An Interview with

CARL CHAMBERS

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Conducted by Nancy Stern

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Carl Chambers Interview
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Abstract

Chambers discusses the initiation and progress of the ENIAC project at the University of Pennsylvania Moore School of Electrical Engineering. He recalls the conditions under which John Mauchly, one of the ENIAC designers, came to the Moore School in 1941, Mauchly's l943 proposal to the Army for a computer project, the National Defense Research Committee's initial denial of funds because of its commitment to analog computing, and the start of the ENIAC project six months later. Chambers describes the interactions among the ENIAC staff, and focuses on the personalities and working relationships of Mauchly and J. Presper Eckert. He recounts their conflicts with project director John Grist Brainerd, and the commercial interests they first envisioned in l944. Chambers discusses John von Neumann's involvement from l944 in the EDVAC project, the financial strains that accompanied this project, and the patent disagreement that led Eckert and Mauchly to resign from the faculty. He concludes with his views on the importance of the 1946 Moore School summer course, "Theory and techniques for design of electronic digital computers," now known as the "Moore School Lectures" in disseminating computer technology.

DATE: 30 November 1977   INTERVIEWER: Nancy Stern

LOCATION: Philadelphia, PA

STERN: This is an interview with Dr. Carl Chambers at his office at the University of Pennsylvania, November 30,

1977. Dr. Chambers, you were about to tell me about John Mauchly's work prior to '43. Now, I know that he came to

the University in '41 to participate in the Engineering Science Management War Training Course for math or physics

MS's or Ph.D.'s.

CHAMBERS: To take that course. I interviewed him to admit him to that course. In asking him why he wanted to

study, he said he wanted to come to the Moore School because he was interested in the development of the

computer. He thought that we would be sympathetic here and he wanted to get to know the people and take a

course. The opportunity to take a course was a way to get associated with the Moore School.

STERN: He knew about the Moore School's reputation with respect to --

CHAMBERS: --Interest in computers, yes. And quite a few interests other than computers also. Various

possibilities in addition to the differential analyzer. There had been several attempts to make devices for solving

algebraic problems through the years before that, as well as continual improvement in the differential analyzer over

the years. He knew about this work. That's the reason that he chose to come here.   At the time that he came, he

had already had a little computing device which I suspect you've been told about. It used neon tubes as trigger

circuits. And he'd done some simple arithmetic work on the little desk set-up, using those triggers. This was long

before the ENIAC or any digital computer was even considered here--even considered beyond some ideas that

people had which were not of the nature that later became the ENIAC. I was in charge of the course. Burks came at

the same time. Eckert was one of the instructors. He'd been a graduate student here so he was an instructor in the

class--in the laboratory.   At the end of the course, Mauchly and Burks were the two people from the group of about

30 students in the course who were continued as instructors here on the staff. The course was designed to change

people with master's or doctor's degrees in mathematics or physics, into electronic engineers. It took 6 or 8 weeks-I forget which.

STERN: These people came on their own volition to take a course like that. They weren't sent by any university.

CHAMBERS: No. This was offered through letters going out to anybody who wanted to come. They were not sent by any university.

STERN: And they weren't given draft deferments to get involved in this.

CHAMBERS: No. Well, see this was '41, and it was before Pearl Harbor. At that point, I don't suppose they were drafting anybody with those qualifications. Later, they were in positions that were not being drafted any time.

STERN: Did the courses focus at all on computational methods, or was it more or less an electrical engineering?

CHAMBERS: It tended to focus on electronics as contrasted to power. But it still covered the basic circuit theories and subjects of that nature applied in engineering, as contrasted to those that were applied in physics. That's the only difference. It did tend to emphasize communications and electronics, because at that time we knew that radar was a subject they had to learn; people were very scarce with background for work in radar. So we included studies basic to radar.

STERN: You say that Burks and Mauchly were the two out of about 30 who stayed on as instructors. Were they the only two offered that position?

CHAMBERS: Yes. They were the only two that I know of who were offered staff positions. That was the beginning. Mauchly all the time, even as a student, and for the two years from then until the ENIAC work started was a pest talking about what he wanted--the computer he wanted. At one point, I said, "For goodness sake, write this up and

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put it down on paper so if the opportunity comes for support, it'll be there." And finally he did--a year or so later--he got it done. It was circulated around the Moore School. People have not been able to find an original copy, but the shorthand notes were found. I remember he had dictated it originally. Thus it was recovered, and has been reproduced. This was done because he was trying to sell his ideas. Colonel Paul Gillon learned of Mauchly's ideas probably through Herman Goldstine who learned of Mauchly's paper in early '43. Aberdeen began to get enthusiastic about these ideas of Mauchly's.

STERN: Well, Goldstine writes in his book that he uncovered the ideas as a result of a discussion with Chapline about it. He doesn't mention Chapline's name, however.

CHAMBERS: Well, Chapline, a friend of Eckert and Mauchly, certainly knew of this proposal.

STERN: I'm curious about your reaction to the idea. Did you think it was a good one? Did you think it was something that could be used for the war effort?

CHAMBERS: Well, I didn't think it would ever get done in time for the war effort. I thought it was too long a project to undertake. That was my personal feeling about it.

STERN: But did you think it was feasible?

CHAMBERS: Oh, yes. I thought that it could be done. The biggest problem was the one that I was involved in more than anything else. A reliability problem. The most serious question was the reliability of the vacuum tube, and that's what I consulted on more than anything else in the project. The probability of being able to get a ten minute problem through it, using conventional information about the tubes at that time, came out to be something in the neighborhood of one in three. But even if you had only one good result in three times you ran it, it would still be a useful device.

STERN: A good deal faster than what was currently available.

CHAMBERS: That's right. So that one in three was what I estimated was the probability of getting a problem through the first time. This kind of thinking made us say yes. But I did think it would take quite a few years to get it operating.

STERN: Well, you were right. It wasn't ready for the war.

CHAMBERS: But the original proposal that Brainerd wrote--I think it was Brainerd--promised to get it out in, I think it was, nine or ten months.

STERN: Yes-that was a little optimistic. Now, I assume Brainerd got involved because of his previous dealings with Aberdeen.

CHAMBERS: Yes. Brainerd got involved because he was in charge of the program that had the women computer here, using calculating machines and the Differential Analyzer. He was the one who was in charge of some other projects. I had a couple separately. He was the one who was normally in contact with Aberdeen, and was responsible for those contacts. Early that Spring I met Gillon on the train one time. I had been down in Washington and on my way back. Gillon got on the train at Aberdeen. I rode up with him. The first time I knew that they were interested was at that time when he asked me--what did I think about the proposal of Mauchly's? That was the first I knew that the Aberdeen people were interested. That would have been February or January or somewhere in there.

STERN: Would you think it would be a fair evaluation to say that one of the reasons it got passed so quickly by the government, was because of Brainerd's reputation with respect to the Aberdeen group on the one hand, and Gillon's faith in Goldstine?

CHAMBERS: I don't believe either of those is valid.

STERN: Plus the need. I shouldn't leave out--that was the over-riding feature- -the government's need at this point.

CHAMBERS: Well, in the first place, your first premise I didn't think was valid. You say it started quickly?

STERN: Yes. It seemed to me, based on the evidence that I had seen, that the government funded this project in a relatively short period of time, compared to other government contracts.

CHAMBERS: Not at that time.

STERN: That it was a fairly common procedure for, within a period of six weeks, to grant money for a proposal?

CHAMBERS: Oh, sure. I don't know what timing you're talking about, but the letter of intent to go ahead with work in those days--you could get a letter of intent after a couple of conferences. It was not unusual to have it in two or three weeks.

STERN: On what did the government base its decision? Would you say that because of the war situation, it was fairly common to receive funding if you came from a responsible university and had a responsible project in mind?

CHAMBERS: Well, yes, if there was identification of that project with the needs of the war. They did have to have two or three things. One is that the people had to say that it is worth doing because it would serve the war effort. That was the first thing. The second thing was that the institution that was going to do it would be a responsible institution. Those were the two things that were required, and in the case of a university like this, the second would not take any time. So they didn't even need to have a visitation in a place like this.

STERN: The reason I brought it up was that Mauchly wrote the proposal in August of '42, and no action whatever

was taken on it until Goldstine got involved and Brainerd re-wrote the proposal, essentially, and my concern is why in '43, whereas the proposal from Mauchly was not immediately picked up.

CHAMBERS: Well, the proposal from Mauchly, the one that you're talking about, was written in the summer of '42, but it was an internal document here. It had no work plan or promise of time to report. It didn't go out to any government people.

STERN: Why not?

CHAMBERS: Well because we didn't know of any government people who would be interested in doing it.

STERN: I see. So it was the need that did not make itself manifest until '43?

CHAMBERS: Yes. I didn't know whether it was Gillon or someone else who made the correlation between Army need and the Mauchly device. Gillon visited here fairly regularly, and he had been coming long before Goldstine was here. He sent Goldstine up as an assistant. I think Goldstine didn't arrive until January [1943] or sometime near that. I didn't know that Gillon ever had a copy of it before that. So an interest in it took place when they discovered it here locally, in January, or February or March. I'm not sure which. I think it was probably late February. There were a couple of meetings with regard to it--the possibilities were discussed with various people. I think it was six weeks before the letter of intent got here.

STERN: And that's not unusual-six week period?

CHAMBERS: No, that's fairly long. I would say--if anything--it was a slow one.

STERN: Now, once the letter of intent was out, which was late April, I believe, the Moore School requested some information from the National Defense Research Committee, which had as members Caldwell, and Hazen, and people

like that; and it appeared as if NDRC was, if not hostile to the request, indifferent.

CHAMBERS: I think they were.

STERN: Now, could you shed some light as to the reasons for that sort of reaction?

CHAMBERS: As of that time, my knowledge of that hostility, was mostly hearsay. The hearsay was that they were hostile to it because they had committed themselves to the analog computers for war work.

STERN: Well, those from MIT had.

CHAMBERS: Yes. Well, I think most of the rest. There was only the work by Stibitz, the digital work using relays that amounted to anything. Of course, you had the Aiken digital computers which were moving along at that time, and were hardly doing the same thing.

STERN: I meant more specifically--since Fry and Stibitz were on that committee, that they had their own personal interest in a different type of digital computer.

CHAMBERS: Who was the first one you named?

STERN: Fry--Thornton Fry.

CHAMBERS: Oh, yes. Thornton Fry was with Stibitz. Fry was not a machine designer. But Stibitz was. I don't know that Stibitz was against it as much as concerned about the question of reliability. He had little confidence in vacuum tubes and a lot of confidence on his part. I know that Caldwell was very, very strong for the analog computer. I think that was the basic problem there.

STERN: Except that these people were supposed to be the scientific authorities, judging on anything that might be war-related and might produce results from the point of view of the government. And is it appropriate for people in that position to say, "Well, I prefer an analog technique and therefore don't think we should go with this sort of project?"

CHAMBERS: I don't think they can avoid a background conflict of interest. That is, I don't think that's avoidable when they're so bound up in their own affairs.

STERN: Yet, they had funded NCR and RAC in work on electronic ring counters.

CHAMBERS: There'd been lots of work on ring counters. I taught ring counters in a course in 1935. Ring counters were being used in '32 when I was working at Bartol. We were counting cosmic rays. So there was lots and lots of work on ring counters for a lot of reasons.

STERN: Not necessarily anything related to digital computation?

CHAMBERS: No. The basic concepts, like the concepts of carrying and transferring and the sort of thing that you have to do in your circuitry for the ENIAC, were the new parts of the use of counters. The detailed circuits were different and pretty fancy; that hadn't been done before...by any of these other people. But, this was done in the ENIAC. And second to improve the reliability through the design. To be reliable the circuits not only had to work every time but the currents, voltages and temperatures had to be maintained in narrow limits. Such design throughout the circuitry of inter-relating ring counters with carries and things of that nature, and switching on and off, and other circuits of that nature were new.

STERN: What I thought perhaps was at work with respect to NDRC was some sort of competitive problems between the MIT group and the Moore School group. Do you think that that was evident in the '43 period?

CHAMBERS: Well, I think the MIT group was jealous of the work being done.

STERN: The differential analyzer work--or do you mean the ENIAC itself?

CHAMBERS: No--the cooperation with the differential analyzer had not been bad because what we did was to cooperatively design a larger machine based on the original program up there. The big differential analyzer program that Caldwell was involved in at that point was not in competition directly with anything except the potential of the ENIAC. It was not in competition with our mechanical one here. We were not competing. I don't think there was any jealousy there at that point. No, this was only in connection with the ENIAC--it was clear that their big differential analyzer was in competition for the big computing problems with the proposed digital computer, electronic digital computer.

STERN: That's the Rockefeller Analyzer-they were working on it, right?

CHAMBERS: Yes, they were working on that. This was the most powerful computer that was envisaged, except for the competition here.

STERN: Now, were the people at the Moore School aware of that, because I understand it was a secret project? I'm speaking about the Rockefeller Analyzer. That work was being undertaken at that point.

CHAMBERS: You mean the analog one that Caldwell was working on?

STERN: Yes.

CHAMBERS: No--I don't know how much was secret, but we generally knew about it.

STERN: RCA was approached in '43 to assist the Moore School in working on the ENIAC. There are documents to

that effect. The idea from Pender was perhaps to make a joint venture. RCA said they weren't interested. They would supply whatever informal assistance was necessary, but that they were not interested in any sort of formal arrangement. Could you shed some light on this?

CHAMBERS: I never heard of this.

STERN: I know that you worked for RCA for awhile.

CHAMBERS: That was quite a few years earlier. There were lots of recommendations for getting information that would help us do the work from various places, and RCA was one of them. I know there was one approach that I made with RCA. But this was on the reliability question. What I wanted to try to do was see if we couldn't get some vacuum tubes that had passed life test to be used as tubes on this because their continuing breakdown probability would be low. The tubes that had been on life test for a short time would have been seasoned and would have been better tubes to use. I tried to find out if there were enough of those available that we could use for our system. It turned out that during the war they'd cut out their life tests so they didn't have so many. There were other contacts with regard to finding out what they had done on ring counters.?

STERN: The function table came from RCA's work, too.

CHAMBERS: Yes, they had in some of the devices, some of the circuitry used for function tables, and National Cash Register had done some work on counters of some kind. There was this kind of exchange information. I didn't know of any proposal to be a joint undertaking.

STERN: There are some documents that were collected from the Honeywell Trial that indicate that, and then there's a deposition from Jan Rajchman.

CHAMBERS: Well, Rajchman was a consultant, but this was on a specific circuit.

STERN: Could you shed some light on the ENIAC staff--the interaction between people; how that really worked? I know there were official titles that everybody had, but I'm curious as to how it actually functioned.

CHAMBERS: Well, the titles varied from time to time. There were a lot of personality conflicts. Mauchly was most erratic. He was not one that could be an organizer at that time. And he knows that. Eckert was mostly, almost all the time, so far ahead of the thinking of other people that he rankled people-- particularly Brainerd. It came to the point where he ignored Brainerd. On the other hand, with respect to the work that everybody was doing, he was over their shoulder all the time. There wasn't a single one of the staff who was doing a bread board set-up that he didn't tell him where to solder the joint.

STERN: So he was very much the supervisor.

CHAMBERS: Oh, very much. No question about this. He was the complete supervisor. And he'd come in the next morning and tell them to tear everything up and change it because it was going to be revised as a result of his overnight idea for improvement.

TAPE 1/SIDE 2

CHAMBERS: Eckert's knowledge of circuits and so on was superior. They were glad to get the advice, glad to get the ideas, glad to learn from him.

STERN: So within the laboratory itself, there was very little tension?

CHAMBERS: Very little, I think. There was a man that was in charge of building the device at that time, under Eckert, he was in charge of the girls doing the wiring of the whole big set-up and so on--what's his name? Who was in charge of building?

STERN: Well, I can names some of the engineers. Sharpless, was it? Davis. Shaw. Shappard. Chedaker?

CHAMBERS: Chedaker of course was concerned because the designs were likely to get changed, and that was hard on his production line. This was the nearest to any serious problem that I can think of, within the group. I don't think Mauchly ever did give any orders to any of the wire men or engineers, in any fashion. He was in an advisory position, basically, advisory to Eckert with regard to the system planning. But Brainerd was tied up in so many other things that he didn't give much attention to it, and he and Eckert didn't get along very well at that time. Eckert was coming to me frequently complaining about the situation. It wasn't too long before there had to be a freeze on the design.

STERN: Before there was a freeze on the design, before we get into that, you said that Mauchly served more or less as an advisor. Specifically to Eckert. Now, the terminology used in the trial was a "sounding board." Did he make any specific contributions after the period in which the proposal was accepted? Would you say it was an intangible kind of contribution as opposed to anything else?

CHAMBERS: Well, you mean here some particular idea? There doubtless were some. I'm quite sure that there had to be some. But then how many specific ideas I couldn't say. Let me give you an example of the kind of thing which would happen. The concept of a delay line came up. Mauchly might have had the concept that a circulating memory would be a help in a computer. On the other hand, Eckert probably got this idea of a specific circulating device as a way of storing the data. I'm sure that he would have gone and talked to Mauchly about what that would mean to putting it into the arithmetic system. And because this would be an entirely different kind of system--the way the inputs and outputs would come, and carries, and things of this nature, it would be quite different. Eckert and Mauchly would be the ones that would work out the kind of changes required. Mauchly would be invaluable in that kind of thinking.

STERN: It is fairly common in engineering projects of this sort to have a person like Mauchly involved in a systems

sense, to use a term that you used before--or is it an unusual thing?

CHAMBERS: Yes, in a team project was usual to have somebody of this kind. It's even more so now than it was then. There's more tendency to think about a project in terms of the logic of it rather than the circuitry of it, directly. This was normal. Now, he was not as adept of circuits as most people who get into that are.

STERN: Did he have as much knowledge as a graduate engineer?

CHAMBERS: He was as much a graduate engineer as anybody else, actually, but his approach to things is not that of circuitry. To him that was the chore part of it. I think this is normal.

STERN: That there be a person who does not specifically make the contributions to the engineering?

CHAMBERS: Such activity is as much engineering as design. Frequently that person is the engineer who knows that it is possible and gives the orders to everybody else. The circuitry design is done by people underneath him, rather than by him.

STERN: So even a person with Eckert's capabilities in engineering would frequently seek out a systems type person like Mauchly to talk to concerning these ideas.

CHAMBERS: Oh, he always conferred with him. I'm quite positive this happened because Eckert similarly came to me many, many times. The family was pretty well irritated because Eckert would come out to our house on Sunday and start to talk about mercury delay lines or some other current idea. He would neither go nor would he accept our invitation to dinner. He was so thoroughly involved-- everything else was outside. He was that kind of person. This is the way he did it with Mauchly about the whole system.

STERN: You mentioned some of the difficulties between Eckert and Brainerd. Later it developed that there seemed to

be more of a problem between Brainerd and Mauchly.

CHAMBERS: Well, the problem between Brainerd and Mauchly took place first.

STERN: Okay--can you shed some light on that?

CHAMBERS: There was a personality conflict there which was characteristic. Brainerd is an analytical person; when he goes after a problem he works out all the details and does all the algebra and algebraic calculations in great detail, and looks for all the detailed items as he goes through it. This is characteristic of Brainerd. The opposite kind of approach to the same problem is the way Mauchly goes after it. He goes in spurts and jumps over details, if he gets disgusted with progress he stops and goes to something different, and back and forth. On other projects, prior to the ENIAC, this conflict had started. It started long before the ENIAC contract was made. I think Brainerd was irritated with Mauchly playing around with his computer ideas. I think this bothered Brainerd because he was assigned to work on one of the other projects that Brainerd was in charge of.

STERN: Signal Corps.

CHAMBERS: Signal Corps project. He was out doing something else on his computer ideas instead of doing the work on the Signal Corps project. This kind of criticism was there before ENIAC. I don't think this ever got any better between the two of them.

STERN: You used the term before to describe Mauchly as "erratic." When he dealt with the ENIAC project, I assume that that had his full attention.

CHAMBERS: He gave computers his full attention. He was always looking ahead to see what the next computer was going to be before the work was barely underway on the current one.

STERN: Were his interests from an intellectual point of view or from a commercial point of view at that time, do you

think? Do you think he thought about commercial computers?

CHAMBERS: Oh, the commercial point of view didn't come in at all until later--I would say, in 1944 or '45, somewhere in there. The idea of the company and undertaking things from a commercial standpoint did not become significant until spring of '46.

STERN: What about Pender during all of this? Depending on who you talk to, you get all these different viewpoints about Pender, and I'm not sure I can really picture the man.

CHAMBERS: I'm not sure what you want to know. Pender was at that time, the father image of practically everybody. That was the way it was in this lab. I think that would be more like that relationship than anything else. And he was concerned about trying to straighten out fights when he could. He didn't have too much confidence in Mauchly. None of us had much confidence in Mauchly, at that time. We were afraid he would go off and do the wrong thing. Mauchly knows it. I told him this. So it isn't a secret. I think the one that caused more trouble than Pender was--the one he disliked most was Goldstine, because Goldstine was trying to put his foot into things and Pender would say, "That's none of your business. This is our job and not yours. You get out of it." And that was his attitude. He never was quite so firm about it, but Goldstine would run over Brainerd's head to Pender and Pender would try to chase him out of the office. The friction was strong between Goldstine and Brainerd, too; and to some extent between Goldstine and Eckert, because Goldstine tried to run things.   But Pender was pretty much removed from the work. He didn't get very many of the details except when he was called in to settle disputes.

STERN: Well, the tension, from my reading, seems to have begun after the finalization of the design, from the summer of '44 on. The summer of '44 was when the design was frozen, when von Neumann became involved, and then September of '44 was when that letter was sent out by Eckert to the other engineers, asking them if they had any interest in claiming patent rights on the ENIAC. This was the letter that so incensed Brainerd. I wonder if you can just give me some direction on that issue.

CHAMBERS: The requirement that a patent be issued on this project was an Army order that came through Goldstine to Eckert, and he was told to write and find out if anybody had any patentable ideas, because the contract required that these disclosures be written.

STERN: So that it is not fair to make the assumption that because Eckert did this, he was interested in making a profit from his inventions.

CHAMBERS: I have a feeling that Eckert, at that point, felt that he did have this interest. I think the Army order triggered his interest. It was about that time that he had decided that he might want to go into this on a commercial basis. That was my impression. I think that the tone of the letter would indicate this. Up until that time he hadn't had any such reason for doing this. But the letter was clearly one to find out of anybody felt that they had any inventions that they should disclose.

STERN: But the directive at that point clearly came from the government-via Goldstine.

CHAMBERS: Yes. He pointed out that the contract required it, and he pointed it out to Eckert. He probably didn't point it out to Brainerd.

STERN: Now, was it appropriate, under those circumstances, for Eckert to have written the letter, or really, should it have been Brainerd's job to do that? Did Brainerd have a right to get as upset as he did about that?

CHAMBERS: Well, I don't know that it mattered at that point. Either one could have done it. Normally, Administration would require the Technical Director to see that the disclosures were written.

STERN: Do you think Brainerd got as upset as he did because of the fact that Eckert was doing something without his express direction or because he felt that Eckert wanted to commercialize on this ?

CHAMBERS: Both, but mostly the first. He didn't like the wording of the letter.

STERN: What was the University patent policy at that time?

CHAMBERS: The University policy at that time by early Trustee action was that except in health related inventions the inventions belonged to the individual with "shop rights" to the University. Several of us among the faculty had patents under this policy. During the war, the government contracts normally required "shop rights" to the government.

STERN: But Eckert and Mauchly left because of the Moore School patent policy.

CHAMBERS: That was later in 1946. When Travis returned from the Navy to become Supervisor of Research, he wanted to be able to offer patent rights by the University to the comp anies sponsoring the research. To be able to do so he sought to have all staff members being compensated from contract funds to sign an agreement to assign any patents to the University as a condition of continued engagement. Among those who refused to sign such a statement were Eckert and Mauchly. The agreement was interpreted by some to require all patents previously invented but not yet issued to be assigned to the University. The old policy was still in effect, even at that time. It hadn't been changed by any Trustee action.

TAPE 2/SIDE 1

STERN: But you would have agreed with the idea that it should be changed--for new projects, but not for the previous grant funds.

CHAMBERS: Probably some changes but certainly it shouldn't be retroactive in any way.

STERN: I see. Okay, I did not recognize that there was a distinction. It's a very important one. Didn't Travis realize

that by pushing this, he was going to lose Eckert and Mauchly?

CHAMBERS: It's only a timing question. He was going to lose Eckert and Mauchly anyhow. They were leaving. But they would have stayed through another six months, perhaps.

STERN: They claim that that's not the case.

CHAMBERS: Who?

STERN: Eckert.

CHAMBERS: Eckert and Mauchly?

STERN: They have reason to claim that because from the point of view of the Honeywell case, it's better for them to appear as if their commercial interest was a result of the Moore School action rather than anything else. But I see no evidence that they were immediately thinking about leaving.

CHAMBERS: You're talking about 1946?

STERN: Right. It's your recollection that their thoughts were elsewhere. I know that Eckert was offered a job with von Neumann...

CHAMBERS: Oh yes, and they were offered a job with IBM and offered a job with RCA. Several companies approached them. Old Man Watson talked to me about trying to influence them to come to IBM. I talked to Eckert about his future. Now, it could well be said that this was precipitated by the Moore School. My belief was that they might have stayed through the initial design of the initial construction work, getting the things moving under EDVAC--but I don't think much beyond that. I know that at that time they got their own patent lawyer.

STERN: It was before this.

CHAMBERS: I'm sure the idea was for them to go into commercial business. In fact, I don't think Eckert at any time had a feeling that he was going to make a career at the university. I don't believe this was true even during the first part of the work. I think he always felt that he was going to be in industry. I'm not sure that he had felt that he would start a business. I think he always intended to be in industry. Mauchly, on the other hand, probably would have loved to stay on in the university. He hadn't been very successful as a teacher, but as a source of research ideas, he was excellent. I don't think he was thinking of industry.

STERN: Eckert negotiated with the Census Bureau for the university. This was during the end of 1945 and the early part of '46, and then when they left the university, they negotiated with the Census Bureau for the university. The was during the end of 1945 and the early part of '46, and then when they left the university, they negotiated on their own behalf. Now, to your knowledge, was it the initial discussions with Census on behalf of the university. I'm not clear on this. This is, the testimony and trial is unclear on this. Were negotiating with the Bureau of Census on their own, all along, or in fact, on a directive from the Moore School that said, "See if you can get a contract with the Census Bureau to do this work."

CHAMBERS: I never heard of any proposal from the Moore School to do any kind of work with the Census Bureau. How a computer might be applied to work on the census may well have been all the discussion was about. It would have been perfectly normal for them, as faculty members, to talk to people at the Census Bureau about the possibilities.

STERN: I read Mauchly's testimony last night, in fact, in which he claimed that Pender had asked him to see if he could negotiate such a contract.

CHAMBERS: He did?

STERN: For the Moore School. But there's no other record of that.

CHAMBERS: I suspect, if anything, this was just a conversation about it, probably. I can imagine Pender talking to Mauchly and saying, "Where can these things be useful? Who might be willing to support work in this? Where can they be used?" And Mauchly saying, "Oh, the Census Bureau might have a need for it." And so on. In other words, Pender may well have said, " You might look and find out where we can get support for it." The Census Bureau may have been specifically discussed.

STERN: Yet, when you say it was perfectly natural for Eckert and Mauchly as faculty members to talk with the Census Bureau over a possible application--do you think they were doing it as faculty members, or do you think their minds were on the thought of having this as their own commercial project?

CHAMBERS: I know this: that they were planning for some time before to sell their rights to somebody. They wanted to commercialize on their patents, on a royalty basis or something. They were looking forward to this. This goes back as far as their idea of getting the patents, back to '44 probably. Probably shortly after they were reminded that patents ought to be filed, the idea of getting a patent came to their minds, and a patent is gotten for commercial reasons, as far as they were concerned. So I suspect it goes back that far. But I don't think that they were planning to be partners in a venture or planning to set up their own operation. They were still validly consulting for IBM.

STERN: Why didn't they plan to a partnership?

CHAMBERS: Well, because IBM didn't want to take it that way. They wanted to take them as employees only.

STERN: That is, they didn't want to actually buy their ideas?

CHAMBERS: They didn't have anything at that point to sell, specifically. After all, what happened was that [Henry]

Straus came along and offered to set them up in business, and this was more attractive than any offer that they got. I'm not sure when that occurred.

STERN: That was later. That was already after they formed their partnership and then their corporation.

CHAMBERS: Then they had somebody, they did have some others, because I remember some shares in their corporation were owned by Sheppard, for instance. They were the ones that tended to back them. Did that start right away?

STERN: No, the only thing that started right away was a verbal commitment from the Bureau of Standards or the Census--on the UNIVAC project. That might have caused them to consider their own company as opposed to going with IBM.

CHAMBERS: Well, that commitment would have drawn anybody. I suppose that they must have been thinking about forming the company after that.

STERN: Getting back to Travis' feelings during this period. It was inevitable that Eckert and Mauchly wouldn't be with the Moore School for very much longer, but yet they could have completed additional work on the EDVAC, and Travis was pushing this issue about retroactive patent rights almost to force them out. Did he recognize that? Did he care?

CHAMBERS: I don't think he cared.

STERN: That seems to me somewhat inconsistent--if he was interested in establishing a large research organization, keeping them would have been a good way.

CHAMBERS: Well, as he was viewing it at that point, he did not anticipate difficulty in replacing anyone. I think he

felt that getting contract support was more critical than getting staff. He could either have contracts and lose a man, or having no contracts to support a staff.

STERN: How did Pender feel about losing Eckert and Mauchly?

CHAMBERS: I don't think Pender thought too much of Mauchly. And I think Pender always viewed Eckert as a student, and never looked forward to having him as a permanent staff member.

STERN: Even with Pender's recognition about the value of the computer research program at the Moore School.

CHAMBERS: Well, I'm not sure that Pender was enthusiastic about the idea of there being a big research undertaking here. He like research, but he didn't want this to dominate the institution. That's what Travis was looking for.

STERN: Then why did he appoint him as supervisor of the research?

CHAMBERS: Well, Travis, of course, came back and he had to have somebody as supervisor of research. In fact, I went down to talk to Travis in Washington before I came back, about taking this position; they had to have a supervisor of research, but to do it as extensively as Travis undertook to do it when he got here, I don't think was what Pender had in mind. He wanted it to be less grandiose.

STERN: Why?

CHAMBERS: Well, because he was always a very, very strong educator, and research is a tool for education--that's what he wanted. Not research for itself.

STERN: Pender had his own commercial orientation--he formed his own corporation.

CHAMBERS: He was an investor and consultant. That's all.

STERN: So you would say, more than anything, he was an educator, and saw the role of the university as one of education as opposed to research.

CHAMBERS: That's right. He wanted research as a required part but not as a big research institute.

STERN: The idea of major research projects seemed to emanate before the war. Why did the government fund such projects?

CHAMBERS: Well, the government funded the differential analyzer, and there were quite a few projects that the government funded of various kinds. But prior to the war, these were done in the sense that they were graduate research undertakings, for graduate students. They were not in business to do research. There's a distinction here. The big research institutes with its professional staff not Faculty and students that were associated with universities, and there were lots of them, was what Pender was not in favor of.

STERN: I still find it difficult to understand Travis' motivations if he really wanted this major research pursuit--electronic computers was one area where you could get an awful lot of funding at this time. Why precipitate a move of the two major people involved in the field?

CHAMBERS: Well, the point is that he thought he had enough staff to handle the EDVAC without them. He didn't need them.

STERN: Do you think Eckert and Mauchly saw themselves as a team throughout all of this, or were they pushed in that direction?

CHAMBERS: They were pushed in that direction. They didn't see themselves as a team. Even at the time when they were being approached about positions, there was no freezing of options. They didn't even look at themselves as a team. At least Eckert didn't.

STERN: I think that Mauchly did. He saw himself as part of a team.

CHAMBERS: I don't know that Mauchly had thought it through as Eckert did. He didn't know what he was going to do. I don't think Mauchly ever really was awfully anxious to go off on his own until they were faced with doing it. I'm not sure he had as many other offers, either.

STERN: Mauchly received an offer from IBM. That's about it that I know of. Well, then, what made Eckert go...Wouldn't he, from his point of view, have stood to gain more from going to work for say, IBM--IBM offered to set up a lab for him. Or even to go with von Neumann at the Institute.

CHAMBERS: Eckert's father was a real estate developer and I suspect that his father wanted them to organize their own company. Knowing his father, I would probably put it down to this.

STERN: Travis said in his interview that one of his major jobs was to straighten out the financial situation that had evolved because of the ENIAC and EDVAC contracts being initially part of the same contract--that the funding of the two were causing problems for the Moore School. Do you know anything about that?

CHAMBERS: Yes, this was true. The workers did not specifically keep track of the project they were working on. They thought of it as the same title. But the contracts listed them as though they were separate projects. There were commitments to finish the ENIAC, terminate that contract. When it was finalized, the work was supposed to have been paid but they ran out of funds, and they were working on the EDVAC too. The ENIAC work was being charged against the EDVAC funds. This was happening. People in the lab didn't know the difference, they charged to where the money was. So that money had been spent on the one without the other. So one problem was getting more money to finish the work on the ENIAC's testing and so on; it was quite a problem negotiating with the Army, and

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also a problem of separating the charges that had been made to the two. This was a big problem, because the EDVAC was just getting started. A problem of getting government to support for one and continue with the other. And he had to straighten it out. No question about it. This is what he left for me, and I had to get out of this one... Three EDVACs is what we agreed to do. We got contracts--I think it was $90,000 each, or $97,000 or something--the total cost of EDVAC. It turned out that by the time I got back into it after Travis left, the funds were all gone, and the EDVAC wasn't finished at all. We were in real trouble, and we had a commitment to have an EDVAC built for the Signal Corps as well. We had an awful time getting that done.

STERN: Now I understand. I could never understand the reference to EDVAC 1.5. I guess that's one of those EDVAC's you were talking about.

CHAMBERS: I think it probably was a technique to change the contract from an EDVAC 1 to an EDVAC 1.5. That's the kind of activities that you tried to devise to make the contract legal.

STERN: You organized those Moore School lectures in the summer of '46. What was your motivation in that regard?

CHAMBERS: Well, it was an opportunity to tell the world what we'd been doing, and it gave a lot of people training. Many institutions had wanted to send visiting scientists to learn about our work, far more than the Moore School could handle. The course solved this problem for us. The enrollment was limited to one per institution so that the knowledge could be spread as widely as possible.

STERN: So it was kind of an effort to put the project on the map, even more so than it was at the time. The Moore School already had pre-eminence in the field of computer?

CHAMBERS: To let the profession know what we had accomplished industry and researchers jumped on the bandwagon at that point. That was my philosophy, at least. For our students and our people sow the seed in other places was the best thing for the Moore School to do.

STERN: The best from an academic point of view that is.

CHAMBERS: That's what we were for.

STERN: Also, do you think it is unprofessional or unbecoming for academic people to be interested in the commercial rights to something? Or is this entirely natural?

CHAMBERS: Well, I think from an engineering standpoint it's unfortunate that they are not more so. This is a tangible aspect of engineering, which is supposed to make things useful, make knowledge useful for people. This is also a part of the corollary--that is, the educational institution shouldn't be the entrepreneurs. I felt we shouldn't build any more computers. Our predominance continued for a long time, student wise. The number of computer developers that came out of here in the early computer days is more than any place else. No other institution did anything like we did, from that standpoint.

STERN: After awhile it should become an industrial pursuit, you think.

CHAMBERS: It should be industrial, yes.

STERN: And you believed that engineers should be interested in the commercial application of their work even if they are working at academic institutions.

CHAMBERS: Over the history from the second world war until about 1970. Over the history since the second world war the demand that faculty be decorated by the Ph.D. has moved engineering education at the higher levels, progressively, toward research investigations where the goal is aimed at other Ph.D.'s without follow-through to mankind utility let alone commercial or industrial utilization. When a new Ph.D. becomes a faculty member and guides a brilliant student through a Ph.D. program to become a new faculty member, be becomes even further removed from

the real world of industry.

CHAMBERS: Faculty members who are second and third generation Ph.D.'s, are not engineering-usefully directed. Once you've got your Ph.D., you keep on doing the same thing you did before-not doing it for applications. In this way, engineers were being lost. That's what I was preaching throughout the '60s. That we should start to get people more involved in useful pursuits and useful knowledge, and not just knowledge for knowledge's sake. And I think it's taken hold. I think it took hold because of the reduction of research support in academic institutions. It's harder to get jobs in pure research, so they went into industrial research.

STERN: What about the problems that are realized from something like computer development which began as a wartime pursuit. There was kind of a secrecy surrounding the whole thing to begin with, and then that secrecy is lifted, as it was in '46, and then you have people interested in doing industrial work; they're concerned about patents and priority, and they too place secrecy on the developments. How do these ideas get disseminated if everybody is so close- mouthed about what they're doing?

CHAMBERS: Well, it's surprising how little close-mouthed it is. I mean, what happens is there is a time before papers get published about something they're doing--but the dissemination in conference goes on anyhow. And most companies don't have a secrecy operation which is the equal of the wartime secrecy. The duration is seldom more than six months.

STERN: I gather that one of your motivations, when we talked about the lecture series, was to do that kind of dissemination. At the time, in fact, there were people that complained they didn't know what someone else was doing.

CHAMBERS: Well, yes. There were people who didn't know anything about what was going on. To do it in papers

would have been slow. Awfully slow.

STERN: And particularly in a field where changes are so radical--by the time the paper is published, the idea is obsolete. Did you ever talk with Eckert and Mauchly after they left the Moore School?

CHAMBERS: Not very often and less in recent years. I haven't seen Eckert for so long now.

STERN: I meant more specifically-not in a formal way with respect to the university, I know that they came back to give lectures at the Moore School, during that period. But aside from that.?

CHAMBERS: They came back; we had lunches.

STERN: Right. Aside from that, there was no further contact between Eckert and Mauchly and the Moore School?

CHAMBERS: Well, Eckert was on the Advisory Board for Research in the University-Graduate Studies. He served in various capacities of that kind; not very diligently, but he's done it. Once in a while, not very often. And Mauchly's been around. I talked to Mauchly about the possibility of coming back on the faculty when he decided to get out of Sperry Rand, I talked to him about the possibility of coming here. This was back in 1958. I don't know what you're getting at. The contact had been normal.

STERN: There wasn't any over-riding friction after they left.

CHAMBERS: I don't know that there was any formal relations. I'm not sure how many. I know I visited their facility at times, I saw their work on computers in the early days, and talked to them about it, and they showed me all the new ideas and so on. Yet there wasn't any specific coming back. I think some of the people working on the delay lines talked to Eckert about some problems, but I don't think there was any formal ascensions. I'm not sure I know what you're trying to get at.

STERN: Okay. Let me say this --how did the Moore School learn about important new developments in computing after '46?

CHAMBERS: There has continued to be an active group working in computers with ties to industry and other institutions. This became a very active business in the technical societies pretty soon thereafter so that the technical society relationship and the contacts was the biggest way for that to happen. Former students visited the school from time to time.

STERN: Conferences that are held by societies and that kind of thing?

CHAMBERS: There was the organization of an Institute or Society for presentation of papers and discussion.

STERN: ACM?

CHAMBERS: No, that was later. I think the first one was a mathematical group.

STERN: Society for Industrial and Applied Mathematics? SIAM?

CHAMBERS: No. I guess it was SIAM. A lot of system work was done. Patterson's work was sometime presented through SIAM. That society was very active. And of course, we've always had some computer conference here.

STERN: You mean informal discussions or arrangements for other groups. I have a sense again that there was a difficulty in communication between groups at this point. And that the government made an effort to bring groups together by distributing reports and so on.

CHAMBERS: I would not say that was true.

STERN: That there was a difficulty--or that the government assisted?

CHAMBERS: I have no feeling of a difficulty of getting an exchange of ideas. You must remember you're talking about a more complex unit of work; I mean, the individual computer, as a computer, is a highly complex device. It's much more complex from a technical standpoint than almost any other device that had been in use before. As a consequence, unless you have hands-on activity with a computer, it's only little pieces of it that you can get by talking to somebody. Communications about computers was not like a little letter to the editor telling him about a new discovery in physics. A new procedure in computers could change the way you carry out the memory, and why you have to change the way you do addition. The whole system is changed. All you can tell about is the change in one thing, and then a knowledgeable person has to sit down and work it out himself to figure out how that affects everything else. But I don't think there was any organized attempt to block this.

STERN: No, I didn't think so much that it was organized. I just thought it was, by its very nature, just difficult.

CHAMBERS: Well, it is. Because of the complexity of the thing that you're talking about.

STERN: Right. In the spring of '47, there was a meeting back here at the Moore School in Dr. Pender's office. Among those present were von Neumann and Eckert and Mauchly. The patent issue regarding the EDVAC was discussed. I think you were at that meeting. Could you give me some information about that meeting?

CHAMBERS: Well, this meeting was requested by the Army patent lawyers. He made the statement that he didn't care whether his ideas were patentable or not; he didn't want to own them anyhow. The Army and Eckert and Mauchly were very anxious because their filing date deadline the middle of June was fast approaching so they wanted to get it cleared up so they could go ahead and file. The Army was trying to find if there were patent applications to file other than those of Eckert and Mauchly.

STERN: Before the meeting there was some concern on the part of the Moore School and on the part of von

Neumann that the Army was partial towards Eckert and Mauchly in this regard, over the patent issue. Do you recall

anything about that?

CHAMBERS: I think this was that the patent people wanted to be sure, or to find out what the feeling was with

regard to the rights of other people in these patents.

STERN: But you don't think they were particularly partial towards Eckert and Mauchly?

CHAMBERS: I didn't get any sense of that.

STERN: That's a letter written by Jules Warshaw to Travis or Pender, I'm not sure which, saying that von Neumann

made this accusation and it was his sense that it was correct.

CHAMBERS: Warshaw sense that it was correct?

STERN: Yes.

CHAMBERS: It wouldn't have been Warshaw. That would have been Travis who said that.

STERN: Warshaw signed the letter anyway.

CHAMBERS: I know. Now, Warshaw was only signing the letter for Travis. That was all.

STERN: If von Neumann was not interested in the patent rights, why did he bring an attorney to that meeting?

CHAMBERS: This is typical of him. He didn't say that he did not have patent interests. He said that he didn't want

to own any patents.

STERN: Obviously. But I wish he were here so I could ask him that particular question. But it seems totally inconsistent that he can make that statement and yet have brought his own attorney.

CHAMBERS: This was not a very pleasant meeting.

STERN: I read the minutes. A very interesting meeting. The outcome as I understand it, was that von Neumann would make no disclosures because he was not patenting anything, and they asked Eckert and Mauchly if they would make disclosures to von Neumann so he could judge whether he had any rights, and they said they would consider it. And that was it. But I don't think they ever did it. It that correct?

CHAMBERS: I don't know whether they did or not. I have no knowledge about it later. But I don't know that they promised to do that either.

STERN: I think the minutes do reflect the fact that Mauchly said, "Well, I'll think about it" or something like that. "I'll consider it," I think he said. Which--my sense was that it was more a way to terminate the meeting than anything else. But it was certainly acrimonious. I mean, you would say that?

CHAMBERS: I'm sure it was.

STERN: From the period in which Eckert and Mauchly were at the Moore School, do you think I've left out any major areas of consideration?

CHAMBERS: I don't think so. There was a whole group of other people that were later involved in the operation, the discussion. The only person of those that I know of that had any serious question with regard to his rights was Sharpless with regard to the delay line memory. I think that's the only one that might have made any possible issue.

To what extent this was an idea that he had worked on or had been assigned by Eckert, and how much he had done himself, I don't know.

STERN: How about Burks?

CHAMBERS: Well, Burks was a good organizer, a good detail person. He helped a good bit with the programming, designed layout and so on. But he was not very inventive. He was assigned aspects of the project. It was typical that he was chosen to write up a report of the meetings on the design of the EDVAC.

STERN: Travis had told me about some friction between Mauchly and Burks that I have no idea about at all. Do you know anything about that?

CHAMBERS: They weren't too friendly. Mauchly's lifestyle was little liberal and Burks' was a little bit prim, and it may well be that the lack of friendliness was due to this. I don't know of any time when there was any specific problem.

STERN: What do you mean by "liberal" lifestyle?

CHAMBERS: Oh, he was just as likely to work from midnight to 10 o'clock the next morning as he was to work at any other time.

STERN: I see. Liberal lifestyle today has a different connotation.

CHAMBERS: I think the other kind of connotation also was there, to some extent. On the other hand, Burks was clearly a well ordered person, in the opposite sense. So there was no real friendliness between them. I don't think Burks was ever as deeply, emotionally involved in research.

STERN: Well, I've got to talk with him, but it seems to me he must have had some motivation for coming to the Moore School to begin with.

CHAMBERS: Well, he was a unique member of the team. He was not a mathematician or a physicist. He was a philosopher. He came with a Ph.D. with a philosophy major. I think he was doing this because he thought philosophy was not going to contribute to the war effort, and he wanted to get knowledge of something where he could be useful for the war effort. This is the motivation. At the end of the war, he wanted to go back to philosophy, and wanted very much to go to the Department of Philosophy here. But this time his philosophy had been associated with the logic questions and logical computers and so on, and the Philosophy Department here tended toward history of philosophy at that time so there wasn't any sympathy. It was for this reason he went back to Michigan--to the Philosophy Department there.

STERN: He went with von Neumann for six months or so.

CHAMBERS: That was just a stopover.

STERN: I wonder why he did that?

CHAMBERS: Well, I think this was to help von Neumann with his project.

STERN: You don't think there was any intent to stay there for any extended period?

CHAMBERS: I don't think so. That may have been a possible idea of staying at the Institute, I don't think so. I think he wanted to get back into philosophy.

STERN: Do you think I've touched all bases as far as you're concerned?

CHAMBERS: I think so. Of course the picture of Eckert and Mauchly after they left the Moore School is very interesting but the computer industry itself with respect to the competition between companies is really a very interesting one.

STERN: I'm at the point now where I'm working on their Bureau of Standards involvement, and it's hard to find people who were involved from the other perspective. That is, the Bureau's perspective, or the Census' perspective.

CHAMBERS: Well, there weren't very many of them in it. That list of members must have gotten through the trial--or one of the trials. The list of people that attended that class. I've always intended to try and look that up, and find out what became of them. There were people in here from the Bureau of Standards; there were people from several agencies.

STERN: [John] Curtiss gave a lecture.

CHAMBERS: Curtiss. There was somebody else from NBS--Sam Alexander, yes. He was, I remember, the best one down there. He was senior to Curtiss, wasn't he?

STERN: No, I think he ran one of those labs for Curtiss.

CHAMBERS: That's right. Anyhow, he was the one that knew more about computers than anybody else. I always thought he was good. We had some people that weren't on that list, too, that came in for part of it. For instance, [Jay] Forrester came down for part of the course, to sit in on it.

STERN: Well, from the work that's been done on Whirlwind, they claim that that course was one of the foremost factors in changing Whirlwind from analog to digital.

CHAMBERS: Oh, yes. Forrester had been down, I think, before the course too, to see it. But there were some

people from Forrester's Whirlwind lab who were down to go through the whole course; maybe one or two, if I remember right. And Forrester himself came down for some of the lectures. But I don't think he was involved. I think he was just a sit-in.

STERN: The course was funded by ONR and Army Ordnance, I believe. Is that correct?

CHAMBERS: I thought we still got most of the funding out of the Engineering Science Management War Training (ESMWT) program.

STERN: Well, I read the transcript of the Honeywell trial and your testimony said that that had run out in the spring. You were hoping to use that funding.

CHAMBERS: I guess that's right. We organized it under that funding and then ran it under the other.

STERN: But you had no difficulty getting government funding for it?

CHAMBERS: I don't remember. No, I'm pretty sure we didn't have any trouble. It was a good group. An awfully good group. It was an awful job to try to get the books out about it. The publication that is. It was hard. In fact, I don't think I even have a copy.

STERN: There's a copy downstairs in the Moore School Library.

CHAMBERS: Of the whole thing? I wasn't sure that they ever had it. Well, somebody's dug them out of the archives.

STERN: Some of them are just abstracts because you couldn't get all of the papers.

CHAMBERS: Yeah, some of them. We couldn't get it all-we used wire recorders, and they weren't very good. Not

like these.

STERN: Okay, Dr. Chambers. Thank you very much. I appreciate it.

CHAMBERS: You're very welcome.

END OF INTERVIEW