us how the equipment worked and stuff.

HOLBERTON:

Who was that?

BARTIK:

I don't know, but he was a very

HOLBERTON:

Very tall fellow? Tall, thin fellow?

BARTIK:

Talented, a very handsome, he was slender, a very attractive man. Very bright. But in any case, he was much more supporting of us —

HOLBERTON:

Yes, than, than the other people. Yes.

BARTIK:

So, in any case, because there was no diagram of it,

HOLBERTON:

Oh yes. No changes could be made to it; we asked him if we could take that fourth difference board apart. Take it down and make a diagram.

BARTIK:

Take it down and make a diagram —

HOLBERTON:

And we made little holes, and filled out the holes in the paper. Yes, you're right.

BARTIK:

The head of the department was very much against this because her view was that, if we fouled it up, then, since there wasn't a diagram, no one could ever put it back.

TROPP:

[Laughter]

BARTIK:

So the man said, well he had complete confidence that he could put it back. So, he gave us permission to do this and this caused considerable friction at that time,

HOLBERTON:

Mhm.

BARTIK:

Because we were allowed to do this.

TROPP:

It was even against IBM policy to have you mess around internally like that.

BARTIK:

Well no, he was a military fellow.

HOLBERTON:

Well, that, that was different. This was the maintenance man and the book.

BARTIK:

Oh no it isn't, he wasn't a maintenance man.

HOLBERTON:

Well no, I'm talking about little Smitty, and when I got the book from Smitty to find out just how you delay a circuit, just how you delay the cycle. That was against it.

BARTIK:

But in any case that's a —

TROPP:

Yes, that was against policy.

BARTIK:

So, in any case, we did spend a great amount of time drawing this diagram of the fourth difference board but, we did not design that. That was already done.

HOLBERTON:

That's right, yes.

BARTIK:

We were just making a diagram of it so that a person could work on it and learn how it worked.

HOLBERTON:

Well, we must have put one together then after we made the diagram.

BARTIK:

Well, as we took it off one board we put the wires back on another.

HOLBERTON:

Back on, okay.

Were you in the room when that fire thing went off and I went in hysterics? [Laughter]

BARTIK:

It was, well because, there was considerable tension, because it sounds funny, but that was a very elegant board, and as I understand it, it was the only one anywhere that allowed a tabulator to do fourth differencing.

HOLBERTON:

Without insertion of blank cards to do it. That was the thing that it delayed its own cycle.

TROPP:

I know earlier they had done some second differencing for certain kinds of tabulations, I think with railroad accounts. Back in the, even in the thirties, but I don't know of any example of a fourth difference and boards that were set up for that.

HOLBERTON:

Well, see, in order to understand it, you really had to know about how you could delay cycles, which we weren't being taught at all.

BARTIK:

But, in any case, I must say that when we came back from Aberdeen we certainly were well trained.

HOLBERTON:

Yeah.

BARTIK:

And we had a lot of motivation because we all felt that we'd be scalped if we ruined

TROPP:

[Laughter]

BARTIK:

The board, so consequently we didn't even take a wire out until we had checked and checked, and checked.

TROPP:

So really what you were doing then was the beginning of a,

HOLBERTON:

A program.

TROPP:

Of a machine program.

HOLBERTON:

Oh, yes it was. Oh yes it was. It really was. Mhm.

BARTIK:

Well, of course, the old punch, those boards, wiring boards were programming boards.

HOLBERTON:

Sure, yes.

TROPP:

But nobody used the term at that point.

HOLBERTON:

No, no.

TROPP:

You wired it to do something,

HOLBERTON:

Right.

TROPP:

Set up a plug board and you can see, downstairs on the first floor, you can see the exhibit of Wallace Eckert's machine that he used for astronomical calculation with the plug board at the base of it

HOLBERTON:

Right.

TROPP:

That he had set up and I think he cannibalized that from some equipment that originally belonged to Ben Wood. They were doing tabulation statistical work on machine scored examinations. [Laughter]

BARTIK:

Well, it's my understanding you know, that the man who designed that is the man that headed up the Aberdeen section at the time that we were there. And I feel very badly that I can't remember his name.

TROPP:

Well, well, when you came back to, to the Moore School then, what was the state of ENIAC at the point? When, when did you first see it?

BARTIK:

They were still building it then.

TROPP:

They were still building.

HOLBERTON:

Oh, yes.

TROPP:

When were you first introduced to the ENIAC diagrams and what this machine was going to look like?

HOLBERTON:

As soon as we came back at the end of the summer.

BARTIK:

That was like August or September.

TROPP:

The end of the summer of '45?

HOLBERTON:

Yes. August or September of '45. Yes.

BARTIK:

Yes.

HOLBERTON:

They didn't really have anything set up for us to do.

BARTIK:

There was nothing for us to do. There were no programming manuals.

HOLBERTON:

There was nothing there really and the only way we could learn was getting hold of these block diagrams.

TROPP:

So the first problems that you had then were learning the block diagrams for ENIAC?

HOLBERTON:

Yes. And as I recall, Betty and I were put on the function table and Kathleen McNulty was put on the multiplier and I don't remember what, what the other two were put on, because I know, after we finished going through that, I went on to the master programmer. And I, I really had learned that.

TROPP:

Was Adele Goldstine part of that original group?

HOLBERTON:

I didn't even know her.

TROPP:

When did she —

HOLBERTON:

I didn't meet her until the, the time of the demonstration. I didn't even know she was even a part of it. She was his wife and it was, Goldstine's wife, and I do remember that when Kathleen McNulty was asked to help with the demonstration, at that time Betty and I were working on the trajectory, which was supposed to be the first program we were going to do on the machine, and they asked Kathleen if she would help Adele with the demonstration. And I was appalled, "Why Adele, what does she know about the ENIAC?" Because I didn't even know she was involved in it. We didn't really have any contact with them, even though Goldstine was our boss. At that time John Holberton was really the one who was telling us what to do. We didn't really; we were sort of floating around and being an initiative on our own most of the time.

BARTIK:

Well Adele taught, she was affiliated with the, that computing group in Philadelphia, because when I first came here

HOLBERTON:

She taught one of those courses? She taught courses in how to do inverse interpolation on calculators and things of that kind. So that the new people coming in had a training course that met two or three times a week

HOLBERTON:

Oh, I see.

BARTIK:

For an hour or so and she and Mary Mauchly. Mary Mauchly taught some of them.

HOLBERTON:

Oh really?

BARTIK:

Oh, yes. So that they were associated with this computing project but as instructors in you know, in computing methods.

TROPP:

Mhm.

BARTIK:

So I knew her, in fact, my introduction to her was very interesting to me. Because we were sent over for the training course and I came from a small teachers' college and women were not allowed to smoke. And if you smoked you had to go off to the greenhouse or some place, sneak around and smoke. And so I was a kind of naive farm girl from Missouri and I came in the class and Adele Goldstine walked in and had her hair in an upsweep with a cigarette hanging out of one side of her mouth and she walked over as the lecturer, threw her leg over the table edge and began to lecture with this cigarette in her mouth.

HT&BARTIK:

[Laughter]

BARTIK:

Well, I thought this was one of the most exotic women I had ever met.

TROPP:

[Laughter]

BARTIK:

And she came from Brooklyn, but through education and various and sundry things, she had eliminated a lot of the Brooklyn accent. But, once in a while she would say words like "fundamental" or "bottle" or something of that kind and her Brooklyn accent came back. But Adele Goldstine, from the first, struck me as a very sharp, exotic, exciting kind of a woman. And, so I knew her from

HOLBERTON:

Yeah, I didn't know her.

BARTIK:

That time when I first came to Philadelphia.

TROPP:

Her prime role originally seems to have been as an instructor then in mathematical techniques for computation still using —

HOLBERTON:

Desk computers.

BARTIK:

Desk calculators.

HOLBERTON:

Yes, this was before the ENIAC.

BARTIK:

Right.

TROPP:

Desk computers. Then it was after this that you went to Aberdeen for your tab training, came back, began to learn something about what this machine was supposed to do in terms of, at least block diagrams and internal circuitry.

I think the most interesting aspect then is to talk about this demonstration program, the trajectory program. How you got assigned to that and what it involved?

BARTIK:

Well, I think that the, the thing that is hard to understand now with all the training materials and with all this planning that goes into doing anything: At that time it was new and no one knew what to do. First of all, we had to design the programming sheets that you even — How do you write down a program? How do you program? How do you visualize it? How do you get it on the machine? How do you do all these things? So, you know, when you are just starting, things evolve.

HOLBERTON:

That's right.

BARTIK:

Somebody would come along and say, "Well, I do it this way and when I have to make a change it's easier." Or somebody else would say, "Well, I have something even easier." You know, this kind of thing. So to try to visualize a program, on a hard copy. It was —

HOLBERTON:

Well, not only that, but seeing the machine being a parallel thing, you had, you had to have some means of showing this parallelism.

BARTIK:

Plus timing. You had to —

HOLBERTON:

That's right. That's when we developed the pedal, what we called pedaling sheets.

BARTIK:

That's right, to pedal through.

TROPP:

So the timing, the timing was interesting, because it was an asynchronous machine.

HOLBERTON:

Yes it was, you bet it was. You had to know whether it was one cycle or four cycles that you were going to pick up an output pulse to energize the next accumulator, yes.

BARTIK:

Plus you have to understand, we had to physically design how you would—

HOLBERTON:

Hook up.

BARTIK:

Set switches, how you would hook up digit trays, program trays? Which wires would come out of what switch and go on what socket of the tray? So you really needed a three dimensional kind of a thing to show it. And it —

HOLBERTON:

It was really new taking a mathematical equation and even having been through this business of, of hand trajectories, it really didn't help us too much because we didn't have the same kind of integration formulas. We couldn't use the same kind of integration formulas where you go back and check and correct it and put a new number down as we did on paper. That's when that Heun equation, that Heun method of integration came in. I remember getting a copy of that and we were supposed to put that in our method. And I know I relied upon you quite a bit for the mathematics of the work that we were doing at that time.

BARTIK:

But the, the, so anyway, I think the idea for what we should do came about by, probably from John Mauchly because his view was that well the machine was designed to do a certain thing. Therefore, you know, it should be able to do it. So ENIAC was specifically designed to do trajectory, so consequently that was the thing that everybody tried to do on the machine. And we found it very easy to learn that you do this step, step one, then you do step two, step three, but I think the thing that was the hardest for us to learn was transfer of control which the ENIAC did have through the master programmer, so that you would be able to repeat pieces of program. So, the techniques for dividing your program into subroutines that could be repeated and things of this kind was the hardest for us to understand. I certainly know it was for me.

HOLBERTON:

Well that's, that's, well, that's the part that I specialized in because I, I had developed, I had one of these GNOMA pencils, you know, these four color gold, a gold pencil too, and I had made a four color picture of the master programmer. .. Not as it looked on the machine, but as it would look maybe from a block diagram concept.

TROPP:

Mhm.

HOLBERTON:

And what leads went to what places and control what part of the routine. This, this is an area that I really did specialize in.

TROPP:

I remember one of the very first things in some place in my office when I was given, you know, sheets by various people. One of the first sheets of a block diagram applied to a program,

HOLBERTON:

Mhm.

TROPP:

I think has your name on it.

HOLBERTON:

It probably does. Since I wasn't really a mathematician and a pretty good logician that has always been my, my forte anyway, even today.

TROPP:

I think this is one of those sheets that Grace Hopper gave me and as I remember, it has your signature at the bottom

HOLBERTON:

Mhm.

TROPP:

And it may be the very first, at least one that I have seen,

HOLBERTON:

Mhm.

TROPP:

Of the block diagram approach to programming a problem through a machine.

BARTIK:

Well, you had to somehow, because it didn't fit in with the rest of the way we were doing things, laying down the program that, it didn't seem it fit in too well.

TROPP:

You know it's interesting as you look back because here you had the conception of the machine in John Mauchly's head,

HOLBERTON:

Mhm.

TROPP:

and you had the engineering of the machine that went through a variety of stages through people like Pres Eckert and the, the other people like Burks and, and individuals who designed separate parts of the circuitry. And the machine was designed, as you said, to do a trajectory problem; and at the same time nobody had thought about how you were going to get this problem on or what was going to happen in the machine itself until you finally got a result at the other end.

BARTIK:

Well, I think, I think that if you could understand why logical diagrams were ever started in the computing business and why they're still used today,

TROPP:

Mhm.

BARTIK:

You can understand because a logical diagram allows you to visualize things, well, we didn't have any tools like this. We didn't have a concept of a logical diagram. .. And we didn't have all of the standardization that we have now of this symbol means a certain thing and that symbol means something else. I mean, starting fresh we didn't have any of this. So our problems were as programmers, were to design something that we could visualize what we were doing and also to devise something so that someone else could understand what we were doing to check it.

TROPP:

[Laughter]

BARTIK:

This kind of thing.

HOLBERTON:

It was also, you have an inventory of things that you can use on the machine, and once you have used that up you can't use it again. So you essentially had an inventory control problem that once you used a certain, accumulator switch setting you couldn't use that same transceiver or receiver again for anything else because it had already been used up. So you essentially had to have a, have a check off thing too to get, to make sure that you didn't

TROPP:

See what was —

HOLBERTON:

Overload and the accumulator didn't have that many — well, plus you had to worry about how digits were running around trays.

HOLBERTON:

Oh yeah, trays tracking.

BARTIK:

I mean each …. Accumulator not only had a certain number of control switches,

HOLBERTON:

Twelve, yeah.

BARTIK:

Twelve control switches, but it also had a limited number of digit input-output channels,

HOLBERTON:

You couldn't put a shifter on the output. [Laugh]

BARTIK:

And a program with mixed output channels, so consequently you had to worry about the interconnection of units as well as what the unit itself was doing. So, with only twenty accumulators we certainly couldn't …. Use one accumulator just for traffic.

HOLBERTON:

Yeah.

BARTIK:

We didn't have that many.

HOLBERTON:

Right.

BARTIK:

So that well, the micro-programmers today have the same kind of problems.

HOLBERTON:

Yes they do, yes they do.

BARTIK:

That we had, it's very, very similar.

HOLBERTON:

It's getting more and more back to the very kinds of things that we dealt with in the micro-programming area. I see more and more of this, you know, coming back.

TROPP:

Let's get into some of the specifics of this trajectory program.

HOLBERTON:

Well, as I recall, Betty Jean and I were the only two who weren't downstairs doing whatever it was they were doing down on the machine. We were up, by this time we had a nice room upstairs, towards the front of the building. And we were put on this trajectory, it was going to be, presumably, after they got finished [with] the demonstration and what not, this was going to be the job that we would do.

BARTIK:

Well, this was to run real…

HOLBERTON:

[Laugh] Real.

BARTIK:

Problems.

HOLBERTON:

Yea, we were working on the first of what we thought was a real problem.

BARTIK:

We thought that once the machine was accepted that we would be getting raw data from Aberdeen

TROPP:

Mhm.

BARTIK:

And that we would have to compute firing tables

HOLBERTON:

Mhm.

BARTIK:

And compute these trajectories.

HOLBERTON:

Mhm.

BARTIK:

So that our problem was being designed as a very practical problem for Aberdeen to run trajectories.

HOLBERTON:

Mhm.

BARTIK:

So we were very concerned that it be realistic. You know, that we had the precision that you needed, that the function table would be set up.

HOLBERTON:

We didn't even we weren't even given the value, so I remember John Holberton gave us the values that we would use, what, what .. G and H and what not we were going to use, just for our first go around because it wasn't a real, it wasn't a real job that was being given to us from, from Aberdeen as far as the initial data or anything like that. We, essentially — but it was going to be a realistic kind of thing.

BARTIK:

Yes, because we had to worry about ranges,

HOLBERTON:

Yes.

BARTIK:

Ranges of functions and we had to —

TROPP:

How about the problem? Suppose you had to get a particular value out of a function table? Were you able to set up a way to interpolate?

HOLBERTON:

Yes,

BARTIK:

Oh yes.

HOLBERTON:

Yes it did. That's right. That's one thing the function table did have, is interpolation, yes. Mhm.

BARTIK:

So, in any case, we felt that this particular trajectory was a very practical program that Aberdeen would be running

HOLBERTON:

Mhm. Mhm.

BARTIK:

Consistently. And I do want to say one thing about it and that was that when we first started everybody was trying to program a trajectory. Because everybody had to learn the machine, everybody had to learn how to do a trajectory.

So, we didn't know how to do it at all, so everybody was trying, and we were interchanging ideas of how to do it. But, Kay McNulty was the first person that taught me the concept of repeating sections of program. So it was very practical in terms of doing this trajectory problem because the idea of not having to repeat a whole program, you could just repeat pieces of it and set up the master programmer to do this. And I do remember that that was crucial because we were running out of switches and

TROPP:

Yeah. Yeah.

BARTIK:

Everything and you had to be able to reuse some of them. Well, how do you reuse it? And as far as I'm concerned, she was the one that, that first showed me anyway, the concept of subroutines

HOLBERTON:

Subroutines. Mhm.

BARTIK:

On the ENIAC, on the ENIAC. And then what, this concept is really very crucial because once you've learned that then you learn how to design your program in modules

TROPP:

Mhm.

BARTIK:

So that you can reuse them.

TROPP:

Mhm.

BARTIK:

And so the other concept was that the subroutine didn't have to use the whole machine. In other words, you could have two subroutines going simultaneously in parallel.

TROPP:

Mhm.

BARTIK:

And so this idea of modularizing and developing subroutines and things of this kind, to me, were really crucial in learning how to program.

TROPP:

That, that's really fascinating because I, my mind just boggles at this whole thing you were faced with. You know, today,

HOLBERTON:

Well we're pretty well [clears throat]

TROPP:

If you want a program, you pick up a telephone and you say, put such and such a program into the machine and you key it in and away you go.

HOLBERTON:

Yeah, so you, so you make a mistake so you use a little bit more memory.

TROPP:

Right.

HOLBERTON:

So you use it up.

TROPP:

Right.

HOLBERTON:

That wasn't the case then. I mean everything was crucial.

TROPP:

Well, you had twenty words of memory. .. You

HOLBERTON:

Any change you made was crucial to what, what you had to deal with.

TROPP:

Mhm.

HOLBERTON:

You didn't have that; well for one thing you didn't have that many cables, that many trays that you would put numbers, or the pulses for, for stimulating the next program element. You didn't have that much equipment.

TROPP:

It, it's also interesting that you know, today where Boolean algebra is part of

HOLBERTON:

Mhm.

TROPP:

just everybody's ordinary arithmetic, and you just, you know about it and it's part and parcel of the way you think and operate, and the thought of a computer as a logical machine and a collection of logical symbols is … [inaudible]

HOLBERTON:

I think we also learned quite a bit when, Nick and Stan Frankel were there. As far as what —

BARTIK:

Well, they taught me one thing and the most exciting thing they taught me was that you could run a punched card machine with the cards upside down and backwards and it didn't make any difference just as long as you knew what it was doing. And I couldn't believe it.

[Laugh]

BARTIK:

I had learned punched card equipment and I must say this creativity, this sense of doing things different, things are different now. .. You don't run punched cards the same way all the time. And I'd never even thought of such a thing.

TROPP:

Mhm.

BARTIK:

But when they came and gave me this deck of cards and said put it in the machine upside down and backwards, WOW! I knew that these two men were not going to be guided by what everybody else was doing. And I don't know, it may sound kind of weird, but that represents, that particular incident, represents a kind of creativity and excitement those two men generated.

HOLBERTON:

Yes.

TROPP:

Mhm.

BARTIK:

.. Just to be able to do such a thing.

TROPP:

When, when do you remember them first showing up at the Moore School?

BARTIK:

It was in the winter, because Stan had summer pants on and nearly froze. [Laugh]

TROPP:

So it was either in late '45 or early '46 then?

HOLBERTON:

It had to be late '45.

BARTIK:

Yeah, I think

HOLBERTON:

Before Christmas, it was before Christmas.

TROPP:

Before Christmas of '45?

HOLBERTON:

Yes, yes.

TROPP:

And they were there originally as I remember, to work on a Los Alamos problem

HOLBERTON:

Yes, Manhattan Project. Mhm. In terms of some predictive aspect of the feasibility of what eventually became the Super?

HOLBERTON:

Yes. ..

BARTIK:

Well we, I mean I didn't know what it was.

HOLBERTON:

They did things to that machine I think that at that time we didn't really consider, like cutting the accumulator in half.

BARTIK:

Yeah.

HOLBERTON:

Putting shifters on the input or the output, what

BARTIK:

Right, right.

HOLBERTON:

To me it was a new idea.

TROPP:

Well, did they cut it in half because it didn't have a big enough memory?

HOLBERTON:

They didn't have enough … That's right.

TROPP:

They went from twenty words to forty words by cutting it in half.

HOLBERTON:

Not only that, but they had, they had to worry about that the value stored in the same accumulator: both negative or both positive because it was a complement machine, they couldn't have positive and negative numbers in the same accumulator.

BARTIK:

Right, right.

HOLBERTON:

So there was a lot of planning and a lot, I think a lot of learning for us was done at that time.

TROPP:

Well I, I'd like to back up on …

BARTIK:

Well, I think it was that I want to point out though what these guys had and what it meant to us. And that really is the idea that you can create and make this machine do whatever you like, just as long as you obey the rules.

HOLBERTON:

Mhm.

BARTIK:

So, they did these things, I mean, they tell you you have an accumulator that's ten digits long. Well, most people, and I would say even us, we were so frightened of this thing that we would never think of splitting the accumulator in half, you know.

And the concept that as long as you obey the basic rules, you can do anything you like within —

TROPP:

As long as you

BARTIK:

Its capabilities.

TROPP:

Don't do something on the machine

HOLBERTON:

Well, you know the thing that I remember —

TROPP:

That's capable of, of violating a law of physics.

BARTIK:

Right.

HOLBERTON:

In that case, you know, I was worried about the accuracy. There they were with a ten digit accumulator going to get only five digits out of it.

And I can remember one of them, I don't remember which one it was, said that "We will be glad if we get one digit of accuracy," and I was appalled, you know.

TROPP:

Yeah.

HOLBERTON:

Using a computer now and they're going to get just one digit of accuracy, within the ball park essentially.

TROPP:

Who was it who taught Metropolis and Frankel what ENIAC was all about?

HOLBERTON:

Oh, I don't know. It must have, must have been Eckert and Mauchly, I don't know. Because they were dealing directly with, with Mauchly.

TROPP:

Yeah, because what they were doing was so highly classified.

HOLBERTON:

Right. That's right. We weren't, we were not told what it is we were doing. That my husband knew because he knew enough physics to know what those equations were doing and he had graduated as a nuclear physics in the thirties when nobody knew that they were. So he was aware of what was going on. I had no idea what was going on.

TROPP:

Mhm.

BARTIK:

Well, as yeah, well, they had been here before and had been here because as I understood it, their problem was classified and there was no alternative for them learning the machine. So that, it was my understanding, that they came and had a concentrated series of consultations with people that knew about it.

HOLBERTON:

Yes.

BARTIK:

And learned how to, how to use it and then went back

TROPP:

And so in a sense —

BARTIK:

And programmed their problem.

TROPP:

I was going to say in a sense they learned how to program in the same way that you learned how to program.

BARTIK:

Right.

HOLBERTON:

Well we, we did a re-do of—when they came back the second time—the mapping on the floor, because I remember all of us got together and reshuffled the whole setup.

TROPP:

Mhm.

HOLBERTON:

And that was one of the things that I remember doing as far as, as far as the setup itself was concerned while they worked upstairs. And a whole bunch of us were on that. Getting, a new setup for the same thing. So we would, and we had to have some of these adapters changed to different shifting operations and what not. This little fellow downstairs used to do that, change a shifter for us and what not.

We did a re-do and that was to me an education too, of seeing the problem in a different light, and, you know, put on the machine a different way.

TROPP:

Well, in terms of, terms of problems of programming you were, you were up at Aberdeen. I'm trying to remember what Aberdeen had. Of course they had differential analyzers.

HOLBERTON:

That's all.

TROPP:

Did they, they had a Bell relay machine.

BARTIK:

That hadn't arrived. That hadn't —

TROPP:

No, not the Mod 5 hadn't, but they, there was an earlier machine that I think was just called a Ballistics Calculator. Now didn't they have that at Aberdeen at that time?

HOLBERTON:

No, they had a multiplier and they had three pieces, separate pieces —

TROPP:

They had a thing called a Relay Interpolator about 1942 I think, something.

BARTIK:

Well, I never saw it so I don't know anything about it.

HOLBERTON:

I don't remember that. No, I remember the multiplier because that gave so much trouble.

TROPP:

So you weren't, you weren't introduced then to any kind of automatic computation

HOLBERTON:

No.

TROPP:

At Aberdeen.

HOLBERTON:

No.

TROPP:

Were you, did you have any knowledge of what was going on at Harvard? During this same period?

HOLBERTON:

Not at that time, not until we got the invitation, no.

BARTIK:

No.

TROPP:

So in that same period when you were trying to learn ENIAC from scratch, Harvard was

HOLBERTON:

We didn't know anything.

TROPP:

An unknown, totally unknown quantity.

HOLBERTON:

Well, nobody, nobody, well, for one thing, we weren't even allowed, you know, to say at home what we were doing. It was a very secret thing.

TROPP:

Mhm.

HOLBERTON:

And I, I remember that because of my father who taught mathematics, and yet I wasn't able to tell him anything I was doing.

TROPP:

How about that, that test problem, or the trajectory problem when they came up with the demonstration. That must have [inaudible]

HOLBERTON:

Well, we were doing it, you know, not, our time frame was not going to be for that and I remember when we were told that they were going to use this thing and we were really not done at the time we were told this. It was like a crash program to get it done and, and Marlyn did the desk, the hand computing one that would check whether we had it tested and I remember,

TROPP:

Marlyn?

HOLBERTON:

Marlyn Westkopf

TROPP:

Westkopf.

HOLBERTON:

And Ruth Lichterman did all these little pieces of paper you put in front of every one of the accumulators to say what the circuitry was, taken from our, our sheets and it really was a crash thing and they weren't giving us very much time to get it on the machine. It seemed to me it was less than two weeks to get it on and running before the demonstration.

BARTIK:

I think it was like two days.

HB:

Oh no, oh no. It was longer than that.

BARTIK:

Oh yes. I'm almost positive because what happened was we were sitting there and Adele and, Adele and Herman Goldstine invited Betty and me to their house for tea. Well, we certainly had not had any contact with them

HOLBERTON:

Mhm.

BARTIK:

Prior to this and so we were saying to each other, I wonder why they are inviting us to their house for tea? So we, they had an apartment in West Philadelphia and we went out there and I can remember they had a cat and I remember it jumping all over me and we had tea and so everything was very cosy and all of a sudden Herman asked us if we could get our trajectory on the machine for the demonstration. Well, I almost fell off my chair. [Laugh] We had never had any idea that it was going to be used.

HOLBERTON:

Yeah.

BARTIK:

For the demonstration. So we had been dying to get our hands on the machine and to see if any of our programs would run and we immediately said yes, that it was absolutely ready to go, but they began questioning us just how, how complete the trajectory program was.

And we told them it was absolutely complete and we could run it right off the bat,

TROPP:

[Laughter]

BARTIK:

We could set it up and run it. So they said, "Okay, do it." [Laughter] So then we immediately went back the next day and worked like mad getting all the, the labels we, because each unit, you had to plan labels and put, they had little slots on the front of each

HOLBERTON:

To show the settings.

BARTIK:

Piece of gear to show the settings of every switch. And —

TROPP:

So it really was a visual display then of the program

HOLBERTON:

Yes.

TROPP:

And it was laid out on the, on the side of the [inaudible]

HOLBERTON:

Right.

BARTIK:

[Inaudible] Yes.

HOLBERTON:

Without, without any real seeing of the sequence of the thing because the wires were all sort of mixed up there.

BARTIK:

So in any case, we worked like mad to do —

HOLBERTON:

I thought we had about a week.

BARTIK:

Well, my own impression is that we had two days.

HOLBERTON:

I know it was a crash thing because we came back the next day and we'd find the wires weren't where we thought they were and Marlyn and, and Ruth would go around checking that the settings were the way we had left them because they would make changes whoever was debugging at night. You'd come back, you know, and it wasn't what you had, they didn't change the

BARTIK:

Well, I'd say —

HOLBERTON:

Cards and nothing was, nothing was —

BARTIK:

Yeah, but I think you are thinking about other programs that happened which was a constant problem with this kind of a machine. For test engineers to test a piece of equipment they had to use some of the switches and program cables and things. So, consequently, your program would be destroyed. And this occurred every time anybody tested anything and so we became absolutely paranoid about switch settings. [Laughter] You know, you check switch settings, you check and you check and you check. But my memory is that we had like two days and

HOLBERTON:

I don't see how we could have done it.

BARTIK:

That was all to prepare this test problem. .. Well, we could have done it because we really were ready to go and were so —

HOLBERTON:

Except we had never been on.

BARTIK:

That's right, and we were so anxious to, to get on the machine.

Well, in any case, we came back and immediately began preparing all of the routine things for getting it on the machine. And then, of course, we put it on and it worked up to a point, but we couldn't get it to stop. I think it kept —

END OF SIDE I SIDE II HOLBERTON:

Well I, I think that actually I was well aware that this was breaking new ground, I really was.

BARTIK:

I don't, I knew that we were breaking new ground, but I don't think that the force of it hit me until the publicity began.

TROPP:

Mhm. And this was in [clears throat]

BARTIK:

I really think that the stimulation of outside people, the concepts that people jumped to immediately, they jumped immediately from a big machine like this doing calculations to one in every home, this kind of thing.

HOLBERTON:

Yes.

BARTIK:

And you know, to me this was so farfetched from the kind of thing we were doing that it seemed to me like these people were really crazy. Because, I mean, that machine was like forty feet of equipment [laugh] and you certainly don't

TROPP:

I see. The

BARTIK:

Put that kind of equipment in a home.

HOLBERTON:

That part of it, that being one in every home, I didn't consider that thing, but as far as the significance of it, I was really very much aware of it because of, of my background, the family being in mathematics and having desk computers at home and this kind of thing, and so I was fully, .. You know, that's the reason I was so eager, I worked sixteen hours a day, I mean, it was just great.

TROPP:

Mhm.

BARTIK:

I don't think though that anybody …. At that time really divided decision-making down into its component parts the way they do today. Now, to me I had a hard time making the leap between repeating a sub-routine to making a decision, a human decision.

TROPP:

Mhm.

BARTIK:

And to me the idea that all decisions could be broken down into little binary decisions

TROPP:

Mhm.

BARTIK:

Was a concept that was very exciting to me and I spent as much time thinking about how a human decision could be broken down into these little minute binary decisions kind of thing.

TROPP:

Bits with the various tracks open to you and weights assigned to them and decisions made on the basis of alternative routes.

BARTIK:

Right, and to me when this leap was made in the publicity surrounding the ENIAC—that it was a thinking machine—I had a hard time with it because —

HOLBERTON:

Ah, that, that was ridiculous.

TROPP:

Yeah.

BARTIK:

I really did because to me everything was so painful

HOLBERTON:

Yes.

BARTIK:

And so difficult to do. [Laughter]

HOLBERTON:

Yes, it was. Yes it was.

BARTIK:

But the amount of work that had to be done before you could ever get to a machine that was really doing any thinking, to me just staggered the mind and I found this very annoying.

HOLBERTON:

I remember that the morning of the demonstration. Betty Jean and I were still trying to work out some problems in the trajectory; it wasn't printing out every one tenth of a second to start with or every two tenths and then every second afterwards. It just wasn't doing that, it was printing out at eight tenths, 1.8, 2.8, like this. And we were put into this room, and I imagine the demonstration must have been late in the morning because we were in that room beside the machine working on this thing and Dean Pender and that other tall fellow, Cheticker came in this little room. Dean Pender, who was a very stately gentleman with white hair, I really had never talked to him before, he came in, and he had a paper bag in his hand, and he said to us, "Go to it." And he handed this paper bag and walked out. And we opened the paper bag and there was a fifth of liquor and I think Betty nearly had hysterics.

TROPP:

[Laughter]

HOLBERTON:

Here we were trying to get this bug out of this problem but we never did, it went on the way it was.

And I think the next morning, I woke up and in the middle of the night thinking what that error was. I came in, made a special trip on the early train that morning to look at a certain wire, and you know, it's the same kind of programming error that people make today. It's the, the decision on the terminal end of a do loop, speaking Fortran language, had the wrong value. Forgetting that zero was also one setting and the setting of the switch was one off. And I'll never forget that because there it was my first do loop error. But it went on that way and I remember telling Marlyn, I said, "If anybody asks why it's printing out that way, say it's supposed to be that way." [Laughter]

TROPP:

I wish I could remember the exact quotation, but it was a story of Wilkes's of the first programs that were run on EDSAC. And he talks about finding the mistakes and correcting them and so on, and he said, "Here I was doing the debugging not even knowing the word, and not knowing I was going to spend the rest of my life doing that." [Laughter]

HOLBERTON:

Well you know, the thing is we did develop the, the one word that's in the language today, which is "breakpoint," at that time. Because we actually did pull the wire to stop the programs so we could read the accumulators off. This was, I mean we actually broke the point, and that was where the word came from.

TROPP:

I would like to hear about that demonstration on the, on the first day. I think that must have been wild.

HOLBERTON:

Oh, it was. It really was wild.

TROPP:

Well did you get some, some raw data then for the first time?

HOLBERTON:

No, we used our own little simulated trajectory.

TROPP:

You used all the simulated information?

HOLBERTON:

We just used information that was built up, initial base for the trajectory was, and Marlyn Westkopf had done the hand computation so that we were in the ball park of, of what the answer should be. But it was a long time later, after we had had people come over from the Mathematics Department though to, to talk to us about it, I mean, Rademacher came over, because we were not getting the answers we were supposed to be getting then. They looked into round off errors and they looked into truncation errors.

TROPP:

Mhm.

HOLBERTON:

And it was later found out that actually the Heun equation was not put on the machine correctly, and this was a long time later.

TROPP:

I'm not familiar with this class of integral and I'm curious as to what kind of, what, what form of integral it falls into?

HOLBERTON:

I don't know. I think it's a, it's very similar to Simpson's rule sort of thing.

TROPP:

So it's a —

HOLBERTON:

But somehow we were not applying it correctly, and we didn't know that for a long time later until at Aberdeen we had real data, and they had done hand computation and we weren't getting —

TROPP:

It, it's a specialized form of numerical integration then?

HOLBERTON:

Yes, it is. Yes, it is.

TROPP:

When you are talking about the Heun equation.

HOLBERTON:

Yes, in fact that equation was given to us, you know, after we had started to program the trajectory. I don't know where it got drummed up from, but it was after we had gotten started

TROPP:

Mhm.

HOLBERTON:

That someone had come upon this.

BARTIK:

The thing that did happen with this particular trajectory problem was that it didn't stop at the ground, it went on and dug a hole in the ground.

HOLBERTON:

Well that was, it was also another one of those master programming cut-off errors.

BARTIK:

This was one of those errors of how do you stop exactly when you're finished?

HOLBERTON:

Well, because it wasn't sampling on, on the change of sign and in the second order of H.

BARTIK:

So that day was quite an exciting one. We kept running it over and over, the problem over and over again and then we would take the cards out of the trajectory and run it through the tabulator and then we used several part papers,

HOLBERTON:

Mhm.

BARTIK:

If I recall, it was folded scored paper, and we used to take it out — well what we did, we took it out of the tabulator and ripped off sheets and…

HOLBERTON:

Gave them away.

BARTIK:

To people who came to the demonstration.

TROPP:

Do you remember some of the people and some of their reactions to the demonstration?

BARTIK:

Well, the reactions of the people to the demonstration was .. very exciting, I mean ..

HOLBERTON:

We had a luncheon after it, I remember, over in the museum. Remember that?

BARTIK:

Oh, I didn't go.

HOLBERTON:

You didn't go?

BARTIK:

I didn't go to any luncheon.

TROPP:

Do you remember some of the people, and some of their comments?

HOLBERTON:

I sat at the same table as the fellow from Science Service

TROPP:

Mhm.

HOLBERTON:

Because I had never heard of Science Service before,

TROPP:

Mhm.

HOLBERTON:

And I don't remember who he was, and I don't remember, because it seemed to me there was a pre-press release that was made up for the press.

TROPP:

Right. I've got a set of those pre-press…

HOLBERTON:

Yeah. I think it was something like that so that —

TROPP:

Releases that were out and they're, they're —

HOLBERTON:

It was actually an extremely good demonstration, there was no question about it. I haven't seen any really other than, than one at Michigan one time when they, they programmed the, the equation of motions with, with the billiard balls, that was anywhere near as exciting as to see those numbers build up with the lights out and all these neon things, you know, going. It really was an impressive thing.

BARTIK:

Well, the thing about the ENIAC, and this is something that Pres Eckert said in his speech at Franklin Institute, was that this is where the ENIAC is where you get the idea that when a computer works, lights flash.

HOLBERTON:

Yes and the reason for that was that the panels over the accumulators, the matrix that stored your ten digit decimal numbers, was a ten by ten matrix. Well, the way they actually got that to be a visual display was they had drilled holes in the panel that fitted over the vacuum tubes that were in the decade counters

TROPP:

Mhm.

BARTIK:

That held the numbers. So you had the ten by ten matrix of lights.

TROPP:

Mhm.

BARTIK:

So consequently, when you were doing calculations these lights were flashing as the numbers built up and as you transferred numbers and things of this kind. So you had the feeling of excitement

HOLBERTON:

Yes, yes.

BARTIK:

Of really a lot of things going on because of that and then the punched card reader and punch were reading periodically.

TROPP:

You see if you could have taken a motion picture of those lights then you could have actually,

HOLBERTON:

Oh, yes.

TROPP:

You could have reproduced the numbers.

HOLBERTON:

Oh yes, absolutely.

TROPP:

As they were coming in and being built up.

HOLBERTON:

And they were systems, you know, when you are building up to an error where it might take a half a minute to get to the point where you really want to stop it, you could look at that thing and have someone stop the machine at the point where it was, you know, getting close to going negative or whatever it was that you wanted to do. You could, you know, you could see it, yes.

TROPP:

You could see the build up visually occurring and the numbers literally coming up.

HOLBERTON:

Oh, yes. Oh, absolutely.

BARTIK:

They were very essential to debugging, very essential. That's the only way we did,

HOLBERTON:

That's right.

BARTIK:

That's the only way you read what the machine…

HOLBERTON:

Had. That's right.

BARTIK:

Stored, what it was doing.

TROPP:

Mhm.

BARTIK:

But it was from the ENIAC and from this demonstration where people saw for the first time, saw calculations taking place.

HOLBERTON:

That's right.

TROPP:

It seems, listening to your description, it seems like everybody who had problems or was connected with the machine, had to go through the same exercise you went through. Now, you described what Metropolis, Frankel, and Von Neumann must have gone through at some point. Clippinger must have gone through this at some point.

HOLBERTON:

Well, yes.

TROPP:

Everybody who came over to do a problem had to start from scratch.

HOLBERTON:

That's right. You know, that made such an impression upon me that, that the first course I gave when I went to work at Eckert-Mauchly on the UNIVAC I. I actually gave a course from the block diagrams. I felt everybody had to learn a machine at that level. To me that was the way you learned a machine.

TROPP:

Well, that's a —

BARTIK:

Well, I think you learn it from the logical level.

HOLBERTON:

Mhm.

BARTIK:

As a matter of fact that experience was probably the —

TROPP:

Yes, but nobody had realized that at that point. That came a few years later. The idea of the logical nature of a machine of that sort. I don't think that was really apparent in the early stages of ENIAC. Did you realize that really?

HOLBERTON:

Well yes, because you couldn't do anything really except repeat what a desk calculator could do without the, the master programmer which was the logic. You really couldn't do anything more.

BARTIK:

Well, I think also you had to learn, because of debugging,

HOLBERTON:

Yes.

BARTIK:

To know what all those lights meant.

TROPP:

Mhm.

BARTIK:

You had to know exactly how the machine did things because they had, from the very start, you could make the machine do one add time

TROPP:

Mhm.

BARTIK:

At a time.

HOLBERTON:

Mhm.

BARTIK:

And then you could visually examine all the lights to see if it had performed the function it was supposed to.

HOLBERTON:

Mhm.

BARTIK:

And various pulses showed up at various times in…

HOLBERTON:

That's right.

BARTIK:

Accumulators. And if you didn't know the logic of the machine, you wouldn't know what it meant.

HOLBERTON:

Well not only that, but if you didn't know the logic of the machine, you, you could very easily make an error in the area of taking off when, when an accumulator becomes negative, taking off the PM thing, pulse from that thing and sending it into the program stage which would be the wrong timing,

TROPP:

I see.

HOLBERTON:

And it would not energize the next instruction going along because of timing. You had to really know that whole twenty digit cycle.

TROPP:

The blueprints of that machine are absolutely fascinating because you can, I can see now, or I could after Arthur Burks went through the blueprints with me, I could see how you could take a number and do things with it all the way through that blueprint.

HOLBERTON:

Yes.

TROPP:

And I don't know that I could have made the jump from those huge sheets of prints to the block diagram that you described. That was all I had ever seen.

BARTIK:

Well actually, you know, that was a trial and error I guess, you know, it really was.

TROPP:

That was really quite a jump.

HOLBERTON:

How do you display what it is you are try

TROPP:

Mhm. Well, you know, looking at it from today's language, that was, what they now call, I guess, in-house programming, which has totally vanished. Everybody who had, who was going to use the machine had to learn how the machine operated and essentially learn how to put their own problem on.

HOLBERTON:

And you know, yes, because of that you learned from what someone else picked up and in that way you got a repertory of techniques,

TROPP:

Mhm.

HOLBERTON:

Because each person was attempting a new program and a new kind of thing and something new was thought how to handle that. It wasn't, you know, a set of techniques.

BARTIK:

The other reason why a lot of innovative things were done with the ENIAC was the fact that it was too small for most of the problems that people really wanted to —

HOLBERTON:

That's right.

BARTIK:

The trajectory fitted it nicely. The twenty accumulators held the variables and the function tables were right for the functions you needed and things of this kind.

But the war ended in 1945 and the push for the firing tables was over. So then when everybody in the country started to think about what problems to put on the ENIAC, every mathematician knew he had a problem that he had been trying to do and started to think about how to put it on the ENIAC; well, most of them, except perhaps Lehmer's little problems, they were always too big for it. So consequently, you always had to be changing it or to think of something new and innovative in order to get a problem or.

TROPP:

Or ways that you could break the problem down into smaller portions.

BARTIK:

Right. So that what, the way it actually worked was that we, as programmers, would be assigned or were assigned to specific problems. People were trying to put a problem on the machine. Generally there were two people involved. One that knew the problem and one that knew the machine. And so the limitations of the machine could be fitted to the, to the problem and the problem could be changed to fit the limitations.

TROPP:

Were you involved in Lehmer's problem?

BARTIK:

No.

HOLBERTON:

No. Lehmer did that all.

TROPP:

He did it all by himself. That was one of the very first problems run.

HOLBERTON:

He used to come on, you know, in the evenings and run for a while.

BARTIK:

Well, we were always fascinated that he had this big machine and he was excited about this little problem and just used the tail end of the accumulators and stuff. I mean, here was this exciting problem that Lehmer would be doing and he would be over there in the corner using half an accumulator or something.

BB&TROPP:

[Laughter]

HOLBERTON:

I couldn't figure out why anyone would want to know about prime numbers anyway.

TROPP:

[Laughter]

HOLBERTON:

Sort of playing games on the machine.

BARTIK:

It seemed like using an awfully big machine for such a little dinky problem.

HOLBERTON:

I thought it was very similar to the thing that we, that we put on there that flashed Moore School, Moore School on the lights, do you remember that? By a deck of cards coming in. [Laugh]

TROPP:

Oh, you got the lights flashing?

HOLBERTON:

Yes, it made it look like the words Moore School, yes.

TROPP:

Like a neon sign going on and off.

HOLBERTON:

Yes, yes.

TROPP:

Do you remember some of the early problems that you got involved in?

HOLBERTON:

I remember one for Dr. Goff who was in the Towne Scientific School. I don't remember what the problem was, but I remember Dr. Goff was quite short and he was bringing in some visitors one time to see his problem run and after he left the answers weren't right. So we figured out where he had been standing, you know, and I remember him standing in front of one of the accumulators, I mean in front of the function table, and he was shorter than the function table and I figured out just about where his hand would be and we started checking with our sheets as to any switches that were turned, and sure enough he had turned a switch and didn't turn it back.

TROPP:

[Laughter] He was showing somebody how you moved the switches then.

HOLBERTON:

Yes.

BARTIK:

Well, certainly one of the earliest things I would say for even the geniuses that came to look at the machine, to understand was that those switches meant something and the fascinations that people have with machines. They would come in to a demonstration, or people would just come into the room and they would flick switches. This is human nature, you see. You see a switch, you flick it.

HOLBERTON:

That's right.

TROPP:

Like a kid. [Laugh]

BARTIK:

And everybody, from the lowliest to the highest person that ever came in to that room flicked a switch.

HOLBERTON:

That was standard operating procedure. Go round and check the machine, the whole bunch of us after anybody had been in there for a demonstration.

TROPP:

Well, when you had a problem running then, all of your switch settings were all listed on these little slips.

HOLBERTON:

Oh yes, they always were. Oh, yes.

TROPP:

So that you could just go over and just match —

HOLBERTON:

But that's a time consuming thing. It really is.

BARTIK:

When you have as many switches as that machine had.

HOLBERTON:

Especially when the power kept popping.

TROPP:

When did you first run into Von Neumann?

BARTIK:

I never met Von Neumann until — I had seen him—, but I never personally met him until we began programming the machine, or transferring, translating the ENIAC from a parallel machine to a serial machine.

HOLBERTON:

Didn't you see him during the time of the Dommler code?

BARTIK:

I had seen him but I never met him until we began doing that and he consulted with Aberdeen at that time and we used to go to Princeton to work on the program that translated it into a serial machine. And so we used to work and then we'd go see him for half an hour a day and discuss alternatives.

The thing that happened to the ENIAC was that it soon became apparent that there would be practically no through-put if every problem had to be set up by setting up all these switches and ...

HOLBERTON:

We were having a lot of problems with cables. Intermittence in cables and that kind of thing, and the minute you had to [tear] the machine down and put it back together again, another unsoldered joint or something like this would develop take a very long time to, to get those things out.

BARTIK:

So it became very apparent that some other operating procedure had to be done in order to get any kind of through-put out of the ENIAC. So the function tables became used as programming tables. So that, and that the setup of the machine —

HOLBERTON:

The machine was hard wired then at that point.

BARTIK:

The machine would, it's like firmware. We made the switches and cables on the accumulator —

HOLBERTON:

For a certain new instruction code in fact.

BARTIK:

We began, we considered that firmware. So that the only thing that you changed thereafter were the instruction codes which were then stored on the function tables. And the function tables had twelve digits each, for each position, for each argument. So, the way it was actually done was that we divided each function in the function table, into six, two digit instruction codes. And we devised an instruction set like machines have today, and so your program consisted of setting switches on the function table. ..

TROPP:

Because this is what, where the controversy comes up about the origin of the stored program concept, which was first demonstrated by using the function tables on ENIAC.

HOLBERTON:

Yes.

BARTIK:

Right.

HOLBERTON:

Yes.

TROPP:

In this manner. And as I say, you can even call it microprogramming in the way it was used.

HOLBERTON:

Yes, yes.

TROPP:

And I guess the origin of that is the center of the debate

HOLBERTON:

Well …

TROPP:

In terms of the conception of this jump from a so called, special purpose machine into a general purpose internally stored program.

BARTIK:

Yes, well I've heard it said that this was anticipated in the design of the ENIAC, but I don't know. The push as far as I'm concerned and the pressure for me, because my group in Philadelphia actually did this with Dick Clippinger and Von Neumann and Galbraith and Giese —

TROPP:

Which Galbraith is this, the economist?

HOLBERTON:

No.

BARTIK:

No, Galbraith the ..

HOLBERTON:

John.

TROPP:

Was he the industrial engineer?

HOLBERTON:

No, no.

BARTIK:

His name isn't John Galbraith.

HOLBERTON:

No, no it's not, it's not John.

BARTIK:

He was at Colby University —

HOLBERTON:

He's down, he's still down at Aberdeen, I believe in charge —

BARTIK:

No, Giese is the one.

HOLBERTON:

Oh, Giese is there.

BARTIK:

Giese is there, but Galbraith is someplace else.

TROPP:

How do you spell Giese's name?

BARTIK:

I think it's —

HOLBERTON:

G-u-i-s-e isn't it?

BARTIK:

No, I think it's, I think it's G-e-i-s-y, but I may be wrong.

HOLBERTON:

Mhm.

BARTIK:

I think he's director of the Ballistics Research Laboratory.

HOLBERTON:

Yes he is, yes he is.

TROPP:

At Aberdeen?

BARTIK:

Now. But at that time he was, he was a dreamy mathematician [laugh] working for Dick Clippinger at the wind tunnel at Aberdeen and after the machine was moved to Aberdeen, I was married and stayed in Philadelphia. So Dick Clippinger wanted to do some of his problems on the machine, so he let a contract with Aberdeen — [no,] with the University of Pennsylvania, with the Moore School, and I had a group of programmers, ENIAC programmers, in Philadelphia. And it was primarily because Dick Clippinger's problems were too big to go on the machine that he was the one that provided the push for Aberdeen to finance .this change from the parallel machine to the serial kind of operation. And because the programming group at Aberdeen — or political reasons which I suspect, our group did it rather than the group at Aberdeen. Because this group in Philadelphia was really under Dick Clippinger's guidance.

TROPP:

Yes, but you don't remember conceptually where the ideas came from?

BARTIK:

Conceptually, I haven't any idea.

HOLBERTON:

No.

TROPP:

Dick's story is essentially that he was exposed to the machine through Adele Goldstine in terms of how it operated and must have felt the limitations of getting his problem on, and then got an idea of how to use the function tables in this manner and then spent some time with Von Neumann.

BARTIK:

Yes, we certainly did. He was very crucial to —

TROPP:

Then he spent some time with Von Neumann talking about

HOLBERTON:

Yea.

TROPP:

Using the machine in this way and then Von Neumann provided much of the impetus for the implementation. Along with Clippinger.

HOLBERTON:

Well they had to get, they had to have additional hardware built in order to make it work though, because there wasn't enough to do all that translation and what not in storage to do all the requirements and that's when Kite Sharpless's group came in to build that extra little piece.

BARTIK:

Well, the problem was to break each function, twelve digit function, into six.

HOLBERTON:

Mhm.

BARTIK:

Two digit instruction codes, because, and then what we did was to feed those two digit instruction codes into the master programmer and the master programmer gave out the signals.

HOLBERTON:

Mhm.

BARTIK:

That told, that decoded the instruction.

TROPP:

Mhm.

HOLBERTON:

Mhm.

BARTIK:

The master programmer was used as an instruction decoder. And certainly Von Neumann was very instrumental in the development of the instruction code for the ENIAC —

HOLBERTON:

That's the only argument I ever had with him.

TROPP:

Yea, you mentioned that one time and we don't have it on tape. Why don't you talk about that.

HOLBERTON:

Oh yes you do, it's in that trans thing.

TROPP:

Oh, that's right, that's right. It's in the '67 —

HOLBERTON:

It's the only time I ever talked with Von Neumann and I felt rather bold when I got up and said that, too.

Well, they had the instruction code and it didn't have a stop instruction and he said, "Well, you don't need it, there are all these extra leads and you've got 99 possible combinations and it will go to any one of these grounds." And I was bold and I remember that I felt bold at the time and I said, "But we are not all Von Neumann's, we will make mistakes and it will be unintentional." And he just nodded his head and said, "All right."

BARTIK & TROPP:

[Laughter]

HOLBERTON:

And I felt very proud after. [Laughter] Because I never spoke to the man before.

BARTIK:

I do feel that the personality of Von Neumann, if you have the time, I have a few things to say about that.

TROPP:

Yeah, I'd like that.

BARTIK:

which I would like to.

TROPP:

Yeah, I would like to get Von Neumann's, your impressions of Von Neumann onto this tape.

BARTIK:

Well, Von Neumann seemed very, very shy. He was an amazing combination of a very brilliant man who knows that he's brilliant, but at the same time is very modest and shy about presenting his ideas to other people. And during this consultation with him when we used to go to Princeton and see him like for a half hour a day, we would go in to a room and he would stand in front of the room like a professor, consulting with us, so we would, you know, state to him a particular problem that we had. And we were always very careful before we entered this conference that we had the questions represented fundamental problems that we were having and not just mechanical problems that …

TROPP:

The very careful formulation of —

BARTIK:

Right, so that we wouldn't be wasting his time and so that we'd get the most out of these interviews.

Well he, he certainly wasn't nervous, but I would say he was very shy. He offered his opinions almost apologetically, and if he had to disagree with you, he did so almost apologetically.

TROPP:

Mhm.

BARTIK:

And yet the concepts and the ideas and the reasons — he was very thorough in explaining why we needed a particular instruction or why we could do without an instruction or things of this kind. And it was the first time that I had ever realized the importance of instruction codes, I would say, and why they're important and the logic behind them and the ingredients that a whole instruction set must have. So the thing that Von Neumann had which I've noticed that other geniuses have, and that is the ability to pick out, in a particular problem, the one crucial thing that's important, or the one general principle that you are being hung up on, things of that kind. This, this is the kind of tale. he had. Yet he, he was very restless and he would march back and forth across the room, yet when he presented his ideas it was almost as though he were apologizing [clears throat] for .. disagreeing with you or thinking of a better idea.

TROPP:

Well, you know, it's apparent from comments that people have made, that when they designed the machine at Princeton with the 1,024 words of memory, that from his point of view, this was the equivalent of infinite memory. With the —

HOLBERTON:

Oh, yes. In those days, oh, that sounded fantastic to me, a thousand, [inaudible] great.

TROPP:

Well, it's hard in the time frame because with all the litigation going on and publications like the, the current one that Professor Goldstine did. Now everybody is trying to say who did what and it's almost impossible to go back in that time frame because it was such a mixed bag of people, always talking to each other and ideas and problems going back and forth, it's hard to say who really did what.

HOLBERTON:

That's right. That's probably true.

BARTIK:

Well, I think that's true and it certainly is in my case. I just considered it very exciting

HT&HOLBERTON:

Mhm.

BARTIK:

And a learning experience

HOLBERTON:

Mhm.

BARTIK:

And once I learned something, you know, it was mine.

TROPP:

Sure.

BARTIK:

To use.

HOLBERTON:

That's right.

BARTIK:

And I never even thought —

TROPP:

You may have originated the thing without realizing you had done so.

BARTIK:

That's true.

HOLBERTON:

That's right.

TROPP:

In terms of just conversation and interchange of ideas.

HOLBERTON:

You know that's always true when you are there, the first one to do something. I mean, you know, people say, "Oh, you did the first sort generator."

But I was there. Someone else could have done it too at that time. So if you're there at the beginning you are bound to be a first in something.

TROPP:

Mhm.

HOLBERTON:

You may not even know if you were or not, or you may even have done it simultaneously because ideas come to people who need something at the same time. So you can't always be sure.

TROPP:

Well in, in talking to John Mauchly about, about ENIAC and the fact that some people try to characterize it as a special purpose machine and he saw it more as a general purpose

HOLBERTON:

Mhm.

TROPP:

Machine. The key element is this master programmer.

HOLBERTON:

Oh, yes.

TROPP:

And it's this that really is the crux of any discussion about the ability of ENIAC to solve problems.

BARTIK:

Well, because the thing that —

HOLBERTON:

The do loop. I mean, basically, that's exactly what it is. And you can't have, you can't have a language that doesn't allow you to do interations and decision making.

BARTIK:

Well, I don't think anybody at that time thought of storing masses of information in memory. Now as far as the ENIAC was concerned, the mass storage device were those punched cards.

TROPP:

Mhm.

BARTIK:

The only thing that you had in memory were the things you were working on at the moment. So that I don't think that anybody ever really thought about having tremendous size memory.

HOLBERTON:

You know, and I don't think, you know, people at that time, you know, there were tables of sines and cosines and what not and I don't think that the general people would consider, you know, that it would be economic to re-compute something that had already been done and stored somewhere else.

TROPP:

And it really wasn't economic until the transistor came along.

HOLBERTON:

That's.

TROPP:

And core memory came along.

HOLBERTON:

Right.

TROPP:

That was the first time it was economic to forget about all these tables that had been calculated for decades.

HOLBERTON:

That's right.

TROPP:

And you know, talking to the people who made early tables, they were absolutely appalled when somebody said to them, "Well, why bother to look it up on your table when we can compute it so quickly."

BARTIK:

Right, right.

HOLBERTON:

That's right.

TROPP:

You know, talking to Ida Rhodes for example,

HOLBERTON:

Mhm.

TROPP:

Who was on the Math Tables Project.

HOLBERTON:

Right.

TROPP:

The certain, the sudden realization that all these volumes of tables could now be replaced because you could do a calculation of a tabular value if you needed it, just absolutely blew her mind.

BARTIK:

Yes, because — well, I think even at the first we always thought of storing function tables and certainly we did when we were, when we first started the UNIVAC. We still thought about.

HOLBERTON:

Storing functions.

BARTIK:

Storing functions.

TROPP:

Well, if you look at the Mark I.

HOLBERTON:

Mhm.

TROPP:

You see the same thing. The function tables.

HOLBERTON:

Mhm.

TROPP:

You see its ability to do iteration.

HOLBERTON:

Right.

TROPP:

You see all the things that you talk about in, and realize that you need in order to do mathematical…

HOLBERTON:

Mhm. Mhm.

TROPP:

Computation pretty much the same way that you would do it on a hand calculator, a sort of hand calculators that were hooked together possibly,

HOLBERTON:

Really?

TROPP:

But still the same kind of device.

HOLBERTON:

The only difference would be today if we were using some of these tables, instead of using some of these equations, we weren't, may not have as many differences as we are having. I mean right now in the process of looking into why do we have so many different answers to the [exponential] function

TROPP:

Mhm.

HOLBERTON:

Out of this work on compilers? It's fantastic; and some of them are off by some fantastic amount. And .. trying to find out, is there an error in the original paper that was written in '57? Or just what it is, that is causing this. Presumably it's in the sine coefficients and in the log.

TROPP:

Yet you can go back and pick up the very first publication of the Math Tables.

HOLBERTON:

That's right.

TROPP:

Project which was the exponential function.

HOLBERTON:

That's right.

TROPP:

And it's error free. [Laughter]

HOLBERTON:

That's right. That's right. That's right.

TROPP:

There are no errors in that table unless the printer made an error that nobody's caught, but it's absolutely error free. And those have been replaced, of course, by the ability to do the exponential

HOLBERTON:

Right.

TROPP:

Tabulation when you need it.

HOLBERTON:

Mhm.

TROPP:

I'll turn this off for a second. [Recorder off] About Abe Taub's problem.

HOLBERTON:

Mhm.

TROPP:

Which was different than what I characterized as the environment in which everybody who had a problem had also become a programmer, and you said that the problem —

HOLBERTON:

No they did not.

BARTIK:

No.

HOLBERTON:

Doctor Fogg didn't become a programmer and people with, with the problem would have to put it into mathematical terminology and then be translated.

BARTIK:

I think that's one of the reasons why mathematicians were considered the people that would be programmers because you, the programmer, had to learn the problem.

HOLBERTON:

Mhm.

BARTIK:

In order to program it.

TROPP:

So the first stage was then the translation of the problem…

TROPP & HOLBERTON:

Into mathematical symbols.

HOLBERTON:

That's right.

TROPP:

You want to describe this problem of Abe Taub's?

BARTIK:

Well, time has passed. I know I have forgotten what the problem was, but certainly Taub had nothing to do with programming the problem. What happened was that Adele Goldstine consulted with Taub, and she learned what the problem was, and then she and I programmed it. So, I feel that this is the way they thought about things then. Programmers had to be mathematicians so that they could understand problems from anybody and then they also had to be programmers so that they could translate that problem into the machine.

TROPP:

You know, that attitude prevailed for almost twenty years.

HOLBERTON:

You know, I think there's a difference between those who have a problem and those who are interested in computational methods. When you think of, like Lehmer and, and Frankel and what not, who were really eager to get on the hardware because of, of, you know, determining methods of doing things. As different from someone who has a problem they would like to have it solved, somebody to solve it for them. They're tinkers, I mean people are tinkers.

TROPP:

Do you remember Franz Alt being involved in any of the early problems on ENIAC?

BARTIK:

No.

HOLBERTON:

No.

TROPP:

Or did he get involved later at Aberdeen?

HOLBERTON:

No, he was down there the summer that we were there. Of course, he was a Second Lieutenant, and he was working on the multiplier, on some kind of a problem, because he was going between three machines taking cards. That was when I first met him.

TROPP:

At Aberdeen?

HOLBERTON:

At Aberdeen, before we had gone on the ENIAC, and I didn't meet him again until we went down, when I was moved to Aberdeen again.

BARTIK:

I think though that your point is correct that you either had to have a programmer who was capable of understanding the problem because now, everybody knows the kind of things that are required to mechanize problems, but I don't think…

HOLBERTON:

Mhm.

BARTIK:

everybody recognized that then. They were used to doing them by hand calculations and thing of that kind. And it presents quite a different problem when you are really going to automate it, and somebody can't run and ask you a question.

HOLBERTON:

Pre-decision making in the design of a problem, I think, was new. I mean, you know, when you are doing something by hand, when you get to a certain point and the values don't look [right] you may do something else and you proceed. In other words, the human being comes into the computational process somewhere along the line. This was new because everything had to be pre-thought, everything had to be pre-arranged so that the program would follow path. This was new in, in, in the area of mathematics per se.

TROPP:

Well, it's interesting that of all the intellectual or academic areas to make use of the computer, mathematicians are still among the smallest groups.

HOLBERTON:

Yes, they are.

TROPP:

[Laughter]

HOLBERTON:

Yes, they are. They're still using their, their desk computers

TROPP:

…

BARTIK:

Or the mini computers.

HOLBERTON:

And slide rules, that's right.

TROPP:

Well, it's interesting in talking to an astronomer at Harvard, you know, who knew about Mark I, had been there since the thirties, and sits in his office today with a terminal, and I asked him how he uses the computer today,

HOLBERTON:

Mhm.

TROPP:

And he says, "I still do what I always did, I work a problem out as far as I can by hand or slide rule or this or that, and then when I can't go any farther with that kind of calculation, then I go into the computer."

HOLBERTON:

Well, he enjoys computing, see, he's essentially a man from the old school.

TROPP:

That's right. That's the environment

HOLBERTON:

That's right.

TROPP:

Though that…

HOLBERTON:

Prevails.

TROPP:

Prevailed during ENIAC's day.

HOLBERTON:

Oh, yes.

TROPP:

I mean, the people who had been doing computation like Lehmer for decades or so, did certain things before they went to machines.

HOLBERTON:

Oh, yes.

TROPP:

Or other devices

HOLBERTON:

Oh, yes.

TROPP:

For assistance. And John Mauchly, I think, is still that way to a certain extent. He still does lots of things with raw data before he ever uses machines.

BARTIK:

Well, the interesting thing was though, we felt that we could go to any kind of trouble to keep from using machine time.

HOLBERTON:

Oh, yes.

BARTIK:

Because machine time was the most important thing in the world at that time, because you recognized there weren't any computers. So that pressure on programmers — I don't know what the pressure is today because I haven't programmed for twenty years — but the pressure on programmers then were tremendous. If you fouled up a program and wasted machine time,

HOLBERTON:

You wasted practically your job.

BARTIK:

That was the worst sin that you could commit was to waste that machine time. So that we really became paranoid.

HOLBERTON:

Mhm. Efficiency.

BARTIK:

We thought everybody was after us.

TROPP:

[Laughter]

BARTIK:

For our inefficiency.

HOLBERTON:

You wasted one add time, you were being inefficient.

BARTIK:

So it was fine for us to struggle for two days to cut off the slightest amount on that machine.

TROPP:

So you were really concerned with what a decade later became known as optimization of your program?

HOLBERTON:

Oh yes, oh yes. Well, one of the things that was on the ENIAC, you better well be, because in the mean, error free time came into that thing too.

TROPP:

That was what I was going to ask you.

HOLBERTON:

Yes it did.

TROPP:

There were all kinds of predictions on ENIAC, none of which turned out to be true, but in actual operation, what did you find the general mean error free time to be?

HOLBERTON:

I don't know that we ever really looked at it that way because there were so many variables. It depended upon which chassis was put in, the history of that, the cable, there were so many variables that you couldn't really tell. I mean, sometimes you may really have, you know, a long period of time when you didn't have anything, but there may be some other times when we came in frequently, when we would do all kinds of experimenting with raising the power slowly from the other room in the morning, or leaving it on all night and all kinds of things to see what we could do about tube, tube life.

BARTIK:

Oh, well.

HOLBERTON:

Tube life was certainly —

BARTIK:

Certainly the mean time between failures was, oh, very, very short. In fact —

TROPP:

Now are we talking about seconds or are we talking about minutes when you talk about —

HOLBERTON:

Minutes.

BARTIK:

We are talking about minutes, that's all, yes. Because if you got ten minutes of error free calculation, I think you were very, very happy.

HOLBERTON:

Well, we always did everything twice. I mean and checked the answers.

BARTIK:

And you also preceded every problem with a test problem.

HOLBERTON:

Oh, yes.

BARTIK:

You followed every problem with a test problem.

HOLBERTON:

That's right.

BARTIK:

To know the machine — the ENIAC had no check circuits, of course, so you didn't know whether it made a mistake. The only thing you could say was that just prior to running the problem it didn't make a mistake and afterwards, and then you found all these kinds of things that certain combinations of numbers made mistakes.

HOLBERTON:

Yes. Cross-talk.

BARTIK:

So that this business of determining whether or not you had a valid calculation was a very real problem.

HOLBERTON:

Yes, it was.

TROPP:

So you did the same thing a number of times and if you got the same results, you knew they were [voice fades out].

BARTIK:

We'd rerun the problem and do all kinds of things.

HOLBERTON:

Well, we got to be — Betty Jean and I got to be really excellent debuggers, if I must say so.

TROPP:

Well you had to have been.

HOLBERTON:

Well, we got, well we had two soldiers there and I can remember we would get to the point of telling them what tube it was that was out.

TROPP:

[Laughter]

HOLBERTON:

Then we would get the little .. Goldstine would come, not the same, not Herman, the other little fellow, would come and pull the tube. He was, he was the energetic one and when he left then Spence had to take over and take the initiative then. But by golly, we had to do, really debug to find out what was wrong.

TROPP:

Mhm.

HOLBERTON:

Down to saying, you know, because they didn't know your problem. And …

BARTIK:

Well, it wasn't just that, we didn't want anybody fiddling with the switches because we were paranoid, remember.

TROPP & BARTIK:

[Laughter]

BARTIK:

So that we would rather go to the business of telling them exactly what component it was rather than have somebody come along and fiddle with our switches. So, I would say that during the time that the ENIAC was in Philadelphia, that if that thing ran one fiftieth of the time, I would be surprised.

HOLBERTON:

The probability would increase the longer the setup was on the machine, but just getting a new setup on the machine may take two weeks and by the time you get out a whole series of things, we were just moving those —

BARTIK:

Well, we didn't even turn the machine off, because every time you turned it off —

HOLBERTON:

That's right.

TROPP:

I was going to ask you about that because you didn't have, did you have twenty-four hour operation.

HOLBERTON:

No.

TROPP:

Seven days a week

HOLBERTON:

No.

TROPP:

So that the machine was not turned off?

HOLBERTON:

No. We didn't have operation, but we did have at one series of time, we did keep the power on.

TROPP:

Because I know with the first generation of computers that one of the big problems was when they, some of them ran twenty-four hours a day, but they would shut down on the weekend.

HOLBERTON:

Mhm.

BARTIK:

Yea. And then Monday —

TROPP:

Monday morning it was, how soon are you going to get this thing working again?

HOLBERTON:

Well, I would say at most we probably ran sixteen hours a day.

TROPP:

So that every morning you were really faced with the start up problem?

HOLBERTON:

Not, well there was until a certain point in time when they decided they would keep it on, keep someone there. But I know that after they moved the ENIAC to Aberdeen, I had built up so much, not overtime, it was comp time, that we took three months off and went around the country. So I had built up that much time working a sixteen hour a day, you know, thing.

TROPP:

That's right, the two of you —

HOLBERTON:

No, no, no. John Holberton and Kay Mauchly, Kay McNulty.

TROPP:

Kay, that's right, I know there were three of you on that trip.

HOLBERTON:

Right. That's when we found out when we got to California that one of the function tables had burned up and they gave us an extra month.

TROPP & HOLBERTON & BARTIK:

[Laughter]

[End Of Side II Tape I]

TROPP:

Well, this is the second tape of my discussion here at the Smithsonian with Betty Holberton and Betty Jean Bartik on the 27th of April, '73. Let me get — [Recorder off]

We were talking about this, the real change in the computational environment that ENIAC created. And you asked the question as to why the Mark I which was the first…

HOLBERTON:

Mhm.

TROPP:

example of being able to do sophisticated mathematical problems in a sequential manner didn't seem to have the same impact, and I think it was this order of magnitude that electronics had.

HOLBERTON:

The order of magnitude, that's right. It suddenly, you got an upward leap.

TROPP:

You got an upward leap from something like three to ten additions per second

HOLBERTON:

Right.

TROPP:

up to five thousand additions per second.

HOLBERTON:

That's right. When you get an advance like that all in one big jump, then you have an audience, you can't help it. It's like any other new invention for which it throws out all old methods, you know.

TROPP:

It was so much more spectacular

HOLBERTON:

That's right.

TROPP:

than what was happening at Harvard.

HOLBERTON:

That's right.

TROPP:

And again, I think we mentioned this before we turned the tape on, the environment of Harvard, as you mentioned the environment at Princeton, was not a place that people were happy with having a machine around.

HOLBERTON:

Well, I don't think that they were really happy there at the university either. It was during the war and there was this contract which was gotten and there were enough people who needed the financial assistance, say in the university, to have a contract to keep them on board there. I think it was taken in spite of the attitude, because there were many of the professors there who were not at all happy about having technicians, as you say, and programmers and this kind of thing around the university atmosphere.

TROPP:

Well Brainerd's reluctance was apparent …

HOLBERTON:

Very much so. I was always aware that he was reluctant. And I don't think that Dean Pender really was interested either; when it came to the demonstration, the limelight was great, but as far as that thing being an achievement for the university, I don't think he really looked at it that way.

BARTIK:

Well, I think it was the attitude toward the machine that - and the people that tinker with machines, like people that tinker with their automobile,

HOLBERTON:

Right.

BARTIK:

or people that are automobile mechanics, so that I think that the attitudes in the intellectual community was that this was a come down to be working on machines rather than ideas.

HOLBERTON:

That's true,

TROPP:

I think —

HOLBERTON:

you know the feeling of applied mathematics in those days too was against pure mathematics.

TROPP:

Well, at Harvard the only mathematician I can identify during Aiken, the Aiken era who had any interest in applied mathematics, was Birkhoff.

HOLBERTON:

That's right.

TROPP:

Nobody else in the whole mathematics department

HOLBERTON:

That's right.

TROPP:

had any, any interest or would acknowledge —

HOLBERTON:

Well, this is what part of the problem was. That's right, and I think this was true at the other universities too.

BARTIK:

Well — yeah, so I think —

TROPP:

At Princeton they were like second class citizens except for Von Neumann.

HOLBERTON:

Right. Mhm.

BARTIK:

Yes, well I think that's one of the reasons why Von Neumann was so important— so important, was that he certainly added respectability to being a computer expert.

TROPP:

Mhm.

BARTIK:

And that he saw the value of it and that perhaps is his genius, is the fact that he saw that this was going to change mathematics a great deal, was going to change scientific research.

TROPP:

Well, of course, looking back today at the paper that he and Goldstine and Burks and others authored in, I think '48, the matrix inversion paper, gave such incredible impetus to applied mathematics,

HOLBERTON:

Yes, yes.

TROPP:

because they, you know, demonstrated a use that nobody had envisioned for a machine calculation, that mathematicians who had been not able to solve problems before

HOLBERTON:

Mhm.

TROPP:

suddenly saw an application.

BARTIK:

By the way, John Mauchly tried to get us to do a matrix inversion on the ENIAC very early. As a matter of fact, despite the fact that initially everybody felt that what we should do was trajectories, I think later —

HOLBERTON:

I finally did a 3 by 3.

BARTIK:

Yea. That as the war began to wind down

HOLBERTON:

Yeah.

BARTIK:

Every body saw that the need for firing tables would be gone, so consequently, the ENIAC had to be used for different kinds of problems.

TROPP:

Mhm.

BARTIK:

And I can remember John trying to get us intellectually interested in inverting the matrix. And …

HOLBERTON:

That's the last problem I did when I was at Aberdeen, was a 3 by 3 matrix.

BARTIK:

And, so I remember coming home and discussing this with my husband, and he said, "Oh well, John Mauchly has been inverting matrices ever since he's been at the Moore School." [Laugh] That he was absolutely fascinated by ..

TROPP:

Well —

BARTIK:

methods of inverting matrices.

TROPP:

Well, once you get beyond a 3 by 3 or a 4 by 4, you can't do much by hand. And there were so many problems around —

HOLBERTON:

You couldn't do much more on the ENIAC either in that mode of operation.

TROPP:

But it did demonstrate that it could be done.

HOLBERTON:

Yes, yes, very much so.

TROPP:

There was another, it was quite a period before anybody had a machine that could do a matrix, of any size, say, like a 30 by 30.

HOLBERTON:

Well, memory was so expensive, memory was so expensive, that's where they really had to look to see what could be done. Not that people didn't have the ideas, but, you know, the hardware just wasn't up to what it was they felt they could do, in the area of memory. Not 'till we really got core did

TROPP:

Yeah.

HOLBERTON:

we get into this real computational area.

TROPP:

I guess one of the areas I'd like you to, both, react to. We talked about Von Neumann and I would like to talk about how you saw people like John Mauchly and the role that they played, and Goldstine and Burks and others that you came in contact with. Clippinger, and Frankel, and how, how they looked from your vantage point?

HOLBERTON:

Well, we were lowly programmers, so I looked up to all these gentlemen.

TROPP:

[Laughter] Okay, well, but you did have, you did see them, you did work with them on problems, and you may have had your own personal estimate of the role that they played and the ideas that they formulated and the impact that they had, because you were in a position of actually seeing the results of it.

HOLBERTON:

I don't know that we always —

BARTIK:

Well, I think the impact that John Mauchly had

HOLBERTON:

Oh, yes.

BARTIK:

on me was that . I never — prior to this—understood people having fun with intellectual games, or intellectual problems. And he was a terrific stimulus for you to use your head.

HOLBERTON:

Yes, he was.

BARTIK:

And he taught me that it's fun to use your head and despite the fact that I was a college graduate and had had contact with so-called intellectuals before, I don't think that it ever really hit me that there were normal, ordinary people running around that didn't act queer, that had fun with playing intellectual games.

And I think that that was the effect that Von Neumann had on me that the world of ideas is exciting and there are people that can spend hours on end, and that if you were working with them, that it's fun for you too. So I would say that their — John Mauchly and Von Neumann— were two of the biggest influences, I would say, in my intellectual growth and development, at this time, and it was, was just this idea that these things are fun too.

TROPP:

As I look back, you know, on the people I have talked to, who attended the Moore School Summer Course

HOLBERTON:

Oh, yes.

TROPP:

there in '46, which I think is probably one of the greatest milestones

HOLBERTON:

Oh, yes.

TROPP:

in the history of computers. This is where many of them came in contact with Mauchly and Von Neumann.

HOLBERTON:

Mhm.

TROPP:

And this whole environment of the exciting world of computation to come. And this is where the stimulus was, for people like Wilkes to go back and build a machine. And then talking to people who were with Northrop during the days

HOLBERTON:

Yes.

TROPP:

when John made trips out to the West Coast

HOLBERTON:

Right.

TROPP:

or they came to Philadelphia

HOLBERTON:

Mhm.

TROPP:

to learn what BINAC was going to be all about.

HOLBERTON:

Mhm.

TROPP:

That he seems to have been a, a real catalyst, in terms of dreaming of tomorrow and what was going to be exciting about machine computation.

HOLBERTON:

Yes.

BARTIK:

Okay, now the other aspect. I don't think you should leave Pres out of this,

TROPP:

Right. And then Pres is a —

BARTIK:

because Pres has a different role in this,

TROPP:

Yeah. And I'd like to get into this.

BARTIK:

and it's not the intellectual stimulus that the role — Pres is the one that makes you believe you can do anything.

TROPP:

[Laugh]

BARTIK:

because of his tremendous talent and ability of pulling everything together and making it practical,

TROPP:

Mhm.

BARTIK:

of producing the hardware. So that the effect that Pres had on me was also strong, but it was in this area that things are possible. You can do almost anything. There are alternatives to anything. To see him in operation confronted with a problem is absolutely fascinating because — I don't know either through our educational system or through my own inability to create things, I usually had a tendency to think of one solution for a problem. Well, Pres is a man that has ten solutions for every small problem.

HOLBERTON:

Yeah.

BARTIK:

And so that he opened up the whole idea of doing things in different ways. Of — there are scads of ways to accomplish a solution. You had absolute confidence that this man could solve any practical problem. He could make the gear that would do it.

HOLBERTON:

You know when I went to work with Eckert and Mauchly in '47, the one stipulation that I — in fact that's another insight into Mauchly's his whole makeup is; they started this new company called Electronic Control and they weren't going to steal any people who had any prior training on the ENIAC. They weren't going to try to, you know, hire — they needed people, but they weren't going to hire any, any people who were trained or anything like that. And finally, one day I, I asked and I said, "Are you looking for people?" "Yeah, we're looking for people." "Well, would you hire me?" "Would you come?" I mean this kind of a thing. He wasn't willing to, to offer me a job until I made the overture.

TROPP:

Mhm.

HOLBERTON:

But when I said I would come, then it was on the one stipulation that I would never take any, anything in the way of direction from Eckert, because he scared me to death. And yet, I got there and within two weeks Eckert came over to me and he said, "I give you one week to determine how the I-O synchronizer, this was for the, for the ENIAC, should work."

TROPP:

You mean for the UNIVAC.

HOLBERTON:

For the UNIVAC, UNIVAC. This was this backward reading and re-synchronizing and all this kind of thing. Well, I was scared to death, but I did it. But, I had come, you know, with this fear of him. I don't know, not first hand, because — but it was just, I guess, the, the, the, what people were saying, I don't know.

BARTIK:

Well, his intellect is overpowering, particularly for a person that hasn't worked with him and just meets him casually. Because you have a feeling, I did, what can I contribute to this man.

TROPP:

Yeah.

HOLBERTON:

Mhm.

BARTIK:

What I mean, because he is so overpowering. But the truth of the matter is that he has a fantastic memory and his mind is like a sponge and he's very — working with him is very exciting, because even the slightest thing you say that's new, he recognizes it as new. And he immediately builds on it and, and sees how it can be used in many different ways. So that you increase the sense of your own worth working with this kind of person instead of being intimidated.

TROPP:

Well, I, I think that people overlook this incredible combination of those two men. Because in, in looking at accomplishments through the next decade, after ENIAC, people talk about the tension between the theoretician, and the mathematician and the engineer. The one who has to put the concepts into reality

HOLBERTON:

Mhm.

TROPP:

and the impatience of the mathematicians about, "Why is it taking so long for my ideas to come up." And here, in Eckert and Mauchly you have this marvelous combination.

HOLBERTON:

Well, you have —

TROPP:

of the dreamer and the person with an intellect. [Laugh]

HOLBERTON:

That's right. You had the man, the man who, who comes up with an idea whose idea then changes to be a better idea and keeps building like this, and if you had only that man you never would get anything done, you need the practical man who says, "We'll stop at this point and we'll build that." That's the reason I think it was so good.

TROPP:

Which is why Aiken succeeded and why Babbage didn't,

HOLBERTON:

That's right. I mean —

TROPP:

and why Eckert and Mauchly got a machine built

HOLBERTON:

together, because of the two of them. That's right.

TROPP:

And why before that there had been no machine.

HOLBERTON:

That's right.

TROPP:

And despite what the courts say, and despite what anybody says, ENIAC is a reality. It did work.

BARTIK:

Yes, and I think —

HOLBERTON:

Well, it certainly started a whole new industry.

BARTIK:

I think that's true. I think the combination of their personalities was very important

HOLBERTON:

Right.

BARTIK:

Because as far as I know, in all the years that I ever worked with the two of them, I never heard of any tension between them.

HOLBERTON:

No, I never did either.

BARTIK:

I really —

TROPP:

No, I [think] they both needed each other and they complemented each other fantastically from what I, as I read back into this period.

BARTIK:

Certainly I have never heard John speak of Pres with anything except tremendous respect and I think it was probably exciting for him too. To be a dreamer and suddenly here is a man that can put it into practical effect

HOLBERTON:

Yes, yes.

BARTIK:

and here is a man that knows all of the practical aspects of life and to be fed ideas

TROPP:

Well, this is —

BARTIK:

because Pres is no slouch intellectually, you know.

HOLBERTON:

No, no.

TROPP:

Right, because this is what I was talking about earlier, the idea of pushing a technology that's in existence to limits that nobody had ever thought

HOLBERTON:

Right.

TROPP:

of and using them in a way that nobody had ever used them before.

HOLBERTON:

Right.

TROPP:

And it took a particular kind of dreamer and a particular kind of engineer to do that. Even though you had to invent, they, they didn't have anything new to invent, all they had to do was use everything in a different way. And once they showed the world it could be done, then anybody could do it. Really.

HOLBERTON:

Well, I think I saw them most often in the early stages when I went, before I went to work at Electronic Control, between February when they said they'd hire me and July when they actually got money. I used to go up there on weekends and work.

And they would hold meeting [s] with, I guess about five or six of us, of the engineers, and we would hold the meetings starting Friday evening, maybe seven o'clock after dinner, and we worked until four in the morning. And this kind of thing, you know, batting back ideas, and this is when I really saw that there really, you know, there was no, there was no conflict

TROPP:

Mhm.

HOLBERTON:

and it was a fascinating period of time.

TROPP:

Well, Ike Auerbach described his early period there.

HOLBERTON:

Mhm.

TROPP:

He, he talked about going out to lunch to one of these little sandwich shops.

HOLBERTON:

Oh yes, right around the corner on 13th Street.

TROPP:

And apparently that was a working

HOLBERTON:

Oh, yes.

TROPP:

time because he said all the napkins used to be filled

HOLBERTON:

Oh, you never —

TROPP:

with diagrams and symbols. [Laughter]

HOLBERTON:

I think that's what the computer field is, is a working lunch. I never saw so much of it in my life.

BH, BB&TROPP:

[Laughter]

HOLBERTON:

It really is.

BARTIK:

Well, Press never stopped. Because I never —

HOLBERTON:

He never stops now. When you meet him at a convention and you are sitting down, he'll sit beside you with a new problem that he has on his mind.

BARTIK:

[Laugh] But [laughs] he worked all the time and his, you never thought of it as work exactly, because you were talking to Pres. I don't know, something new was happening all the time. And he always, he always was so well organized in what he was thinking about and seemed so dedicated to it that he just drew you in it whether you were interested or not.

HOLBERTON:

Well, you know that, that was a thing that I found very difficult for me when I got married, that I had lived computers from '47 to '50. I mean I did nothing else but computers, day and night.

TROPP:

[Laugh]

HOLBERTON:

I mean I just thought about computers. And then, you know,

TROPP:

[Laugh]

HOLBERTON:

then suddenly you have to do, you have to take care of something else. And this was a new, this was something new for me. It really was. I had to have some other interest besides computers.

TROPP:

I guess it's somewhere around 1955 that that environment changed in the industry with the, the sudden mushrooming of both machines, people, and programmers.

BARTIK:

Well, I think that the field changed. UNIVAC I, the development of UNIVAC I was probably the most exciting experience

HOLBERTON:

Oh, yes.

BARTIK:

for everybody that ever worked on it.

HOLBERTON:

Absolutely, absolutely.

BARTIK:

Because at this time, you had the, you knew computers were possible, you knew that it was the wave of the future, but the UNIVAC I was the first commercial processing machine and this was the machine where you were going to be able to do quite mundane things with it. You were going to do billing, you were going to do counting of beans, as Pres said, "That all they are used for, is to count beans." But

HOLBERTON:

This was the realization of things that people talked about

BARTIK:

Right.

HOLBERTON:

at the dedication of the ENIAC.

TROPP:

Well, I was going to say —

BARTIK:

It was going to be a very practical machine in that everybody working on it, I think, felt they were pushing back frontiers.

HOLBERTON:

Oh, yes.

TROPP:

Well —

BARTIK:

At that time we were smart enough then to know what we were doing and where we were going.

TROPP:

The sheer drama of that election prediction in 1952 in terms of what you were saying about doing something very different.

BARTIK:

Right.

HOLBERTON:

Oh, I have a story about that.

BARTIK:

Oh, well this is 19—yeah, but when we were thinking about the UNIVAC, that was 1948.

HOLBERTON:

'47, '48. Well, '47. When I went there we were designing then, but we had put BINAC in, as the sort of test machine, in between.

BARTIK:

Yes, but well, when I went there in 1948

HOLBERTON:

Mhm.

BARTIK:

and from 1948

HOLBERTON:

To '50.

BARTIK:

until the UNIVAC actually came out.

HOLBERTON:

Mhm.

BARTIK:

And the interesting thing about John and Pres is the kinds of people that they attracted because of this dual, as in their personality. They, they attracted the very practical engineer who had a lot of talent due to Pres. Yet the people that like to play around with ideas, they attracted them also because of John.

HOLBERTON:

Mhm.

BARTIK:

So that I, I don't think that another combination could really have got together that kind of group. Bob Shaw,

HOLBERTON:

That was a tremendous group.

BARTIK:

Brad Sheperd, Isaac Auerbach, Al Auerbach.

HOLBERTON:

It was a tremendous group. It really was. I mean the, the, the whole feeling in that company. I think it's a shame that today there isn't that much give to a company with an idea. There was more than the eight hour day that you would put in because you believed what you were doing. It was getting this thing which everybody dreamed of.

BARTIK:

When you went to work — I think that. I couldn't wait to get to work.

HOLBERTON:

I couldn't do anything except work.

BARTIK:

Because it was exciting and at coffee break, it was just a working break

HOLBERTON:

[Laugh]

BARTIK:

and a lunch break was just a, you know, you just ate. You weren't doing what you were doing, but you ate and drank coffee or something like that.

HOLBERTON:

I mean you didn't, you didn't feel that you were going to work, I mean, that's [what] the thing is.

BARTIK:

So that the camaraderie, I certainly have never had it since,

HOLBERTON:

No.

BARTIK:

in any work situation I have had.

TROPP:

Well, then, then the UNIVAC environment really was a different kind of environment in the sense that you weren't thinking about ballistics tables or scientific problems

BH&BARTIK:

Oh, no.

TROPP:

per se; and I want to make sure Betty talks about the, the sorting program. Because suddenly you were designing a machine that was going to be used in much more mundane aspects of life.

HOLBERTON:

Right.

TROPP:

In order to do billings or to do some of these things, it had to be able to sort for example,

HOLBERTON:

That's right.

TROPP:

which the ballistics computer didn't have to do.

HOLBERTON:

That's the first problem I started working on in June of '47 when I went to Electronic Control with them, and I had not even read the article that Mauchly had delivered, and I've read it recently, not even aware that he had delivered something on sorting at the symposium there at the Moore School, 'cause we weren't really allowed to go in there and once in a while we would sort of sneak in.

TROPP:

You mean that, that summer program of '46?

HOLBERTON:

We weren't really allowed to go into that. And I remember bringing a deck of cards to the office there on 1215 Walnut Street and turning them .. face down and making decisions and building piles, and built the logic of the binary thing from a deck of cards, without ever having any, you know, anybody tell me anything about how it ought to be done or anything. I just did it from practical sense.

And one of the reasons that I, before I left UNIVAC which was originally Eckert-Mauchly, I felt for all the work that Betty Jean and I had done on sorting methods, it was a shame for people to have to sit down and re-do and re-code that same thing even though they could use the books to do it, if it could be done by a machine. And that's the reason, and it only took six months to program the thing. That's six more months.

TROPP:

I like that "only six months." [Laughter]

HOLBERTON:

Well yes, but the, all these other things now take millions of dollars and what not. They're talking about software development and what not. But that six months is not very much time.

TROPP:

I think that was a very critical program and that's why I wanted to get you both talking about it.

BARTIK:

Yes. Well, I think we recognized early, certainly John and Pres did, recognize early that to make these machines practical in the commercial world, it had to do very mundane things and it had to work on masses of data. Now, I can remember that many discussions I had [with] Pres at that time was what, "What kind of storage medium could you use for files?" Because you needed lots of files for these big problems; and the other one was how to do a sort. Well, at that time the only storage medium that.

HOLBERTON:

The delay line memory was the only thing we had.

BARTIK:

Well no, we — magnetic tape.

HOLBERTON:

Magnetic tape, mag tape. That's right.

BARTIK:

Which we planned to use with the UNIVAC and —

TROPP:

Did you have the mag tape then or did you, were you using the wire?

HOLBERTON:

No. When I first went to, to work at Eckert and Mauchly in '47, at the first demonstration I saw was, was this demonstration of, of tape. And the fellow who was killed,

TROPP:

Was it the metal —

HOLBERTON:

What was his name?

BARTIK:

Frazier Welsh.

HOLBERTON:

Frazier Welsh was, was demonstrating —

TROPP:

Was it a metal?

HOLBERTON:

It was a metal tape. It was not wire, we had wire on, on — of course it didn't work too well, presumably because they didn't use that on the BINAC, they used wire.

TROPP:

Mhm.

HOLBERTON:

But I did see in — I did see —

TROPP:

But you did see some metal magnetic tape in '47?

HOLBERTON:

That's right. That's right, I did. Mhm. He had it going back and forth over loops and this was presumably for a payment of something from Census at the time, where they did have a Census contract, and they were working on that thing.

TROPP:

So then, then the idea came of storing, using these tapes to store information.

HOLBERTON:

To store information, right. And that's one reason why, you know, the UNIVAC I had backward read because of an attempt to cut down the cost of sorting. The sorting on, on, on an electronic machine could not compete with the cost of sorting on a, on a card machine when you talk about the rental thing, we just couldn't meet it at all. And that's the reason that machine was designed with backward, the capability of re-synchronizing information and reading it backward, was just because of that problem of reducing the cost.

BARTIK:

Well yes, because then you wouldn't have to rewind your tapes, you see.

HOLBERTON:

Mhm.

BARTIK:

And I think that the sorting problem was interesting, because — it was interesting to me in any case, in terms of programming because it really sunk in for the first time that a program has to take care of absolutely everything.

HOLBERTON:

Everything, right.

BARTIK:

And when we began to analyze what kind of problems that you have, what, how, how data could be out of bounds, how,

HOLBERTON:

Everything.

BARTIK:

you know, things could go wrong.

HOLBERTON:

It's, it's —

BARTIK:

How you have things that just don't fit in any category.

HOLBERTON:

It's the problem of nothing going on but control, a few things get moved around, but everything else is control, the whole thing is that.

BARTIK:

And so that the concepts of

HOLBERTON:

In fact the whole concept of data of just, massive data processing, you know, was learned from that, from just that experience in, in going through the sorting process really. That was the whole, the whole techniques of, of, of the data processing world.

BARTIK:

We certainly learned what overhead means.

HT&BARTIK:

[Laughter]

HOLBERTON:

Pay check.

TROPP:

What was the real intellectual breakthrough that enabled you to crack the problem of the machine's ability to do sorting?

HOLBERTON:

Well, the machine was designed to do sorting. The UNIVAC had, that was one of the fundamental things of the instruction code and that the reversal of the tape and the reversing of the information and reading backward was so fundamental that even before the machine was designed, we had, we had a program to do what it was supposed to do.

TROPP:

So the idea of sorting then had a good deal to do with how the machine was built. I guess that's what I'm —

HOLBERTON:

It really did. It really had a tremendous influence over it. Yes it did.

BARTIK:

Oh, sure. And certainly the organization of the length of the words — everything.

HOLBERTON:

Oh that, we did a study of that. The length of the buffer and all this kind of thing. We did a study on that and a justification, because we had changed it three times, based upon, you know — originally it was forty word, then it built up to a hundred, which used too much of the memory, we only had a thousand words. Then it was dropped back to sixty because there were more, there more combinations in sixty words per block.

BARTIK:

Now wait a minute, you are thinking about a different thing. You are talking about the tape buffer.

HOLBERTON:

That's right, but I'm talking about the influences it had on the design.

TROPP:

I guess, I guess what, what interests me is the shift in the paradigm from ENIAC say, to UNIVAC,

HOLBERTON:

Oh, well remember —

TROPP:

because in ENIAC you had a machine built whose prime purpose was to do ballistics tables and then you had to learn how to put other kinds of problems on as well as the ballistics problem.

HOLBERTON:

That's right.

BARTIK:

Well, you didn't have to —

TROPP:

In the case of UNIVAC you had certain kinds of problems that you wanted the machine to do. You had to decide how to do them and then you had to make sure that the machine was designed or built in a way to make this most feasible.

HOLBERTON:

Well, remember though, that it is fundamentally —

BARTIK:

Oh yes, you didn't have to sell any of us on a new design. All of us knew what was involved.

TROPP:

Well, what I'm saying is that it's really kind of backwards in terms of the two. Your exposure to ENIAC had been the machine first, how to get the problems on later.

HOLBERTON:

Right. Then we were in designing of the other.

TROPP:

In the other case, here as programmers, people deciding how problems are going to be solved on the machine, then you influenced the design of the machine. Although in the case of ENIAC I'm sure the way of solving the ballistics problems had a good deal to do with its initial design.

HOLBERTON:

I'm sure it did too.

TROPP:

Oh, yeah.

HOLBERTON:

Oh, I'm sure it did.

TROPP:

Yeah. But in terms of other problems it didn't, because nobody knew what the other problems were going to be.

BARTIK:

Oh, yes. I, I don't think there was any question but what John and Pres knew that in order for a commercial machine to be successful it had to do very mundane jobs. And the trauma of the ENIAC, of trying to program to run the ENIAC, anybody that had anything to do with it didn't have to be sold on a,

HOLBERTON:

Oh, that's right.

BARTIK:

on a new way of doing things.

HOLBERTON:

You bet-ya. That's right.

BARTIK:

Because all you had to do was to put one problem on and then you immediately said there must be a better way. And

HOLBERTON:

Well, you remember also, the fact is that the, that the ENIAC really followed the logic of EDVAC, because EDVAC logic came along although the machine itself did not.

BARTIK:

Now wait a minute. ..

TROPP:

Now the EDVAC

HOLBERTON:

EDVAC. EDVAC logic was fundamental —

TROPP:

Project was, that was even before

HOLBERTON:

Before.

TROPP:

ENIAC was completed.

HOLBERTON:

No, I don't mean that, before UNIVAC, before UNIVAC.

BARTIK:

Yes.

HOLBERTON:

Yes, before UNIVAC, because the UNIVAC was originally called the statistical EDVAC that, in-house, we were calling it before it had a name.

And one of the basic things that we felt at that time was if you are ever going to sell the machine to the general public, he better be able to see the numbers and the letters as they are and not as binary things. And that was the fundamental thing in essentially the selling of the product, was to make it a decimal machine with an alphabet stored which people don't do today.

But you had to break into the commercial world, and you could not very easily break into it with binary bits in those days.

BARTIK:

So, this is true. The ENIAC really stimulated the EDVAC and there was no question but that was the way to go and then

HOLBERTON:

Yeah.

BARTIK:

the philosophy of UNIVAC was then let's make it

HOLBERTON:

Commercial.

BARTIK:

practical for mundane

HOLBERTON:

That's right.

BARTIK:

because the EDVAC would still be the scientific machine

HOLBERTON:

That's right.

BARTIK:

with the scientific orientation.

HOLBERTON:

And this is the reason they put so much emphasis on the tape system, because the tape system had to really be able to take that in economics as against the tab equipment then, in the cost of running the job and that was the reason the whole, research program on tape, even to the point of them building their own, plating their own tape, in the early days

TROPP:

Mhm.

HOLBERTON:

and this kind of thing, because it was a fundamental thing that would make it practical is to have a cheap means of storing information and also be[ing] able to read it quickly, which was not one of the, say, primary things in your EDVAC design was anything that talked about the input/output equipment.

TROPP:

Mhm.

BARTIK:

Right.

HOLBERTON:

So this is where, I guess, a real shift is, in the commercial world is, the shifting in that way is in the, in the storage media for large volumes of information.

But I remember in the, in the early days on the, on the UNIVAC, I for one, did not want to establish such things as standards of how you should do, how we should influence other people to use the machine. I was very much aware of not, say, establishing standards in how you should label your information on the tape. Or how you should store or all this kind of thing. It made it difficult.

BARTIK:

Don't you wish you had? [Laughter]

HOLBERTON:

Yes, I do. I do since I am now in the international world of this tape label

TROPP & BARTIK:

[Laugh]

HOLBERTON:

and I have become quite aware of it that I felt, you know,

TROPP:

You had your chance.

HOLBERTON:

theoretically and —

BARTIK:

That's right, you blew it. [Laughter]

HOLBERTON:

Well, but I would give the information to other people like, like Peterson who went out toGE in Tennessee, or Kentucky. I gave him all the information how it developed, you know, what ought to be there and this kind of thing. But I didn't feel that we had enough practical experience to tell the world how to do something.

TROPP:

I guess I'm curious to know —

BARTIK:

The chickens always come home to roost. [Laughter]

HOLBERTON:

It's a shame isn't it, yes. But I don't feel it was wrong.

TROPP:

Who made the decision in UNIVAC to produce such a limited number of them?

HOLBERTON:

Machines?

TROPP:

Yes.

HOLBERTON:

Ha ha. The economic market, of course.

TROPP:

But, but at that time nobody really saw the fact that there was a potential market so much larger.

HOLBERTON:

Well, yes they did, because the fellow at Census, McPherson, James McPherson, I guess it is, whom by the way you should — I was told you should get to talk with, I remember him saying and he was going to give us the Census problem, he said if this thing really does work we have need for 87. I know that was an odd number, but I remember him saying that we have a need for 87 of them. He must have been talking about all the things at that speed

TROPP:

Mhm.

HOLBERTON:

that that machine could do. Now they have many machines of, of much higher speeds. They had that much work to do. But he didn't buy any 87 of them either. In fact [in] the early days there was a shift in the contract that [of] the three original contracts, only one of them held up.

There was originally a contract with Prudential and a contract with Nielsen because I went out and spent six months with Nielsen Company, A.C. Nielsen and what came out of the whole thing, all at the expense of Eckert and Mauchly, was that I improved their, their card system by ten percent and they didn't buy a machine, so there I didn't do the company any good.

So that actually, I think that the amount of money was a lot of money by that time. Originally with the estimate it was going to be $90,000. By that time it had grown to about $400,000. The cost was on a tube count as I recall. That was

TROPP:

That was —

HOLBERTON:

Bob Shaw's way of counting.

TROPP:

Everybody costed machines on a tube count.

HOLBERTON:

Tube count. Well, that's how it was costed.

TROPP:

And when you look back at the costing of the IBM 701, of the Defense Calculator,

HOLBERTON:

Mhm.

TROPP:

that's where they got their base cost and then they threw in a fudge factor.

HOLBERTON:

Well, you know —

TROPP:

The cost that they were going to charge the customer.

That turned out to be too low. [Laugh]

HOLBERTON:

In the early, you know, in the early days with Eckert and Mauchly in their own company, it was rather interesting to be different things, a person on different days. I mean some days you, you'd be programming, sometimes you would be doing logic. Sometimes you would go out with Mauchly selling and that was a very interesting experience to go out and sell with Mauchly.

He was an optimist, much of an optimist when it came to what the machine could do, because he'd always turn around to me and he'd say, something would take about so many minutes and I would quickly say, "double it."

TROPP, BARTIK & HOLBERTON:

[Laughter]

HOLBERTON:

But he would, he would go out and he would have an audience of both the commercial world and the scientific world if that was in their company, and he would have the scientific world really rearing to go and get a machine, but they don't have the funds. It would, and the, the commercial people would be holding back because it has not been proven yet, you know. I saw this many times where the, the people in the engineering world wanted it for their company, but they couldn't, they couldn't get it.

TROPP:

Because sales

HOLBERTON:

Sales—

TROPP:

Were organization control

HOLBERTON:

That's ex—

TROPP:

how much money you could spend on, on —

HOLBERTON:

That's right, and it was the —

TROPP:

areas of this sort.

HOLBERTON:

Mhm.

BARTIK:

Yes, so I think that that's true. That it was strictly economics, and also I think the other thing is the mean time between failures problem.

HOLBERTON:

On the UNIVAC?

TROPP:

On UNIVAC that had been …

HOLBERTON:

Not on UNIVAC. That had been, they had, had check circuits.

BARTIK:

That may be so, but I mean in the, in the early days when funds, when they were really running around looking for funds, because there just weren't that many people willing to put money in the computing industry. And I think that the reliability was the question that was —

HOLBERTON:

I think one of the problems was that just at the point when, when the machine was really ready to go that they lost their backer in an accident,

TROPP:

Right, right.

HOLBERTON:

and that I think was crucial.

TROPP:

This was the man who was the president of the Totalisator?

HOLBERTON:

Totalisator, yes. And he was a fascinating person to work for. He knew what everybody was doing. He, he was just great. When he would come in the company—were you there Betty when he was there?

I felt that he had a tremendous esprit de corps with, with the employees.

TROPP:

I guess one of the things that strikes me, and here I am again editorializing

HOLBERTON:

Mhm.

TROPP:

is that Rem-Rand when they took over, the

HOLBERTON:

It was catastrophe.

TROPP:

Eckert-Mauchly Corporation didn't have the vision.

BARTIK:

Oh, they had no vision whatsoever.

HOLBERTON:

Oh, it was unbelievable, unbelievable, when, when they took over. It was just like having a sales group come in and, and take over something for which they didn't have any idea what they were going to do with it or what direction they really wanted to go.

TROPP:

Mhm.

HOLBERTON:

You lo— there was something lost then, when they took over really.

BARTIK:

I worked in Washington for them in 19 50/51 in the Washington Sales Office. Now I was the only one there that knew anything about the UNIVAC and I was — the job that I had to do was supposedly to help them sell UNIVAC. Well, their salesman used me to make sales of typewriters, would you believe. I — no, they got their foot in the door with me talking about UNIVAC, this exciting new machine, and then they quietly on the side sold a few calculators and bookkeeping machines or typewriters. Because their salesmen didn't know a thing about UNIVAC.

HOLBERTON:

They didn't really want to learn either, because I was on the, on the account out there to put in the first UNIVAC at the Springfield, Illinois, at Franklin Insurance Company, and I would be met by the salesman, and the only thing he was interested in is his commission. Absolutely, he'd meet me every time I got out there, because I had to meet him; when is his commission coming through? He cared nothing about, you know, learning about what this machine was.

BARTIK:

Well, they didn't establish any kind, see, Remington Rand salesmen, all during the war worked on a commission. Now, when you sell a machine that costs over a million dollars, their commission structure broke down; so in many ways, it was their sales force, their sales arrangements,

HOLBERTON:

And their lack of sales.

BARTIK:

their sales management that ruined them because there was no incentive.

HOLBERTON:

There was no reason for the 701 or the 705 to out-beat UNIVAC really at that point in time on the basis of, of sheer design. There really was not.

TROPP:

It was so many years later too.

HOLBERTON:

And it was really, I feel, sale and the whole way in which they picked up the company and weren't quite sure what they were really going to do with it. And at the time, Eckert and Mauchly did have two, two potential people and they looked into both of them and they felt that the, the UNIVAC was better as far as their relationship with the employees than the other company. That was the reason they took that choice, they had two.

BARTIK:

So, so the, there basically was really no sales effort

HOLBERTON:

No.

BARTIK:

in '49 and '50 I was used as a front person to sell other products and, or in one case I, I designed a, a, the logic for the Navy Aviation Supply Office inventory control using a UNIVAC. They basically had me do this to hang on to their Cardex system. So, everything that we did on the UNIVAC front during that era was really to sell other products

TROPP:

Mhm.

BARTIK:

and they saw it as a prestige public relations kind of a machine to build up the rest of it, so — vision —

TROPP:

In terms of lack of vision, my question in this area is, did anybody think of using one of these machines to set up a computational center to solve problems for people who couldn't afford a whole machine? Here you had a machine capable of solving problems.

HOLBERTON:

Well, I think that's basically what, what the Government did. That's certainly what the laboratory there at the Model Basin was set up for.

TROPP:

I'm thinking in terms of Remington Rand.

HOLBERTON:

Remington Rand didn't, didn't want to put any more money in it than, than they had to. In fact there were times when, when it was rather rough to know even whether you were even going to proceed. '53 was a time in which you weren't quite sure, because that was the time when I left the company when they sort of reshuffled.

BARTIK:

Well, there were so many people. Every time they tried to sell people you had to teach them something

HOLBERTON:

Oh, yes.

BARTIK:

about the machine. And you had all these people running off in all directions designing training material. I designed it in Washington for the Census people at the Census Bureau …

HOLBERTON:

Mhm. Al Katz did it up there in Philadelphia.

BARTIK:

Or other people did it for other places, so, that we in the field knew that you had to do this, but Rem-Rand never,

HOLBERTON:

No.

BARTIK:

never developed any overall plan

HOLBERTON:

Well —

BARTIK:

to train you in anything.

HOLBERTON:

Well, I think there was a certain amount of reluctance to, to put in any additional money in that area and that was true with Pres from the very beginning, is that money spent in the applications area rather than in the machine design was itself not a requirement. And when it came to cuts, the cuts were made in this area. That this was essentially a real overhead that you couldn't really see what it was going to do. I think that the software, you know, support in those early days was not very great.

TROPP:

Mhm. Well, you had, because UNIVAC was destined for the Census Bureau, then you must have had contact with the original group in the formation of the Applied Mathematics Section at the Bureau.

HOLBERTON:

You mean Ida Rhodes?

TROPP:

Well, Ida came there, I think, a little bit later. She's one of the people

HOLBERTON:

Right.

TROPP:

I'm thinking of. I'm thinking of John Curtiss,

HOLBERTON:

Yes.

TROPP:

Gertrude Blanch,

HOLBERTON:

Yes.

TROPP:

and the mathematicians that were there. What kind of, of feeling did you have about the future of computation from your contact with that group?

HOLBERTON:

Well, I think that they, they rarely came up to UNIVAC and we didn't get out because we didn't have travel funds to get out. And I'd say that the only contacts that I had was, was the group that was monitoring, say, the UNIVAC I for the Census.

TROPP:

Mhm. That whole period is so fascinating because in 1949 the only machines that are in existence are the ones at Harvard, the Bell machines at Aberdeen, ENIAC, which by then is at Aberdeen, and BINAC.

HOLBERTON:

Well, I went back

BARTIK:

Of course EDVAC. When was —

HOLBERTON:

and read those original contracts —

TROPP:

EDVAC went on the air

HOLBERTON:

Afterwards.

TROPP:

in 1949, but at that point of time there are also a large number of machines on the boards.

HOLBERTON:

Yes.

TROPP:

Raytheon

HOLBERTON:

Yes.

TROPP:

got things on the boards and things were going on at Northrop, the CPC is just around the corner.

HOLBERTON:

Well, I wasn't even aware of how many contracts the Federal Government had, you know, in parallel, looking for something for the Census. I wasn't aware of that at the time. I read that within the last few years at the Bureau in their history catalog. They have there all these original contracts with the various people looking for a machine for the Census and I didn't know other than UNIVAC they had anything else. I thought they were putting all their eggs in one basket.

TROPP:

No.

HOLBERTON:

They were not.

TROPP:

Well, they thought they were originally,

HOLBERTON:

Mhm.

TROPP:

but then decisions were made to try a variety

HOLBERTON:

Yes they did.

TROPP:

of sources and that eventually led them to build their own machines.

HOLBERTON:

Yeah.

TROPP:

And you talked about standards, earlier, I think the big impetus for building their own machines, or at least one of them, or an excuse if you want to call it that, was the fact that nobody knew how to evaluate a machine once it was completed.

HOLBERTON:

Mhm.

TROPP:

And one of the ways that they used to justify building their own machines was to learn something about how you would set standards for acceptance.

HOLBERTON:

Oh, I think they wanted, they were tinkers and they all wanted to get their hand in,

TROPP:

Oh, I think that's what they really wanted, but the other was a good excuse.

HOLBERTON:

and they had all these reports from all the contractors and they could take the best of every one. No wonder they came out when they did. They had all this information coming in from contracts, which since they weren't selling a product they could use.

TROPP:

Well, in the case of Harry Huskey, he was at ENIAC, then he was in England, where they built the Pilot ACE

HOLBERTON:

Right.

TROPP:

under, you know, Turing's group, and so he had both areas of —

HOLBERTON:

Yes, but he was after SEAC, he was, he had the Western, that was following Sam Alexander's group. But Sam had, had, had the all these reports from all the companies that were dealing in the area and could make use of all this equipment. So he had a jump over the other companies in that respect.

TROPP:

Mhm. That's an interesting can of worms, and I think one of the more interesting areas of this project research is the Bureau of Standards.

HOLBERTON:

Mhm.

TROPP:

In terms of machines, both at the pre-electronic era and that first five or six years.

HOLBERTON:

Yes.

TROPP:

I think that's going to be a fascinating study if we can ever get to it.

TROPP:

Well, they have an awful lot there

TROPP:

Oh, yeah.

HOLBERTON:

if they don't throw it out. I have browsed in there myself.

TROPP:

Margaret may not be in a position to organize it because of space and personnel, but she sure isn't getting rid of anything.

HOLBERTON:

Well, let me tell you though one thing is, and I have felt for a long time, that, that they ought to reproduce and that is the chapter in the, in the contract for UNIVAC I and that was written by Eckert — by Mauchly for the Census on programming, is just as good today as it was in 1949.

TROPP:

I've never seen that contract.

HOLBERTON:

It is beautiful. It's Chapter IV, and I, I did Xerox a copy for Savidge recently, because I felt it was so good. The only thing which is not appropriate now is talking about the input/output buffer and its size and what not, but everything else is just as, just as if it had been written today. That's how fores— I mean, looking ahead as they used the computers and how you would do things, it's just great.

TROPP:

You know in the, in the current litigation, this is the thing that is impossible to evaluate in a legal structure, is the impact of the dreamer, the man

HOLBERTON:

That's right.

TROPP:

who could see around the corner.

HOLBERTON:

Mhm.

TROPP:

Bush talks about this in one of his books.

HOLBERTON:

Mhm.

TROPP:

You know there is a tendency to give him credit for anticipating things,

HOLBERTON:

Mhm.

TROPP:

but still the dreamer has an important role.

HOLBERTON:

Mhm.

TROPP:

You know, Bush says, "Don't give me credit for an invention because I wrote an article about it ten years earlier."

HOLBERTON:

Mhm.

TROPP:

But it's still that article that gets people to thinking.

HOLBERTON:

That's right.

TROPP:

And I think people have tended to overlook this aspect of the problem.

HOLBERTON:

Well, whenever you create a problem, you have a man who is going to look for a solution. I don't care what the problem is.

BARTIK:

Well, I think that their foresight was evident in, in many ways. For example, I was out of the computing field for sixteen years and when I came back in 1967 as a writer and editor, one of the first reports that I was asked to edit was one on a[n] electrostatic printer which Pres Eckert had described to me almost twenty years earlier.

HT&BARTIK:

[Laughter]

BARTIK:

At one time, printing you know, has, has not, is not just a, a recent problem, it was a problem from the beginning of designing some kind of a line printer to match the speeds of the calculator, particularly for these mundane problems. So one of the men who was involved in sales, his name is Brown, for a particular application that he was working on, needed to do printing. So he kept asking Pres, you know, about what kind of printing facilities UNIVAC was going to have. So Pres said, "Oh, I don't have time to discuss that now, I have other problems, but we'll take care of it." So, this guy kept being put off and put off and finally he became convinced that the UNIVAC wasn't going to have any printer and that we had no plans for really printing.

HOLBERTON:

Worcester Brown?

BARTIK:

Worcester Brown.

HOLBERTON:

Mhm.

BARTIK:

So he really was convinced that —

HOLBERTON:

There was no future.

BARTIK:

Was no future. So finally one day Pres very annoyed said, "Okay, I'll tell you about line printers." So he took him in his office and spent the whole afternoon and gave him about twenty different kinds.

[End of Tape II, Side I]

[Start Tape II, Side II]

BARTIK:

Well, Pres took him in his office and he proceeded to describe, he spent the whole afternoon, and when he came out Worcester Brown's head was spinning and he said, "Wow!"

TROPP:

[Laugh]

BARTIK:

He said, "Well, that man not only has one line printer, he has ten line printers," you know, ways to do it.

Well, when I worked doing logical design directly for Pres, because when UNIVAC I was designed we had a whole alternate logical design for it in case the mercury delay line memory did not work.

HOLBERTON:

That's right.

BARTIK:

So, he took two programmers and I happened to be one of them, and we did a complete alternative design using cathode ray tube memory.

TROPP:

Mhm.

BARTIK:

And

HOLBERTON:

Not many people know that. You know, that there was another one, it's called E1, E2.

BARTIK:

There was a whole block diagram done, Art Gehring and I did it. And we were the only people he had at that time that weren't involved in very practical problems. We were his testers of new logic and things like that.

HOLBERTON:

Well, you know the thing that's different, the thing that's interesting about this whole thing that never has really come to light, is the fact that what they were working on in design was the ability to feed in the instruction code into the machine and change the instruction code which was, you know, a new, a new phil- this was, now you are talking about with these, with these new microprogramming plug-in unit businesses that are being sold in, in the mini-computing area. This is basically it.

BARTIK:

But anyway, Pres used to spend a lot of time talking to us, or to me anyway, about new ideas he had for, for making these machines practical for these mundane

HOLBERTON:

Mhm.

BARTIK:

calculations. And he recognized very early that I/O equipment

HOLBERTON:

Yes.

BARTIK:

and peripheral equipment was very important in this area. And he —

HOLBERTON:

You should have him ask, tell you about his zeberg memory that he had in his basement. He had one of these juke boxes

TROPP:

Mhm.

HOLBERTON:

and he used that philosophy in one of the early areas, and, you know, he was talking about the removable disc kind of thing as a high speed memory. I know I worked on that.

TROPP:

Just like you change

HOLBERTON:

Yes, yes.

TROPP:

records on a —

HOLBERTON:

Right, yes. That was how you slide them down a slot and what not and change them.

BARTIK:

Well, he recognized the mismatch between the mechanical speeds and the electrical speeds. So he said that for I/O equipment to ever be satisfactory, that for peripheral equipment to ever be satisfactory, we had to get rid of a lot of the mechanical equipment

HOLBERTON:

Mhm.

BARTIK:

and particularly in line printers, and that's how he happened to describe this electrostatic printer to me. He said, "Well, you don't have to have a printer that has hammers where, you know, to hit the paper." He said, "Why, why don't you throw ink the same way we're throwing electrons in the cathode ray tube kind of thing." He said, "Why don't you throw the ink then you don't have the mechanical problems."

TROPP:

You don't have any sound either. [Laughter]

HOLBERTON:

The thing about these two men, in working so close with, with both Eckert and Mauchly, is that even today I hear a very few new ideas that weren't discussed within the company in, in the forties and the early fifties. It's amazing.

BARTIK:

So that Pres certainly had the idea to, I mean, had the ability to think of the real crucial problems which was the mismatch between mechanical devices and electronic devices and ways to use electronics

TROPP:

Mhm.

BARTIK:

in what we think of as mechanical devices.

TROPP:

Yeah, it's interesting because I had the electrostatic printer described to me very recently and I have still to see one.

BARTIK:

Oh, really?

TROPP:

Yes. I still haven't seen one in operation. I've seen the heat typewriter

HOLBERTON:

Mhm.

TROPP:

that NCR puts out. But that's not as revolutionary or even as silent as this idea of an electrostatic printer, as you say, just throwing the ink at the paper at electronic speeds.

BARTIK:

Yes, so in any case, when I came back into the business and began reading about this, or editing this report on the electrostatic printer, well, you know, I though well — [Laughter]

HOLBERTON:

Just left yesterday.

BARTIK:

Right. I'm still here. And certainly Pres used to describe drums to me.

HOLBERTON:

Oh yes, yes.

BARTIK:

I don't know when drum research really started.

HOLBERTON:

It was during the war.

BARTIK:

But he used to —

TROPP:

Yeah, ERA.

HOLBERTON:

Yeah.

TROPP:

This group

BARTIK:

Drum storage was already there?

TROPP:

that came out of NSA, was it NSA here?

HOLBERTON:

Yes.

TROPP:

Yeah.

BARTIK:

But certainly Pres knew that the commercial market was not going to be cracked until you had random access memory.

HOLBERTON:

Well, you know, that's the reason I stopped working on, on the sorting methods. Because in the, in the, after a certain point in time, I felt there were going to be ways by which you were going to be able to avoid sorting and I wasn't going to waste my, my life looking into all the nitty-gritties of every different method of how to sort any more.

TROPP:

Well, you, you mentioned in the conception of ENIAC, you had two separate designs. One for —

HOLBERTON:

No, this was

BARTIK & HOLBERTON:

UNIVAC.

TROPP:

I mean UNIVAC, excuse me, the electrostatic

HOLBERTON:

Mhm.

TROPP:

or delay line

HOLBERTON:

Mhm.

TROPP:

storage acoustic delay line,

HOLBERTON:

Mhm.

TROPP:

and the electrostatic tube. Did you think in terms of drum storage as a third alternative?

HOLBERTON:

No.

TROPP:

At that point?

BARTIK:

Well, no,

HOLBERTON:

No, not for main memory.

BARTIK:

Not for, not for main memory.

TROPP:

Not for main memory.

HOLBERTON:

They felt it wasn't fast enough. Because they really had not developed the coding techniques that were really required to get what they needed in, in the accuracy of constant use of a drum, really, back there. They weren't willing to rely upon that.

TROPP:

Mhm.

HOLBERTON:

But I can remember the, this, the, these two projects going on simultaneously and there was a decision made, and I believe it was in January, and I don't remember whether it was '48 or '49, but

TROPP:

Yeah.

HOLBERTON:

which way to go and it was on the basis of the research that they were doing at the time.

TROPP:

Well, I think at that point in time of the two —

HOLBERTON:

And it was the right decision.

TROPP:

Yea. I was going to say, if you look at the machines that were built and got on the air first

HOLBERTON:

Yes.

TROPP:

the technology, because of radar developments,

HOLBERTON:

Mhm.

TROPP:

of delay line was far, farther along.

HOLBERTON:

Well, there was a problem with the read round ratio and, and problems were not being —

TROPP:

Yes, but it was still farther, farther along than it was with the —

HOLBERTON:

Yes. And RCA was trying to develop their Selectron tube and it just wasn't going.

TROPP:

Yeah. A couple of years later, the electrostatic memory was pretty far along.

HOLBERTON:

Mhm.

TROPP:

And at that time the decision might have been a different one had you made the decision in

HOLBERTON:

That might have been, might have been, right.

TROPP:

'51 or '52. Because before core memory became a reality, the electrostatic tube was getting pretty good. [Laugh]

HOLBERTON:

Well, I still have a copy of the codes that were developed, the whole development cycle of the UNIVAC code from the very beginning developments through the final C10 code, and also the E1 through E2.

[Digression on Archival Holdings]

HOLBERTON:

And I even have old BINAC coding and this kind of thing and printouts and — you know.

TROPP:

I'd like your comments on BINAC because here's another area where the stories are at absolute variance in terms of what BINAC, when BINAC really ran; did it run?

HOLBERTON:

Yes it did.

TROPP:

And the, as I can piece things together, sometime in 1949 there was a problem run on BINAC in Philadelphia before it was shipped, dismantled and shipped to the West Coast.

HOLBERTON:

What problem was that?

TROPP:

It would be a problem in number theory.

HOLBERTON:

Oh well, I don't know anything about that, but I can tell you the three weeks I was on the machine, day and night, I didn't — two weeks it was, I didn't leave the company. I was on the machine sixteen hours and eight hours off and I slept in the ladies room. I was working on, essentially, the simulation of the sorting system that was to be used on UNIVAC I in calculating the, the delay because of a single I/O input buffer and a single output buffer in a three way —

TROPP:

You were using BINAC

HOLBERTON:

I was using —

TROPP:

for the simulation?

HOLBERTON:

That's right. I used a random number generator and simulated various item sizes and I was on that machine and finally, they were going to ship it on a Monday, and Sunday I was absolutely, I couldn't think. I said, "I can't use it."

TROPP:

The question that has come up with everybody can cite places where one of BINAC's computers worked, when you're thinking of BINAC as two machines in parallel.

HOLBERTON:

Well, I was using them together. I was using them together.

TROPP:

That's the thing that's come up. Nobody can seem to be able to verify the fact that both banks were operational simultaneously.

HOLBERTON:

Oh, yes. Oh, yes.

TROPP:

But they were, they were —

HOLBERTON:

They were when I was using it the last two weeks before it was shipped out. It certainly worked.

TROPP:

I can't, once it's delivered to Northrop, apparently it never did again.

HOLBERTON:

Well, is this the one they put over the mountain or took up in the airplane or did something or other …

TROPP:

Well, I don't know if that's what they planned to do, but they never did.

HOLBERTON:

Oh, I see.

TROPP:

But apparently they could never get both banks.

HOLBERTON:

It was running beautifully, it was running beautifully those two weeks before it was shipped; and I didn't use it the Sunday before it was shipped, I don't know whether somebody else did, but I was too tired.

TROPP:

Well, both banks did work?

HOLBERTON:

Yes they did, and I always ran that way. I wasn't running on a single bank.

TROPP:

Yeah, because your other one was the check, and as long as everything —

HOLBERTON:

That's right. That's right. I was working on something that finally appeared in a manual and I wasn't about to, to put out stuff that, you know, wasn't checked.

TROPP:

Do you have any idea about what happened after it got to the West Coast?

HOLBERTON:

No I do not, I do not.

TROPP:

You weren't part of the group that went out there to help

HOLBERTON:

No.

TROPP:

install it and get it going?

HOLBERTON:

Not at all. Not at all. No.

BARTIK:

Wasn't Al Auerbach? Have you ever talked to him?

TROPP:

I haven't talked to him, but I know he was part of that group.

BARTIK:

Al Auerbach.

HOLBERTON:

Yes, he was.

BARTIK:

Oh, my gosh, he was the one that tested it, he worked on it day and night.

HOLBERTON:

Yes. I was going to say there were only a very few people who, who really had the inner workings and knowledge of, of BINAC and Betty Jean and Gehring and Al Auerbach, Bob Shaw, who is no longer living.

BARTIK:

And Marvin Jacoby.

HOLBERTON:

And Marvin Jacoby. There were very few people who were allowed to get that close to the circuitry. Now I used the machine and I worked on the instruction code, but I did not get into the, the circuitry.

TROPP:

But you did have BINAC fully operative,

HOLBERTON:

I certainly did, I certainly did.

TROPP:

and fully running both banks simultaneously?

HOLBERTON:

I certainly did.

BARTIK:

Well, Al Auerbach would know more than anybody because —

HOLBERTON:

He had to tune it. He tuned it.

BARTIK:

He was the one. I'm surprised. Was his testimony in the court case?

TROPP:

I don't know. I haven't gotten to that. The question, one of the questions in my mind where little things like priorities come up and it's pretty well documented when EDSAC went on the air. So EDSAC is listed as the first internally stored programmed computer that really ran. Now this would be in May, I think, of 1949. Now BINAC was operative in its time period, it's conceivable that BINAC ran problems in both banks before EDSAC.

HOLBERTON:

I don't know. I would have to look on, on one. I don't even know if the dates are on them. I don't think even I would have —

TROPP:

I don't know if they would be on yours, but I think, according to, to John Mauchly, that there were other test problems on the BINAC.

HOLBERTON:

I'm sure there were, yes.

TROPP:

And the problem now is to locate them.

HOLBERTON:

I mean, I don't know when Old Faithful was —

TROPP:

The BINAC is really kind of a candidate for the same, the same award. I mean, which one of these present day computers, which is what they were, got on the air first. And documented in terms of problems and things. Of course EDSAC is, is listed as that, but BINAC is a candidate. I just don't know.

HOLBERTON:

I don't know.

TROPP:

I don't think the dates are as important as the fact that the two occurred roughly at the same time.

HOLBERTON:

Mhm.

TROPP:

Because it was in that, in that year that BINAC was shipped to Northrop wasn't it? It was 1949?

HOLBERTON:

I think so. I think so. It was well past being tested by that time.

TROPP:

You didn't get involved in it though?

HOLBERTON:

Oh yes, she was involved in the logic, but not in the use.

BARTIK:

No, I programmed their missile simulation, their guidance system. Marvin Jacoby

HOLBERTON:

Oh, that's right.

BARTIK:

and me worked on that

HOLBERTON:

Mhm.

BARTIK:

and I programmed it. Now I never really ran it because I went off and was doing this alternative design to, for UNIVAC.

HOLBERTON:

Mhm.

BARTIK:

So that I really wasn't programming, but I worked on that for a long, long time,

HOLBERTON:

Mhm.

BARTIK:

the program for the guidance system.

HOLBERTON:

Now I started out working on that thing when I first came to Eckert and Mauchly too, on that guidance system for that thing.

TROPP:

Yes, I think I'm wrong about the problem.

HOLBERTON:

I didn't know it was going to be an airborne computer originally.

BARTIK:

I got there in '48, so '49 is in the ball park.

TROPP:

Yeah.

HOLBERTON:

Mhm.

BARTIK:

The other person, I don't know, Brad Shepherd was, you know, designed the memory for that.

HOLBERTON:

Mhm.

TROPP:

I think BINAC was designed to be airborne.

HOLBERTON:

Oh, I know it was. It had weights.

TROPP:

It was never used that way.

HOLBERTON:

No, because it, it had certain leads and what not that were supposed to track, in other words, signals from various areas coming in. There were eight of those things.

TROPP:

It was called the SNARK Missile Project, which at that time of course, also was classified.

HOLBERTON:

Right.

BARTIK:

Yes, well you had two problems associated with that. One was to design the mathematics to do this and the other one was to get the vehicle that would use it,

HOLBERTON:

Mhm.

BARTIK:

in a practical way.

HOLBERTON:

How did you get it to go over the Pole and not have your sines and cosines go haywire? [Laughter] That to me was a problem, getting accuracy at the point where it got to be zero [Laughter]

TROPP:

Right. It was so close to zero

HOLBERTON:

Right

TROPP:

you couldn't tell the difference.

HOLBERTON:

That's when I first started, I thought how can you do it?

TROPP:

I think I'm wrong about one of the early problems. I think it was a pseudo random generating

HOLBERTON:

Oh, yes.

TROPP:

function.

HOLBERTON:

Oh, yes.

TROPP:

I think that would have been one of the very first

HOLBERTON:

Certainly, I made use of that.

TROPP:

problems that was ran on BINAC.

HOLBERTON:

Yeah. Because I used that in, in — I used the routine in that later simulation.

TROPP:

And unfortunately I don't know that anything is left of that first program, and that, that may be the very first program that was run on a stored program computer.

BARTIK:

Well, we had it singing songs and stuff and playing music.

HOLBERTON:

Well, that was done at the demonstration because that I did the night before the demonstration, and I don't remember when —

BARTIK:

And when was the demonstration?

HOLBERTON:

When was the demonstration in relation to shipment?

TROPP:

That would have been fairly late

HOLBERTON:

Fairly late.

TROPP:

in '49.

HOLBERTON:

It would have been in the spring. Yes.

BARTIK:

I see.

TROPP:

It would be interesting. I, I would like to untangle the dates on BINAC, because I have two different sets of input. I have the input from the Philadelphia construction group, the builders, and then I have the input from the people who never saw Philadelphia who were at Northrop.

HOLBERTON:

There was a picture in a Sunday supplement of Hugh Livingston and myself at the console, and I don't know the date of that, but I could sure find it out and that was be— long before the thing was shipped.

TROPP:

Mhm.

HOLBERTON:

And we were running on the machine at that time.

TROPP:

Would that have been in Philadelphia?

HOLBERTON:

Yes. It was in —

TROPP:

One of the Philadelphia papers.

HOLBERTON:

Yes.

TROPP:

So if I were to go throughout the archives of the *Enquirer* or the —

HOLBERTON:

No, I've got the copy. I've got the picture and it may, it may say the date on, on the thing I have copied down. It was in a Sunday supplement.

TROPP:

Aha. That would be interesting because I haven't seen anything of that, of that sort, and BINAC is intriguing. It's an interesting machine because in a sense it was a pilot for UNIVAC.

BARTIK:

Yes.

HOLBERTON:

It was. It was, basically that's what it was for. That was the, in the contract with Census, they require, you know, various stages in BINAC to be accomplished, before paying for the thing.

BARTIK:

Well, that was the justification for taking the time out to fool with it.

HOLBERTON:

To do it, that's right.

TROPP:

Of course then, one of the problems with BINAC, at least problems that are given today as reasons for its failure to perform when it got to the West Coast, is the rush to get it out there before it was really ready to go.

HOLBERTON:

I don't know. The only thing that — I don't know about that, because it was running so well when I was using it the last two weeks, but I do know that it required a tremendous handling of that memory tuning and Al Auerbach was, was the man essentially for that.

TROPP:

Mhm.

HOLBERTON:

To get that memory to perform.

TROPP:

I'm sure there is evidence, for example, of the large group of people from Northrop who came out to Philadelphia,

HOLBERTON:

Yes.

TROPP:

who spent a good deal of time

HOLBERTON:

Yes, they were there.

TROPP:

there being

HOLBERTON:

Trained.

TROPP:

trained in the use and service and maintenance

HOLBERTON:

Mhm.

TROPP:

of BINAC.

HOLBERTON:

Mhm.

TROPP:

And ..

BARTIK:

Was the machine ever used?

TROPP:

I don't —

HOLBERTON:

Not really.

TROPP:

Not really.

BARTIK:

They just got it and it sat there?

HOLBERTON:

Oh, Baker was, was connected with it for a year, wasn't it?

TROPP:

Nobody got it going. Didn't it eventually go to Point Magoo?

HOLBERTON:

I don't know.

TROPP:

It went some place from Northrop. It didn't stay there too long, but it never really did anything functional at Northrop and I don't know that it did in its next setup.

HOLBERTON:

Well, now one of the difficulties with that machine was the input, and when you put information in you also had to type in the gain control. And if you made an error in typing something other than a 2, the whole memory was destroyed and you had to start over again. And that really was a pain in the neck. That if you made an error in the typing of that one digit, you had it. It just locked the whole thing up, because you typed it in.

TROPP:

Well, with the, I say it's unfortunate about the economic climate and the other aspects because BINAC was just a prototype machine.

HOLBERTON:

It was. It really —

TROPP:

Would have been great, but BINAC as a functioning computer.

HOLBERTON:

Mhm.

TROPP:

just apparently didn't, didn't make the grade. But the machine that it led to, UNIVAC,

HOLBERTON:

Yes.

TROPP:

of course, is a totally different story.

HOLBERTON:

Right.

BARTIK:

Well, I don't think anyone ever treated it as anything but a prototype.

HOLBERTON:

We didn't. We didn't really.

BARTIK:

It was, it was —

TROPP:

Yea, but to Northrop, to Northrop it was something else.

HOLBERTON:

To Northrop it was a product, yes. Right.

BARTIK:

Yes, to Northrop that may be true,

HOLBERTON:

Mhm.

BARTIK:

but it was just kind of a nuisance that we had to fiddle with it when we realized that our real job was designing UNIVAC.

HOLBERTON:

Well, one of the things it did show though was that, that the UNIVAC I design was changed from a four megacycle memory back to a — was it two and a half? Two and a quarter? Because of the problems that we were having with, you know, with the memory.

TROPP:

That's interesting because people were talking about a one megacycle memory

HOLBERTON:

Mhm.

TROPP:

at that point in time and Wilkes, in order to get on the air, decided to go for a half a megacycle

HOLBERTON:

Mhm.

TROPP:

which is what EDSAC had.

HOLBERTON:

I see.

TROPP:

So pushing it to two and a half let alone four

HOLBERTON:

Right, right.

TROPP:

is pushing the art a long, long way.

HOLBERTON:

Right. But the thing was, that was a major problem though when that four megacycle memory was not holding up. It meant that a contract which had been signed with the Government with certain speeds, we had to really do some, some change and additional cost. Instead of having twenty word tanks we had ten word tanks in the memory, in order to come back close to that speed again.

TROPP:

Yes, well of course there was a problem in terms of an airborne guidance computer

HOLBERTON:

Yes.

TROPP:

in constantly changing and readjusting

HOLBERTON:

Yes.

TROPP:

the direction from information that was coming in and the re-computation

HOLBERTON:

Yes. Mhm.

TROPP:

that had to be done. So you had, they knew they had to have high speeds.

HOLBERTON:

They knew they had to have that. That's right.

TROPP:

So it wasn't a question of staying with the technology and settling for a half a megacycle.

HOLBERTON:

No, because the signals would be coming back before you had the preceding computation finished if you didn't —

TROPP:

That's right.

HOLBERTON:

That's right.

TROPP:

Yea. So there were other problems involved in,

HOLBERTON:

Mhm.

TROPP:

in BINAC that were different than the problems any other computer was faced with.

HOLBERTON:

Mhm.

TROPP:

And, of course, it was many years before there was airborne

HOLBERTON:

That's right.

TROPP:

computational guidance systems available.

[End of Tape II, Side II]

[Start Tape III, Side I]

TROPP:

This is the third tape in our discussion this afternoon with Betty Holberton and Betty Bartik, and I'm going to allow them to talk, hopefully uninterrupted by me, on the roles and aspects of various individuals like Kite Sharpless and Chuan Chu and others.

BARTIK:

Bob Shaw.

TROPP:

Shaw, right, and then I'll get out of the way. Okay?

BARTIK:

Well, I think that Bob,

HOLBERTON:

Bob Shaw.

BARTIK:

I always considered the perfect computer man one of the most well rounded figures that was on the scene and I think that the fact that John and Pres could attract this kind of a person: He was not only an engineer and a brilliant engineer, but he was also a good logician and he could write well, he could teach, he could do all kinds of things. And

HOLBERTON:

at the same time having the handicap of being an albino.

BARTIK:

And not in good health.

HOLBERTON:

That's right.

TROPP:

But he's still around.

HOLBERTON:

No, no. He's dead.

TROPP:

He's dead?

BARTIK:

Yes, he died —

HOLBERTON:

He had a tremendous influence upon me, I think. Just because of his ability to teach us, and somehow he was an excellent teacher on the, on the ENIAC. He would come in and answer any questions that we would have; in fact, he came in quite frequently.

BARTIK:

Well, that's because that he was a well rounded person and could understand problems that we were having. He was human oriented

HOLBERTON:

Right.

BARTIK:

and he wrote very well. In fact, Bob Shaw drew all the block diagrams for UNIVAC I, the logic diagrams for UNIVAC I, in a period of about six weeks, every one of them.

TROPP:

Mhm.

BARTIK:

And one of the jobs that I did with the UNIVAC was to Arthur Gehring and I put in the check circuits. And in the, in the course of this we were given the job of checking all these block diagrams and when any changes were made to find out what the ramification would be for other parts and to bring all of them up to date. Well, of all those initial UNIVAC I block diagrams there were no fundamental errors. There wasn't a single fundamental error, and he did that in six weeks.

TROPP:

Wow!

BARTIK:

It's an amazing —

HOLBERTON:

Well, he - he not only was a good engineer, but you know, he, he programmed well. I was in the — Betty Jean was in the area of the circuitry and I was in the area of the, of the instruction code development and it didn't take very much to, to describe to him something that was needed, and he would go ahead and put it in without ever saying anything, you know, about putting it in. But I do remember it got to the point where there were so many instructions for the machine that Pres put his foot down and he said, "No new instructions in the machine unless it will save five percent of the time and cost less than two percent of the equipment." So that stopped it.

But he really could understand your problems and he was really a tremendous character.

TROPP:

Does he go back to the ENIAC period?

HOLBERTON:

Oh, yes.

BARTIK:

Yes, he did the function table.

HOLBERTON:

He did the function table. That's the reason, when Betty Jean and I were working on learning the function table he was a tremendous assistance.

TROPP:

Mhm.

HOLBERTON:

Because when we were given this function table we weren't really given anything as to what it really was doing and it did have this ability to interpolate which, you know, if it isn't described in print, you're not quite sure what those circuits do and what's the purpose of it. And I do remember him describing what this was for and how it worked.

TROPP:

Mhm. So he must have been then fairly important when ENIAC was converted to a serial machine, when the function tables —

HOLBERTON:

No. He was working on EDVAC at that point. No, he had left. He was at Princeton.

BARTIK:

He worked for the — Von Neumann at the Institute.

HOLBERTON:

Yes.

TROPP:

Oh, so he went to Princeton when Von Neumann organized his group.

HOLBERTON:

He went to Princeton. That's right. And from there he went back to, to UNIVAC.

BARTIK:

Well,

TROPP:

Well —

BARTIK:

in the meantime, he formed a company that failed.

HOLBERTON:

Yeah.

TROPP:

I, I promised not to interject, but there is a question at this point and it's one that I, I want to raise, I do raise with everyone. What caused Von Neumann to break away from the Moore School rather than stay around and be involved with the construction of EDVAC to spin off instead and go to Princeton to build his own machine? Do you remember the clash?

BARTIK:

What do you mean, left it? He never left it.

HOLBERTON:

He never was part of it.

TROPP:

Well, he wasn't there, but I think, and again, maybe

HOLBERTON:

He was a consultant.

TROPP:

my memory is bad, but wasn't there a hope at one point that he would stay on at the Moore School or be involved rather, in the construction of EDVAC?

BARTIK:

Not that I know of.

HOLBERTON:

Not that I know of. As far as I was concerned he was always a consultant, just as he had always been a consultant for Aberdeen Proving Ground

TROPP:

I see, I see.

HOLBERTON:

because during, down there, he would be on this Advisory Commission. He would come down and you would go through a problem you were having in some area of ballistics or what not. He was a member of that.

TROPP:

Okay. So there were —

HOLBERTON:

So in this era he was still a member of this team who would go with Aberdeen Proving Ground's problems.

TROPP:

Okay, I didn't mean to digress.

HOLBERTON:

So I don't know that he was, I don't know whether EDVAC was part of Aberdeen's contract or not.

TROPP:

I didn't mean to digress but —

HOLBERTON:

No, but I mean, I don't, I don't think that —

TROPP:

Somewhere there seems to have been some kind of a clash and I just wondered if, if it involved Von Neumann.

BARTIK:

Not that I know of.

HOLBERTON:

Not that I know of.

BARTIK:

I know nothing about it if —

TROPP:

How about Kite Sharpless? Why don't we talk about him.

BARTIK:

Kite was the picture of the perfect gentleman. He was well educated, he had a Quaker background, and at the time I met him he was about forty years old, but already had white hair. But he had this young looking face. And he was intelligent, and he had a lot to do, as I understand it, with designing the cycling unit?

HOLBERTON:

That's right.

BARTIK:

And the multiplier and the accumulator.

HOLBERTON:

He certainly was in the area of the cycling unit and he also took over any of the problems after a period in time when the machine was turned over to us, he was the contact point for anything that we would have. We had to contact Kite.

BARTIK:

You mean engineering problems.

HOLBERTON:

Engineering problems, that's right. In relation to any of the equipment it was Kite that was the one who was assigned rather than any other engineer, regardless of what part of the machine they were involved with, Kite Sharpless was the one we essentially got in touch with.

TROPP:

He was at the Moore School from the very beginning of the ENIAC project wasn't he?

HOLBERTON:

I don't know. I don't know about that.

BARTIK:

He certainly was prominent when we came on the scene

HOLBERTON:

Yes.

BARTIK:

and was considered, you know, one of the people that was significant in the design of the machine.

TROPP:

Mhm.

BARTIK:

So the value of a person like Kite and the ability of I mean of the, Kite was another all round guy that would work on a, on a lot of different things and was knowledgeable about a lot.

HOLBERTON:

You know, it was a marvelous team of men, even from a personality point of view and, and, and the way in which they worked together. I mean I never really saw any conflicts among the people.

TROPP:

Not only were they very talented

HOLBERTON:

Yes.

TROPP:

but they seemed to, personality-wise, them seemed to be smooth.

HOLBERTON:

Yes. Well, I think as a group of people, I'm hard put to find a group of people today whose attitudes in twenty-five years have changed and what not to be that group of people.

TROPP:

Mhm.

HOLBERTON:

It may have been the times. It may have been the fact that we were at war or what not, I don't know, but I, I, I really felt that, that it was really a very, a very excellent —

TROPP:

Well, we can't discount the war-time atmosphere. I know many times when I asked Grace Hopper whether or not they considered various things, she would say, "We didn't have time for those things, we had a war to win,

HOLBERTON:

Yes.

TROPP:

we had a problem to solve. And all of our energies, collectively, were concentrated —"

HOLBERTON:

I think one of the things is when everyone is under pressure, and they were under pressure to get this thing done that, you know, the whole idea of cooperation is just felt.

BARTIK:

Well, I do think though that you have the Bob Shaw, the kinky — all round man but he had a kinky sense of humor, and he stuck various logic elements in the function table that everybody said it wasn't computer logic, it was Bob Shaw logic that went into it.

TROPP:

[Laughter]

BARTIK:

And he enjoyed this role of — but I don't mean to say that it wasn't logical. It was, he was very logical,

HOLBERTON:

Yes.

BARTIK:

but the point was it wasn't obvious logic, it was —

HOLBERTON:

That's right, that's right. It was so subtle.

BARTIK:

And he also had this same kind of sense of humor where he liked things that were kinky and out of the ordinary. And Kite's humor was much more human and the foibles of human beings and things of that kind.

And so that this elegant Kite Sharpless and this Bob Shaw, who would probably be a hippy today,

HOLBERTON:

Mhm.

BARTIK:

if he were still alive. Even at, whatever age it is.

HOLBERTON:

Because he was interested in social problems too, for one thing. He really was. He was very much interested in what was going on in the world.

TROPP:

Mhm.

BARTIK:

And how these things would be used

HOLBERTON:

Right.

BARTIK:

and how they would be used

HOLBERTON:

Yes.

BARTIK:

in a social significant light.

HOLBERTON:

That's right. He was interested, even way back in those, those days, about the problem of the use of the computer.

TROPP:

Did he have contact with, with people like Ed Berkeley, who seems to have been also sensitive in this area?

HOLBERTON:

I don't know, because well, he did, yes he did in the UNIVAC period, but Ed Berkeley wasn't like that then. When Ed Berkeley came, 'cause he was connected with Prudential at the time when, when UNIVAC was being designed and he was on our floor quite frequently and Bob would have contact with him,

TROPP:

Mhm.

HOLBERTON:

but they are entirely different kinds of characters,

TROPP:

Mhm.

HOLBERTON:

and even though they might arrive at the same solution to something or other, I don't think that they — well, they don't have the same kinds of sense of humor. In fact, I don't think Ed does have a real sense of humor. And — so I doubt whether they would have much contact.

TROPP:

Mhm. Chuan Chu is another name we —

BARTIK:

Oh, Chuan. [Laughter]

TROPP:

Yes. [Laugh]

BARTIK:

Well Chu was elegant, ambitious, beautiful physical condition, and all business.

TROPP:

What was his prime role in the ENIAC?

BARTIK:

Well, it was the —

HOLBERTON:

Divider. Square rooter.

BARTIK:

Divider, square rooter. That was the last that was put in operation.

HOLBERTON:

Yes.

BARTIK:

And I suspect that came about because, I'm not sure that they really intended to put a, a square rooter in the machine. I'm not really sure about that.

TROPP:

As I get the story from, from John —

BARTIK:

The logic for that came from Burks though.

TROPP:

Right. From, from John Mauchly, once they had the divider in, the square root routine was easy to do.

HOLBERTON:

Was easy to do, right.

TROPP:

And because it was a common enough operation,

HOLBERTON:

Right.

TROPP:

if they had had to do a square rooter without the divider,

HOLBERTON:

Right.

TROPP:

that would have been a whole different bag.

HOLBERTON:

Right.

TROPP:

But once they had the divider, once they had solved that problem, which was the most difficult —

BARTIK:

Well, I understand —

HOLBERTON:

Well, we didn't use a divider in the trajectory because we used 1 over H rather than doing the division. We didn't use the square rooter, but I'm not actually aware that we used the divider. Because we stored our tables "1 over" rather than do the division because of speed.

TROPP:

The reciprocal

HOLBERTON:

Reciprocal.

TROPP:

was easier to work with?

HOLBERTON:

Yeah.

BARTIK:

Yea, but I understood that Arthur Burks was the one that worked out the logic, because his background, he has a PhD in philosophy and logic.

HOLBERTON:

Maybe I should ask him why, why the divider has an output that you couldn't use. The fixed time cycle, four — four add time cycle output rather than the determination of the — it had two outputs. One that was given you just like —

BARTIK:

One was a delayed output.

HOLBERTON:

One was a result time output which was essentially when the result, but what you could use the other one for, what did he assume you could use it for? We never could make use of it. The one that came out four add times later and then the one that came out when the result actually was finished. What could you do with that, after you set the problem up?

BARTIK:

Oh, now wait a minute. That is described in the manual if you look at that Betty, I'm pretty sure. That's an output to give you a delayed output that you can use.

HOLBERTON:

It's not delayed from the results, it's delayed from going in.

BARTIK:

Mhm.

HOLBERTON:

So I often wondered why we had never used it and what the purpose was. Well, that's something else.

TROPP:

Did you have contact with Harry Huskey at all during that period?

HOLBERTON:

Oh, yes. Harry Huskey was the bane of my existence.

TROPP:

[Laughter]

HOLBERTON:

He was in charge of the reader punch and Harry was teaching classes at the Moore School and — as well as working on the project. And he'd come in the morning and he would tear that thing down if we had had trouble with the reader, and look at the clock: He had a class! And he'd leave the thing on the floor, while he went and taught a class for an hour and then he would come back and put the thing together.

TROPP:

[Laugh]

HOLBERTON:

And every time he walked in I was scared to death he was going to do the same thing because it may have been just a small thing, it really, we didn't call him in, he just came in, you know, and tore the thing down, go out and come back an hour later and put it back together again. So seeing Harry Huskey coming in was a horrible thing, because it meant you couldn't do anything.

BARTIK:

Yes, but he also did a lot of the block diagrams.

HOLBERTON:

He did, oh, he did, he did a lot, he did the conversion of that, making the input fit in with, with the time cycle of the machine, there was no question about that. But this is just what happened later on when he was still enthused and making an excellent job if it. And that he was becoming the perfectionist, essentially.

TROPP:

Who were some of the other names that came up?

BARTIK:

Well, Douglas Hartree, whom I call the first numerical analyst, at the beginning of the computer industry people used to call him that. They, one of the things that early people discovered is that you needed something other than a mathematician. You needed a new category of mathematics to handle computers. And that the ordinary mathematician just couldn't cut the mustard in terms of

HOLBERTON:

Conversion problems.

BARTIK:

practical problems on the machine. So they decided that what we really needed was something different. Well, what did we need? Well, they said you needed a numerical

TROPP:

Analyst.

BARTIK:

analyst and then they'd say, "Well, what's a numerical analyst?" And people would say, "Well, I don't [know] what a numerical analyst is, but we all know that Doug Hartree is one."

HT&BARTIK:

[Laughter]

BARTIK:

So he was considered, for a number of years, the numerical analyst and the epitome of this new breed of mathematician that the computer industry needed to make them practical and work.

TROPP:

Really in, in some sense the computer industry

spawned that whole branch of mathematics.

HOLBERTON:

Oh yes, it did. Yes it did.

TROPP:

And, let's see, you have people like Hartree and you have people like Alston Householder

HOLBERTON:

That's right.

TROPP:

and you had people who became numerical analysts as a result of the computer.

HOLBERTON:

That's right, yes. Right.

BARTIK:

Right. But Dr. Hartree had built a computer during the war out of Mechano parts.

TROPP:

Mhm. It was a differential analyzer, essentially.

BARTIK:

Right. And so he came to the United States. He liked to come, because if you will remember at that time there was the terrible rationing in England. He liked to come to America to eat.

BARTIK & TROPP:

[Laughter]

HOLBERTON:

That's right.

BARTIK:

As well as, he came here with the dual purpose as I understand, and I understand that.

HOLBERTON:

He was at the invitation of Aberdeen.

BARTIK:

Invitation. And this really came about by Colonel Goldstine, Doctor Goldstine, that this was one of the real talents of Herman Goldstine, and that was to, to see — he early understood, as I understand it, the value of computers, but he also was able to pick the people that could be of significant help in advancing the art. And he was the person that suggested that, that Aberdeen or that the Army Ordnance bring Hartree to this country. Now he had a dual role as I understand it. One was he had a job that he wanted, a problem that he wanted to run on the ENIAC, but he also, they, they expected recommendations from him of the organization of a computing group,

TROPP:

Mhm.

BARTIK:

and an evaluation of the personnel.

HOLBERTON:

That's right. That was one of the things, evaluation of the personnel. I remember that he was —

BARTIK:

If they had the right kinds of people to do the job.

HOLBERTON:

Right.

BARTIK:

In other words, they expected him to report on whether or not the programmers were operating in the correct way. If they had the right kind of programmers. If they had the right kind of personnel to make —

HOLBERTON:

Did you ever see the report, by the way? [Laugh]

BARTIK:

I never read it.

HOLBERTON:

No, I never did either.

BARTIK:

No, but I understand there was one.

TROPP:

It's probably in the files at Aberdeen.

HOLBERTON:

Probably so.

BARTIK:

Yea, I would be interested in seeing it.

HOLBERTON:

It would be interesting to see what his, what his attitude —

TROPP:

Well, you mentioned that Kay McNulty worked with him

HOLBERTON:

Right, yes.

TROPP:

on the problem.

HOLBERTON:

On the problem, aha.

TROPP:

So you remember what the problem was that Goldstine was interested in that Hartree worked on?

HOLBERTON:

No, I don't. I don't remember what that problem was.

TROPP:

Kay would know?

HOLBERTON:

But Kay would know, and she did work on it afterwards, after he went back to Europe. Hartree was over here twice, as I recall. Once he came over by himself, the next time he brought his wife.

TROPP:

Do you remember the approximate dates of those visits, at least the years?

BARTIK:

Well, they were working, she was working on the Hartree problem the same time as I was working on the Taub problem and I can remember specifically. The Taub problem went on the machine.

HOLBERTON:

It was the summer of '46 then.

BARTIK:

went on the machine in the fall of 1946, because I had to leave. I was going to Missouri to introduce my family to my fiance

TROPP:

Mhm.

BARTIK:

and our trip was delayed and delayed because we were trying to get the Taub problem done, and if I recall —

TROPP:

So she was working with Hartree now about the same time?

BARTIK:

She was working with Hartree at that time.

HOLBERTON:

Mhm.

TROPP:

So his first visit then would have been in '46?

BARTIK:

Been prior to that.

HOLBERTON:

'46, yes.

TROPP:

Early '46, or —

HOLBERTON:

I thought maybe he was one of the speakers at that symposium?

TROPP:

In the summer of '46?

HOLBERTON:

Yes.

TROPP:

You are probably right.

HOLBERTON:

Yes, I think he may have been; right. I think that was his first one.

TROPP:

Yes, I think he was there and then he — and then his second visit was the one in which he also gave lectures at Illinois.

HOLBERTON:

That's right, that's right.

TROPP:

That would have been what, '48 or '49?

BARTIK:

Oh, no.

TROPP:

It was not that …

HOLBERTON:

No, no, no, no. It was while we were still there because I remember he threw a party for us.

BARTIK:

I'm sure he came twice in '46 because —

TROPP:

Twice during the same year?

HOLBERTON:

Yes.

BARTIK:

I'm sure he did, yea.

HOLBERTON:

Because once he was there alone and once he was there with his wife.

BARTIK:

Well, it was when he was alone though that he threw the party.

HOLBERTON:

Yes. But then his wife came later.

BARTIK:

Right.

HOLBERTON:

Within a year.

BARTIK:

Oh, yea.

HOLBERTON:

Before we moved to Aberdeen.

BARTIK:

And he was one of the most delightful people that I think I've ever met in my life. He was another person, who had many of the same qualities as Von Neumann, in the sense that he was a very, very modest man, but was a very brilliant man and a man —

HOLBERTON:

But a much more social person though, and easier to meet, I think.

BARTIK:

Well, perhaps that's because we had more contact with him, because we worked directly with him. He came and actually learned the machine. He did follow this technique of: if I had a job to do —

HOLBERTON:

And he wrote a very beautiful article, you know, for — was it *Nature* magazine?

TROPP:

Nature, right.

HOLBERTON:

Yes. Really it was the first description that was put out and I remember that was

TROPP:

That's right.

HOLBERTON:

a major contribution there.

BARTIK:

But he came and he felt he wanted to know, to learn the machine, to do the programming and Kay was assigned to him to be the person to teach him

HOLBERTON:

That's right.

BARTIK:

and help him get his start on programs. And he was loads of fun socially. He knew all the Gilbert and Sullivan

HOLBERTON:

Yes, quite a good actor.

BARTIK:

lyrics and he would sing them if someone would play the piano and had a tremendous sense of humor, a very human person.

TROPP:

Well, that summer session, I told you how I, how I view its importance, you know, in '46. .. One of the things that the people, I guess there were twenty people invited

HOLBERTON:

Mhm.

TROPP:

for that summer session. One of the things they had to do was to learn ENIAC.

BARTIK:

How to program?

TROPP:

Well, I don't think they learned how to program, they learned what ENIAC did, and what it was all about.

HOLBERTON:

Right.

TROPP:

Do you remember any of those people and some of the contacts that you had with them during that summer session?

HOLBERTON:

You mean the, the people who go or the people who were there?

TROPP:

They may not have attended the lectures, but the people who were there as invited attendees who then probably spent some time with and on ENIAC, do you remember that?

HOLBERTON:

I don't know of anyone, the only one I can remember was Gene Smith, who was there as a military man and another fellow, I've forgotten what his name was, that we used to, we went to the beach with him once and what not. And I don't remember any of the other people who were actually, the invited —

BARTIK:

We didn't have that much contact.

HOLBERTON:

We were not really allowed to spend our time. We were not being paid to do that, I think we were told.

TROPP:

I see. How about, we were going to talk a little bit about Adele Goldstine, and the role that she played. Because that's another shadowy area that's difficult to see at this point in time.

BARTIK:

Well, I think that Adele was certainly a brilliant woman. There's no question about that.

TROPP:

You mentioned some of the things she did ear

BARTIK:

Right. And she had the prime responsibility of, and did write the manuals.

HOLBERTON:

When were the manuals finished, by the way?

BARTIK:

I'm pretty sure —

HOLBERTON:

At the time when the machine was delivered?

BARTIK:

Oh, no. I'm sure that they were finished before she got involved with the Taub problem.

HOLBERTON:

I see.

TROPP:

They were finished in mid, the first half of, '46 then.

HOLBERTON:

I see.

BARTIK:

.And I have had occasion to look at them recently and I'm really amazed at the amount of detail of those manuals. So she had that responsibility and she knew the machine very, very well, because she had, you know, written these manuals. And she also ran the Taub problem because we had just gotten the thing debugged and were starting to make the runs when I went to Missouri on vacation and it was finished by the time I came back, which was about two weeks later. So Adele had very practical knowledge, extensive knowledge, of the ENIAC.

TROPP:

Who have we left out so far? Some of the people we wanted to, some of the gaps that you mentioned earlier.

BARTIK:

Mhm. We've mentioned Burks, Huskey, Shaw, Johnny Davis, I guess was another engineer.

TROPP:

Johnny Davis, that's a new name.

BARTIK:

Yea. Well, he was involved with the accumulator.

HOLBERTON:

That's right.

BARTIK:

And I think Kite had something to do with too, but Johnny Davis was the one that really —

HOLBERTON:

Well, I was never sure whether it was really Johnny Davis' design as it was his implementation of the design, because I didn't really consider that he was in the same class as the other engineers that were associated in the major elements of the —

BARTIK:

He was young.

HOLBERTON:

He was young, yea, and well, maybe it's, I just didn't get the feeling that he, that he was really sharp like, like Kite or Chuan Chu or, because he wasn't really —

BARTIK:

Maybe it was because he was a young engineer and —

HOLBERTON:

That's right. He didn't have the experience of the other, that's right. So I thought that maybe he was there in the area of actually implementing a design rather than being in the area of design

BARTIK:

Well, as I say, he was a junior engineer which is —

TROPP:

We are going to run out of time and I have fifteen million questions at this point. One of which I'm going to throw at you, Betty, and that is your trip to Europe in the early fifties. Why you went. What you ended up seeing and doing. Because England was pretty much at a par, possibly even ahead, at that point in time, in terms of the development of machines and getting them running.

HOLBERTON:

Well, it was, well Betty Jean was on that trip too.

BARTIK:

I was —

TROPP:

Were you on that trip, too?

HOLBERTON:

She was on that trip too.

BARTIK:

Oh, sure.

TROPP:

Oh, great. I didn't know that.

BARTIK:

Sure.

HOLBERTON:

Yes.

TROPP:

Well, you can both —

HOLBERTON:

Actually for me it was, it was a delayed honeymoon, because the year we got married

BARTIK:

And I was on it. [Laughter]

HOLBERTON:

I was in the middle of some work there at UNIVAC and really just couldn't take that much time off. And so it really was that.

BARTIK:

But we visited Hartree and we saw the Cambridge machine. But believe you me, no American machine, see I can understand why England went ahead. Because no American would run any machine and consider it running in the condition that thing was in.

HOLBERTON:

That's right.

BARTIK:

There were cables strung across a room. It was like an obstacle course.

HOLBERTON:

Yes, it was.

BARTIK:

They considered this machine up and running. You had oscilliscopes in the middle of the room. You had pieces strung around.

HOLBERTON:

Yes, but Betty, that thing was —

TROPP:

There were three, three cathode ray viewers, as I remember.

HOLBERTON:

I don't know, but I can remember a trough that had something in it. I don't know whether it was a delay line memory of a water bath or what it was.

But the thing I remember being very much impressed with was the fact that they already had a library of subroutines and they already had a technique for getting to a subroutine. They had already established the techniques of the interface between accessing the, the arguments and actually using the routine and essentially relocate— [a] relocatable kind of thing. And I was really impressed. It was paper tape, but that I thought was great, we hadn't done that.

TROPP:

Because people like Wheeler and Gill were working on this problem

HOLBERTON:

Right.

TROPP:

long before the machine was completed.

HOLBERTON:

I can see. Mhm.

TROPP:

They had kind of a year lead time in which Wilkes had gotten them involved to say, "Look, we are going to finish this machine, we are going to have to put problems on it. You guys figure out how we are going to do it."

HOLBERTON:

Well, did we see Wilkes when we were over there? Was he there?

BARTIK:

No, I don't think — I've met Wilkes. I don't know where I met him, but I actually did meet him.

TROPP:

You may [have] met him on one of his visits to the United States

BARTIK:

I don't know.

TROPP:

because he, during that 1946, '50 time period, he made a couple of visits to the United States. '46 he was at the Moore School and in either '49 or '50 he was over —

BARTIK:

Mhm.

TROPP:

And I'm sure he visited UNIVAC, because he visited almost every installation that was —

HOLBERTON:

Well, that's the only computer we actually saw over there.

BARTIK:

Yea, the only computer we saw was —

HOLBERTON:

But I don't, I remember in, in —

TROPP:

You didn't visit Manchester or the National Physical Laboratory?

HOLBERTON:

No, we didn't get up that far, we didn't get as far as Manchester. Stratford-on-Avon, we stopped at the, the Remington Rand place. They never even heard of UNIVAC.

TROPP,BARTIK & HOLBERTON:

[Laughter]

TROPP:

This is in 1951 then?

BARTIK:

Yes.

TROPP:

Because there were a number of machines running in 1951 in England. Wasn't the — well, of course, the Pilot ACE was running.

BARTIK:

Well, didn't Ferranti have one?

TROPP:

Ferranti.

HOLBERTON:

Yes.

TROPP:

There was the Manchester machine.

HOLBERTON:

Right. Well, we didn't, we didn't have any, any contacts really to get in. Hartree was our contact to get in to see the Cambridge computer.

BARTIK:

But I must say that the thing that impressed me about that most of all was the way they, they could do productive work with such a mishmash of equipment.

TROPP:

They didn't have any money to build that machine.

HOLBERTON:

That's right. That's right. It was done on a song, it really was.

TROPP:

You know if somebody gave them a couple of thousand dollars they thought they were extremely wealthy. [Laughter]

HOLBERTON:

I mean the ingenuity, you know, and I was really, I thought that was just great, the fact that they had been able to do what they had with so little.

TROPP:

I mean it was really an extension of the Mechano machine into the electronic age.

BARTIK:

Yeah.

HOLBERTON:

Right.

TROPP:

You know, everything was scrounged. They didn't have the magnitude of the American machines. They didn't have the funding. They didn't have the polish.

HOLBERTON:

They didn't have any air conditioning. The room, you know, was a small room and these racks were just there with the cables above and below and, and you stepped over things and, but it worked.

TROPP:

Yeah, and it did some interesting problems.

BARTIK:

Well, certainly we saw Hartree there and he was very excited and very proud of the and —

HOLBERTON:

That's the last time I saw Hartree actually, was when we were there.

BARTIK:

Yeah. In fact we were even thinking about coming over at one time and program it for Hartree. Remember?

HOLBERTON:

That's right, yes.

BARTIK:

He, he thought England didn't have any programmers like us and he actually suggested that perhaps we might like to come to England, and work for a while.

TROPP:

What was the purpose of the trip to England and, in '51 was it —

HOLBERTON:

Just a vacation, just a vacation.

BARTIK:

Fun.

TROPP:

It wasn't intended as a business trip?

HOLBERTON:

No.

BARTIK:

Heavens no.

HOLBERTON:

It was originally intended, as I say, my husband and I were going on a trip. We didn't give you much time to figure out that you would go along. And she finally did. I don't know, it was less than a month's time, and she said she would go. So we just rented a car and went around England, Europe, a grand tour.

BARTIK:

So that as far as computers are concerned, that's the only thing we did.

HOLBERTON:

Yeah. That was just because we knew Hartree really.

TROPP:

Mhm. So you had no contacts then on the continent with any of the machines that were being considered then?

HOLBERTON:

No, we did not.

BARTIK:

Were there any?

HOLBERTON:

Yes, there was the one in Paris.

TROPP:

By '51, yeah. There was one in Paris. There were some in Scandinavian countries. There was one in Holland; there was a Dutch machine in the process, or at least under consideration.

HOLBERTON:

Well, we didn't, we didn't do anything like that. Strictly pleasure.

TROPP:

There were a number of developments at that point, but I don't know without a chronology

HOLBERTON:

Mhm.

TROPP:

I don't know how far along they were. But there were a number of machines built in Europe. Both Eastern and Western Europe during that 1950-55 time period. Where they were in '51, I don't know.

The Manchester machine was pretty far along then, because, I could be wrong about the year, it was either in '51 or '52 that one of the models was delivered to the University of Toronto, of the Ferranti machine. That had been built for a Government installation, but ended up in Toronto instead. It had been built for one of the British, I think for the National, one of the National Laboratories. So it was done by '51, I think.

And Turing's machine had been on the air for about two years. you know, Pilot ACE also went into operation in '49. There were quite a few machines there.

HOLBERTON:

Mhm.

TROPP:

Had you been on a business trip, which is why I asked you the question.

HOLBERTON:

That makes it different. It was strictly pleasure.

TROPP:

You didn't make, like a visiting fireman, you didn't visit all the fire stations. [Laughter]

HOLBERTON:

Well, the thing was we really weren't in a position to always be in on foreign visitors unless they were totally connected with the machine and putting a problem on. Since we were workers there, we weren't, you know, in the group that met everybody who came, came through the ENIAC, we really didn't. We wouldn't have had occasion unless they worked like Hartree did with us,

TROPP:

Mhm.

HOLBERTON:

or Adele.

TROPP:

Well, one person that we haven't talked about, and I guess it's because she doesn't get into your environment until the UNIVAC days, and that's Grace Hopper. So you have any comments you want to make on Grace's role in the early days when she first got to the UNIVAC period?

Okay. [Laugh] I promised you I would let you go at 6:15, and that's what it is. So I think we'll turn the tape off.

[Recorder off]

[End of Interview]