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Interviewee: Howard Campaigne
Interviewer: Richard R. Mertz
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MERTZ:

This is an interview conducted by Richard Mertz of Dr. Howard Campaigne in Washington, D. C. in the office of Professor Mertz at George Washington University on July 9, 1970.

CAMPAIGNE:

Well, I was born in Chicago, Illinois in 1910; lived there most of my youth; went to Northwestern University, where I got my Ph.D. in 1938; taught at the University of Minnesota until World War II came along; then went into the Navy, where I was engaged in various kinds of intelligence operations; stayed on as a civil servant after the War; am still at the National Security Agency.

MERTZ:

Would you care to expand a little bit on your earlier education? Did you attend high school in Chicago?

CAMPAIGNE:

Yeah. I went to Lindblom High School in Chicago where I graduated, and Northwestern was a nearby school. In those days you didn't have to look very far to get into a school. It's the only one I applied to.

MERTZ:

Did you specialize or major in anything in high school?

CAMPAIGNE:

Yeah. I had a science major in high school.

MERTZ:

Did you find that the training that the high school offered you was quite good, perhaps, or was it about the same that you might expect anywhere?

CAMPAIGNE:

Well, I only went to one high school, so I can't compare them; but I think that the science training was good. It interested me in science. I had a general science student as teacher who was very stimulating, and I had a chemistry teacher who was also very stimulating and got me interested in chemistry. When I went off to college I majored in chemistry, but subsequently found that mathematics was easier. So, in graduate school I changed to mathematics.

MERTZ:

So you went off to Northwestern with the intention of going into chemistry?

CAMPAIGNE:

Right. In fact, I did go into chemistry because I had summer jobs as a chemist, at least two summers as an undergraduate, and I finished the major.

MERTZ:

About when did you graduate from high school?

CAMPAIGNE:

1928 I guess it was, yeah. Or maybe it was '29. It was February '29, actually.

MERTZ:

You mentioned that Northwestern was more or less the obvious and logical place to go because it was near where you lived.

CAMPAIGNE:

Well, that's not the only reason. I had a friend who went there, and he started there a year before I did.

MERTZ:

I see. And he sort of encouraged you to go there?

CAMPAIGNE:

He did indeed, yes. Yeah. My chemistry teacher's name was Parsons, and he subsequently was at the University of Chicago, and then the City of Chicago organized

a--or expanded their junior college into a full college, and he's been very influential there. I suppose he's out now, but he--

MERTZ:

But he was one of the influences. And then you mentioned another friend of yours who had gone to Northwestern the year before.

CAMPAIGNE:

Right. Yeah.

MERTZ:

Was he also a science major?

CAMPAIGNE:

Yes. He was pre-med.

MERTZ:

Now this was before the Depression, actually...

CAMPAIGNE:

Well, it was at the start of the Depression. I started college in September 1929, and sort of October 1929 some of my colleagues had to drop out because banks failed and their tuition disappeared, and that's when things started to get tough.

MERTZ:

Did that have any particular impact on your education, slow it up, or--

CAMPAIGNE:

No, not really, no. My father was able to support me through college, and so I continued right on through. I suppose it made a difference about summer jobs and things like that, although I did have summer jobs.

MERTZ:

But you had had summer jobs, I gather, before you went to—

CAMPAIGNE:

That is correct. Yes, I did. As a chemist.

MERTZ:

And those did continue on through the Depression years?

CAMPAIGNE:

Well, not every summer. Two of the three summers I did get chemistry jobs, and the other one I worked at the World's Fair in Chicago.

MERTZ:

Was that in '33?

CAMPAIGNE:

Yeah, '33. '32 and '33.

MERTZ:

They had a big science exhibit there, didn't they?

CAMPAIGNE:

Oh yes, they did. Yeah, that was, let's see, that was called "A Century of Progress," and it started on the 40th anniversary of the previous World's Fair which had been in 1892, and it was continued for two years. It was in '32, I think, that I worked there in the summer.

MERTZ:

Were you a guide?

CAMPAIGNE:

I was a guide, yes.

MERTZ:

And at that point you were what? A senior?

CAMPAIGNE:

Yes. I was entering my senior year.

MERTZ:

When, roughly, in your undergraduate days did you more or less come to the conclusion that you weren't going to go on in chemistry?

CAMPAIGNE:

I think it was in my senior year, the last few months of my senior year, I decided to go into mathematics.

MERTZ:

Normally, in most curricula in universities the amount of mathematics that is required to go into chemistry is not much beyond, at the most that needed for physical chemistry, which is differential equations.

CAMPAIGNE:

That's correct. Yeah, I took more math. I had, in fact, completed a major in mathematics, but only because it was an easy subject to take on the side.

MERTZ:

I see. So you actually had two fields.

CAMPAIGNE:

I had two majors. In fact, I almost had three. I was just short two hours in the English Department of having a major. Actually I didn't have the right courses to complete a major.

MERTZ:

But the hours you had.

CAMPAIGNE:

I had almost the number of hours, yes.

MERTZ:

And then when you graduated, did you graduate in the spring?

CAMPAIGNE:

Yes.

MERTZ:

Of?

CAMPAIGNE:

Of 1933.

MERTZ:

'33. Did you then go to work that summer?

CAMPAIGNE:

Well, in the summer of '33--I had made application for scholarships, graduate scholarships at several schools, and during the summer I didn't know what the status would be. I hadn't been told. But I did sort of, like the first of August in '33, I did get a scholarship from the University of Chicago, and also another one from Northwestern University. The one at Northwestern was a tutorial fellowship which involves teaching, some tutoring, and I took that one because I got more out of it. So I entered, went back to Northwestern and in the graduate school, and I finished my master's degree that spring.

MERTZ:

What field of mathematics interested you the most at that time?

CAMPAIGNE:

Well, I really didn't know. When I was going to go to Chicago I thought it would be in mathematical physics, but, in fact, I wrote my thesis, my master's thesis, on analysis under Simmons. And then, when I came back the following year and started looking for a Ph.D. subject, Hubert Wall had a new [topic]: hyper groups that he'd ... invented, and had published a paper on and he put me onto that. And I did a lot of reading in group theory.

Actually Reinhold Baer was supposed to come to Northwestern that year, and I had thought I was going to ask him for a thesis subject, and I spent the summer reading a lot of group theory. And so this tied in with Wall's thing. Baer didn't go there. He went to the University of Illinois after all, so he never showed up.

So I started with Wall, reading on these hyper groups and studying them. The following

year Wall went off to Princeton University on a sabbatical for a year, and he wasn't there, so I finished with Miss Griffiths, who was the algebraist there in the [department]. I had already gotten some results, and I managed to get a good result to build a thesis paper on, so I finished my Ph.D. in '38.

MERTZ:

What was the subject of your Ph.D.?

CAMPAIGNE:

Hyper groups. It was called "Some Properties of Hyper groups." Hyper groups are things where you have a multiplication which isn't unique. You get several products out of it. And one of the basic problems at that time was: Can you build these up out of ordinary groups? Can you represent them in terms of ordinary groups? And I was able to show that you could not. Not by the methods that were then used. So I had a counterexample which made a central thing for the thesis.

Then, of course, I started looking for a job and—

MERTZ:

'38. Now this was still—

CAMPAIGNE:

Still in the Depression, sort of—

MERTZ:

The end of the Depression.

CAMPAIGNE:

Yeah. And I wrote a lot of letters to a number of universities and colleges looking for jobs, and I think I sent out forty-two letters or something like that. And I got answers for about twenty-one of them, and I got three offers of jobs.

MERTZ:

Hm. That's not bad.

CAMPAIGNE:

I know.

MERTZ:

Considering the state of the—

CAMPAIGNE:

Yes. I took one at the University of Minnesota, which was the first of the three that was offered. The others were roughly comparable. In those days a young Ph.D. could get 1800 dollars a year as an Instructor. And there were a few jobs at a little bit more. And there were some jobs that were less. Some people got 1400 and 1500.

MERTZ:

With a Ph.D.?

CAMPAIGNE:

Yes. Well, I think a good Ph.D. could get 1800. He could sort of count on getting that.

MERTZ:

Of course, 1800 dollars went a little bit farther then.

CAMPAIGNE:

Oh, it sure did. In fact, it wasn't an uncomfortable salary for a young man at all. It was fairly reasonable. So I went off to Minnesota and—

MERTZ:

Excuse me. This was in the fall of '38?

CAMPAIGNE:

This was in the fall of '38. Yes. And I stayed there in the, the--it turned out that Minnesota had two mathematics departments. One was in their Engineering School, and one was in their Science, Literature and Arts School; and I was in the Science, Literature and Arts. And I taught there until '41, when things started getting exciting in the World War. I had to register for the draft, which was quite upsetting for any young man, so I started looking around as to a soft place to land. And one of the things I was interested in was the possibility of constructing a cipher machine. It was based partly on the algebraic theory of Hill, and I recognized that the theory wasn't any good unless you had some way of mechanizing it. It just was impossible to do by hand. Now, Hill recognized this, too, although he didn't say anything in his publication because I only recently found out that

he got a patent on a device back then.

Well, anyway, I got a little money from the school to pursue this, I got the help of an engineer and we drew up some drawings and plans for this, and I sent it off to the Navy inquiring if they were interested.

MERTZ:

This was in 1940?

CAMPAIGNE:

This was about 1940, yes.

MERTZ:

Excuse me. You were teaching then in--I take it, the math department in the Engineering School of Minnesota was applied math more or less?

CAMPAIGNE:

Yes, that's correct.

MERTZ:

And since you had done your doctorate in algebra this was sort of theoretical--and the theoretical department of mathematics was in the other school. Is that a fair breakdown?

CAMPAIGNE:

Yes, I guess that's fair. The fact I was in Science, Literature and Arts was probably an accident. I, perhaps, could have been in the other department. In fact, some of the people, some of my colleagues did transfer from one department to the other at one time. Just why I don't know.

MERTZ:

Did you have a full teaching load of—

CAMPAIGNE:

Yes, I had a full load. Yeah, fifteen hours, actually.

MERTZ:

Well, were they undergraduate and graduate courses?

CAMPAIGNE:

Yeah, they were nearly all freshmen and sophomores. They had a requirement there which brought in ... lots of sections of trigonometry and beginning algebra and analytic geometry. I taught a course in group theory one year which was sort of challenging.

Anyway, when I wrote to the Navy I got a letter back from what was then Commander Safford, L. F. Safford, saying, you know, thanks for my interest, but no thanks, they didn't have any need for that. But if I were interested in analysis of cipher systems, why, they might be interested. And if I would reply positively they would send me a correspondence course that they had organized. So I wrote and said "yes." And they sent me a correspondence course, which just consisted of a lot of problems. There wasn't any theory or anything, just a lot of problems. But they were challenging and interesting problems.

MERTZ:

Were they cipher problems?

CAMPAIGNE:

Yes, ah, yeah. All cipher problems. They were just puzzles, really, because they were possible to do. And I went through that, and finished the whole course of twelve assignments. And then they sent me a letter and said maybe you'd like to take our second course. And I--

MERTZ:

Excuse me. Roughly when was this?

CAMPAIGNE:

Yes, this would have been now in the early months of '41.

MERTZ:

Ah.

CAMPAIGNE:

And I said fine, send it along. And they sent it along. And these were much tougher problems, but I had finished three assignments when I got a letter suggesting that they would like me to apply for a commission in the Naval Reserve. And I acquiesced, filled

out the forms and sent them in. And that would have been some time maybe around June of '41. And then, of course, there was a long silence and nothing happened. When Pearl Harbor hit the news, a few days later I got my commission in the mail. It was dated the fifth of December, two days before Pearl Harbor.

Of course, now they were mobilizing, and so I went right down to the Naval Reserve establishment in Minneapolis and took my oath of office, which was the day before Christmas in '41; and by five days after New Year's I was in Washington.

MERTZ:

[Laugh]. Moved very fast.

CAMPAIGNE:

Yes, I moved pretty fast.

MERTZ:

Did you, during the summers when you were at Minnesota, did you teach?

CAMPAIGNE:

Yes, I taught summer school some of the summers. I don't remember whether it was all of them or not.

MERTZ:

So you were doing this course for the Navy on the side.

CAMPAIGNE:

Yeah, in the evenings. Looking back on it, it looks like a lot of fun. It was kind of hard work at the time.

Well, when I got into Washington I discovered that they admitted they had slipped in my case. It had become their recent policy to offer commissions to anybody who had completed as many as eight assignments in the first course. But in my case they hadn't--I hadn't noticed it go by, and I had gone much farther than most of them before they actually made good on it. Nearly everybody who was coming in then had come in the way I had. They had somehow or other been recruited to take this course, and having shown an aptitude they were offered a commission. And, of course, people were arriving all the time. And in those early days of the war they had no schooling. They just put people to work. I reported in on Monday morning, the 5th of January, and they said, having done some paperwork, "come back at midnight." So I had a few hours to try to

find a place to live, and at midnight I reported in to work. And sat down at a desk with a lot of people and started going through these things to find out what I could. And a lot of people were doing the same thing. Every day there were newcomers, and a man who had been there a month was an old timer.

MERTZ:

[Laugh]. I was wondering how--to go back just a little bit: your interest in designing a mechanical device at Minnesota. The University supported the project. Was this through the engineering school?

CAMPAIGNE:

No. Let's see. I'm not just sure who it was. They had some money to use for research, and they gave grants to people who had projects that seemed to need it. And they gave me something like 400 dollars to use to get the help of an engineer, or a draftsman I guess he was. You might call him. And he was very helpful. His name was Beveridge.

I had a plan laid out, and what I thought he should do was make drawings of this. But he said, "Gee, you know there are easier ways of doing what you want to do." And he introduced me to stepping relays, which were not as fast maybe, but were easier to, more flexible to combine. So we had a second plan.

MERTZ:

But he had some engineering training...

CAMPAIGNE:

Oh, yes. He was an experienced man. He just did this to earn a couple of hundred dollars on the side.

MERTZ:

Did you ever later find out why there was no particularly great interest in your--in your product?

CAMPAIGNE:

Yea, sure. There were several reasons. One is, of course, that they had a stable of equipments of their own which were considerably more sophisticated than mine. The Hill system, which keeps being brought up, has the disadvantage that it multiplies errors. If there is an error in transmission, the deciphering process will multiply this. So it's vulnerable to transmission errors, which, of course, is the situation most of the time. Therefore, it's of only limited usefulness. And besides that the Navy is inundated with

screwball ideas which are very naive all the time. It turned out in the end –

MERTZ:

But that wasn't so. Obviously it wasn't evaluated by--whoever read your suggestion didn't quite evaluate it as a completely screwball idea because they did, well, encourage you to take the course. I imagine they would not have done that to everyone.

CAMPAIGNE:

Perhaps not, I don't know. It turned out toward the end of the war they did use the system. But they revised again--they designed their own mechanism for it. And they had a very special application where it was quite useful. Not a very general one, but --

MERTZ:

So actually it did see the light of day.

CAMPAIGNE:

In a way it did, yea.

MERTZ:

Who would you say, among the people in the field of mathematics at Northwestern in the instructional staff, or those later who were among your colleagues at Minnesota, were--were there any that you feel you could single out as being important influences on you at this time?

CAMPAIGNE:

Yeah, I guess so. Wall, Hubert Wall, at Northwestern, of course, who started me on my thesis, was a considerable influence. He is at the University of Texas now, has been for many years. E.J. Moulton, who was the chairman of the department at the time I got my degree, and who was dean of the graduate school at the time that I got my first tutorial fellowship, was always favorable to me. I think it was because he was dean that I got that fellowship. I had taken a course under him. He's a mathematician. So--and the last I heard he was down at the University of Miami. He's getting to be an old man--ninety years old or so. The last I saw him was a year and a half ago, no, two years ago, at the national meeting of the ... Mathematics Societies at Cornell.

At Minnesota, R. W. Brink was the head of the department when I left there. He was not the head when I came up. Hart, William Hart, was the chairman then. And Brink, Brink was always a very friendly fellow and nice to deal with.

MERTZ:

And how was--do you recall how your interest in ciphering machines was stimulated? Was it by the Hill—

CAMPAIGNE:

Yes, it was. When I was at Northwestern there were some old copies of the Mathematical Monthly in the office that I occupied. And I looked through them and was reading through them, and there was this paper by Hill. And I was struck by the possibility of mechanizing it. So I later devised a scheme.

MERTZ:

And aside from the fellow, Beveridge, who did help you with the drafting and some of the engineering parts of the problem, there weren't any others who were particularly influential in channeling your interest or focusing your interest in the academic world. It came largely from the Navy.

CAMPAIGNE:

That's correct, yeah. Right, yeah.

MERTZ:

Did they give you--I take it, they didn't charge for this course?

CAMPAIGNE:

No. No, there was no charge.

MERTZ:

And did they give you a diploma or anything when you finished it?

CAMPAIGNE:

I don't remember. [Laugh]. I don't remember. They may have. I should think they would have. I don't recall. It was very interesting. In the second course there was a very interesting assignment. The third assignment had consisted of four problems, and the introduction said one of these four problems cannot be worked, it's not possible. And I was still on that assignment when I reported to Washington. But among some of us who had gotten that far somebody found out that it could be worked and did work it.

MERTZ:

Ah.

CAMPAIGNE:

There were a couple of ways, and they were each exploited by several of us in different ways of doing it. But it was, in fact, solvable.

MERTZ:

So actually whoever had designed the course was in error.

CAMPAIGNE:

Well, he wasn't much in error because it was a difficult, very difficult problem. In fact, it was a bit of cipher which had been used by the Navy only a couple of years before. It was something that had been thought to be unbreakable,

MERTZ:

Aha.

CAMPAIGNE:

Or very difficult to break at the time. It turned out to be easier than, than—

MERTZ:

Than they thought.

CAMPAIGNE:

Yeah, than they thought. In fact, they had already found out that it was easier when I got there. And there had been considerable consternation about it because there were some people who were depending heavily on that type of system.

MERTZ:

You mention, at this particular point there was no formal training. It was sort of chaotic.

CAMPAIGNE:

Yeah, yeah. A month or two later the Navy organized what they called Indoctrination Schools, and all the incoming officers went for six weeks or so to school and learned to salute and learned where the regulations are and a lot of things that I had to learn by picking them up.

MERTZ:

What the uniform was.

CAMPAIGNE:

Yeah, right. Right.

MERTZ:

I gather a number of these people had never had any exposure to military life at all.

CAMPAIGNE:

That's right. That's correct.

MERTZ:

Well, did you find--at this particular point things were quite informal, I gather, and rather casual in the sense that a lot of new people were coming in—

CAMPAIGNE:

That's right. There was a lot of--In fact, I remember vividly one incident. The senior officer in this group that I was assigned to in the Navy Department, in the Main Navy Building, said to a couple of enlisted men, he said: "Take this table and carry it down the hall, and when nobody's looking just set it down and leave it."

CAMPAIGNE & MERTZ:

[LAUGHTER]

MERTZ:

This is the way you dispose of property. Well, I gather within a reasonable length of time things had sort of shaken down.

CAMPAIGNE:

Yes.

MERTZ:

You might want to describe your interest in computers. Perhaps in relation to one aspect

of the prototype of the digital computer, and that is something which could store data, which one could retrieve and perform operations on. This is one aspect of a, of, certainly, the later development, high speed electronic digital computers

CAMPAIGNE:

Yes, indeed.

MERTZ:

which would have some bearing on perhaps your experience as early as when you were getting initial involvement in these—

CAMPAIGNE:

Of course, one of the things that was already under way when I arrived was to use card-operated tabulating equipment to do some of the manipulations. The IBM and I guess others. Powers equipment both were on the market then. You could get these card operated things.

MERTZ:

They had limited columns, didn't they? Excuse me, I just wondered.

CAMPAIGNE:

You mean Powers had limited col—

MERTZ:

How many columns?

CAMPAIGNE:

Yes, Powers has ninety columns and IBM had eighty. ... I've got one right here.

MERTZ:

Haven't changed all that much.

CAMPAIGNE:

No, they haven't, they haven't changed at all, as a matter of fact. There're 80 columns. They're numbered, see there.

MERTZ:

Ah yes, right.

CAMPAIGNE:

Well, none of these equipments had any memory, or what they had was extremely limited. For instance, perhaps they could hold in a buffer the contents of one card between reading it and acting on it, but that's all. And this was a great [handicap].

So, some of our ingenious people were looking for ways to augment this, and they did add relays to tabulators in order to do some special functions. We put what we call a relay gate on the back--and there'd be a number of relays and ... plug boards. Now, IBM itself had some special functions on things, so they had plug boards, so you could do different things.

MERTZ:

On their tabulating and collating machines, didn't they have some?

CAMPAIGNE:
That's right. They did indeed. These did not supply any memory, but they did supply functions. And we put in some relay devices on which was some memory. And, of course, this is very expensive, slow, and by present standards it's an incredible amount of money, but it was something. And we were able to do some functions that way. So there was already being built up a certain amount of extension of the art in this direction of memory.

And as I mentioned to you a couple of weeks ago, Captain Wenger, who was then a Commander, when I came in, Commander Wenger had been active in trying to recruit more resources in this direction. He had been up to see the IBM Company itself. He had been to MIT and talked to Bush. He had aroused Bush's interest, and Bush had gotten some graduate students on this, and they had, in fact, built a device which was supposed to do this kind of comparing and searching data for patterns and repetitions and things like that, which we called the Bush machine.

MERTZ:

Do you happen to recall any of the graduate students who were involved in that?

CAMPAIGNE:

Yes, one of them was John Howard, and one of them was Larry Steinhardt, and another one was John Coombs. And there was a fourth one who I just don't remember. I don't know that I ever knew him.

John Howard and Larry Steinhardt and John Coombs subsequently came into the Navy, and got commissions, and participated in all sorts of activities. But they first came down from Boston to sort of look at this machine and get it back to working again. It was, of course, the first model. It had gone through no development cycle at all. It was very fragile, always getting into difficulties, you know, things going wrong with it. Subsequently Steinhardt, after he came down on active duty, overhauled it and took a lot of the functions off it so as to increase its reliability, and that did work.

MERTZ:

Excuse me. Is Steinhardt still around?

CAMPAIGNE:

I don't know where Steinhardt is. The last I heard he was in San Diego at Convair where he was making special purpose cathode ray tubes, like the CHARACTRON. He's an optical man by training and so electron optics is something he fell right into. Steinhardt was a very brilliant engineer, but kind of unorthodox. He put things together in an unusual way and they would do unusual things. But an ordinary engineer or a maintenance man would be quite distressed by trying to do things--you know, things just wouldn't do what they were originally intended to do. They did something else.

John Howard was a very able and very hard working young man. And he was more influential, I think, than Steinhardt, despite Steinhardt's brilliance. He worked harder.

MERTZ:

Is that particular--the earlier machine that was a complicated one--still in existence or has it disappeared?

CAMPAIGNE:

Well, I don't think it's still in existence. I don't know. It was gathering dust in various corners for a long time after the war, and so I couldn't tell you whether it is or not. There might be pieces. It was kind of a big awkward thing. It would about half fill this room.

MERTZ:

I was wondering if there might be any pieces of it that would be conceivably

CAMPAIGNE:

Couldn't say.

MERTZ:

good as specimen of—

CAMPAIGNE:

I can tell you a little bit how it worked. It used tapes, long tapes, paper tapes which were, as I recall it, 70 mm wide, with 26 or maybe more dedicated places, through which holes could be punched; and there were two or maybe three of the reel tracks on which the long loops of tape could be installed. And these would [be compared] one operation would be for two tapes to go around, and a photo cell look for coincidences of holes in the tapes. And then one of them would process a little, and they would go around again. That is, one would advance with respect to the other and they would go around again. And so about every three seconds you'd get an operation.

MERTZ:

So it was sort of a sequential

CAMPAIGNE:

That's right.

MERTZ:

Comparing.

CAMPAIGNE:

That's correct. Then there was another tape track, so that one tape could go transversely to the other. They crossed them. And this would enable you--if you put a pattern tape on one of them, then you could find patterns in the [main text]. For instance, a word like 'puppy,' which has three p's in it, it could recognize the recurrence of three p's. In a simple encipherment of a word like puppy the pattern will show through. If you locate these things you could find where "puppy" fitted. It seemed to me that that was one of the things that caused the most trouble, trying to find those patterns. The pattern thing just wouldn't work for a long time. And when Steinhardt revised the machine, he got it to doing patterns, but he did this at the expense of dispensing with other functions.

MERTZ:

Aha. But it would do that, though?

CAMPAIGNE:

Yes. Well, we did run it for a long time [seeking] patterns. It turned out there was a problem in which patterns were important and useful in 1942. So Larry revised this thing so it would do that.

MERTZ:

So there still, I assume, was a very serious problem of speed of function of the machine. In a sense, even now you could store, perhaps, on paper tapes quite a bit of material, slow to put them on the tape, and then it would be slow to retrieve it, and to--well, whatever functions you'd write.

CAMPAIGNE:

Right. Right. If I remember correctly we prepared these tapes by having the material first punched into punched cards, and then the punched card reader would read that and then punch a pattern into the tape. For some unknown reason the holes through the tape were very, very small. The tape itself was the standard tape that Kodak uses in packing film packs. And I guess they got this paper stock from Kodak, and it was black on one side and red on the other, you know, it was supposed to be light[proof], so light wouldn't show through. And then they had these tiny little pinholes in it, punched through there, which made the registration quite critical in running these tapes one against the other.

MERTZ:

Yes, I was going to ask if there was not perhaps [a difficulty] this is only tangentially relevant at this point in the history of computers, but some problems in terms of the sensitivity of the photo cells and ...

CAMPAIGNE:

Yes. Well, we used that idea many times of comparing things optically--and it turns out that it doesn't take much light going through the paper to activate the photocell, and the photocells are sensitive sometimes in certain areas of the spectrum where you don't see. It looks kind of opaque to you but it's fairly transparent to this thing. So you keep getting erroneous results because maybe there's a little bit of oil on a piece of tape or something and it's transparent.

MERTZ:

The fibers might even be thin

CAMPAIGNE:

Right.

MERTZ:

Because you can't always necessarily guarantee a homogeneous consistency.

CAMPAIGNE:

That's right. You certainly can't. The paper is hard to make consistent.

MERTZ:

So conceivably that might have been a stimulus for some other means of recording comparisons.

CAMPAIGNE:

Yeah. It was. That's correct, it was. In fact, we went to Eastman Kodak and, you know, sort of offered them the problem, and they said, oh sure, you know, photographic thing, you control the opaqueness of your medium much more accurately with photographic processes.

And using movie film they did prepare a kind of similar device. In fact, several of them; I think, they made several, so that we did later have these other gadgets which compared film. But film has this preparation ..., exposure, development, and so, in other words, turns out to be kind of a nasty processing problem.

MERTZ:

Also storage ..., too, in terms of useful life.

CAMPAIGNE:

Yes, I suppose. We weren't troubled too much by that. We were... our standards were kind of short at that time.

MERTZ:

I assume then at this time another parallel avenue of pursuit was magnetic tape.

CAMPAIGNE:

No. Not true.

MERTZ:

No?

CAMPAIGNE:

No. At the time ... wire recording was the standard, but we didn't use any of that. I don't know why not. I guess nobody had ever thought of putting digital material on wire. But, of course, recording was known. Now the Germans used magnetic tape. They used it for intelligence purposes. They used to monitor things and record it on magnetic tape. And at the end of World War II when we went through Germany looking at their intelligence installations we found lots and lots of magnetic tape. They had very narrow--quarter inch wide--tape, paper tape with magnetic backing on it. When I first saw it I didn't even know what it was. But we were kind of impressed with their use of tape. And so magnetic tape shortly became commonly available and wire disappeared.

MERTZ:

Wire was the avenue. I was thinking of an electromagnetic approach as distinct from a photo light sensing approach

CAMPAIGNE:

Yeah, right. Yeah, yeah.

MERTZ:

and the avenue, perhaps I was premature in saying tape, but there was a wire—

CAMPAIGNE:

No.

MERTZ:

There wasn't that either? Wire?

CAMPAIGNE:

We didn't use wire, either. We never used wire,

MERTZ:

Not that either.

CAMPAIGNE:

and I don't know why.

MERTZ:

[You never even] considered it?

CAMPAIGNE:

I don't know about "considered," but we didn't use it.

MERTZ:

So in essence that avenue was not really explored until after the War, then.

CAMPAIGNE:

Well, I couldn't tell you about exploration, but it wasn't used extensively. Yeah.

MERTZ:

I see.

CAMPAIGNE:

Now I remember some people at the time having wire recorders in their homes. But we didn't--I guess just didn't see a way of using it. So ... the punched cards were about the only thing we used much.

MERTZ:

Yes. That would be the punched card. But the tape itself--

CAMPAIGNE:

Well, we were using punched [paper] tape, too. But we weren't using tape as a recording medium. We were only using it as a processing medium

MERTZ:

Ah, for performing the comp—

CAMPAIGNE:

for the comparisons, right. Now we, let's see, before the war was over we also used a teletype, a coded--see, the coding on the Bush machine was simply one hole in each of a number of dedicated places, so each code was one hole out of twenty-six or one hole out

of ten, or whatever. Then, of course, a more economical thing was the five hole thing where you can have any number of holes punched. And, of course, teletype was already using this on their teletype machines, for the store and forward medium, and we started using that for operating typewriters. There was a fellow named John Skinner who came down from IBM. ... IBM already had an electric solenoid-operated typewriter, and he devised a typewriter, tape reader, and a tape punch unit which the Navy purchased some under a designation CXCO.

And by using a double headed tape reader you could do some comparisons and control functions, and these devices became very useful. You could prepare work sheets [for cryptanalysts]. For instance, in a cipher in which the period is important--and many of them have that property where, let's say, every 25 letters it starts over again, and so you'd like to have the text written out so that 25 letters to a line, ... and then each column has the same properties. Well, one of these electromag--these typewriters could prepare this for you. Much easier.

MERTZ:

And justify the length.

CAMPAIGNE:

Right. Justify it. Line everything up. And if they had to be done in quantity you could do a lot, in a fairly short time.

MERTZ:

Was this again at the end of the War?

CAMPAIGNE:

Well, no. This was during the War. I think we started this... well; we started it when John Skinner appeared. John Skinner appeared in early '42. Now, I think it was a whole year before we had any in quantity that was very useful. But we continued to have more of those, and we actually put some plugging equipment on there so you could do things with them in addition--you know, make substitutions and various things like that.

MERTZ:

So you can actually even add certain functions.

CAMPAIGNE:

That's right. You could do a variety of of things with them. They were really slow and cumbersome compared with a modern computer, but we could do something. And we

began to have rolls of tape which was a way of storing information. A terrible way, because one of the things that happens to tapes is that the roll comes unrolled and some of it's on the floor, and then you step on it and that's--.....

[End of Side 1]

[Start side 2]

CAMPAIGNE:

There was some use of [desk] calculating machines, Fridens and Marchants, because there was some statistics to be done, but it really wasn't terribly broad. One of the things where there was a lot of calculation to be done was in the use of what were called additives. In some countries, and the Japanese were one of these, used digital code to, as a means of communication, and then they concealed this further by taking a list of numbers out of a book and adding them to the [text]. Now what an analyst has to do is sit down and try if he can successfully find one word then he's got a good chance by the redundancy of language of guessing the next one. Then he can continue along. And, of course, the Japanese code was very important and we had hundreds of people ... doing these things.

Now it was of course--it immediately occurred to a lot of people "here's a way to mechanize," and we went to the National Cash Register Company, and they even built a special device for this, which wasn't terribly popular with [cryptanalysts]. I don't know why. Some of these became very adept at doing a lot of these in their heads. They could do--I remember when I first worked on this, the best I could do in one day would be twelve groups. But there was a Warrant Officer there who would always get a hundred every day and sometimes 120 or 130. Way ahead of anybody else. And he didn't want one. He didn't like these calculating machines. The adding machine had to be special because the addition is done without carry, that's to avoid multiplying the errors again.

Well, there were a number of those things built by the National Cash Register Company, but they weren't too successful. We also did a lot of it on tabulating equipment. You could do it by means of cards, and some of our people became very, very adept, at applying these card techniques.

So you could prepare work sheets and you could look them over and say, there, that's a good one, and you could do things fairly rapidly. There were a lot of things we could have done we didn't do. One of them is that we still relied on a typewritten piece of paper to bring back the information from the field. You know, it's so obvious now that that's foolish because what happens when it gets back here? Somebody types it onto a tape ... or on cards or something like that. It had to be on a machinable medium, and it should have been put on [such] a medium in the first place.

MERTZ:

That multiplies the possibility of error, of course.

CAMPAIGNE:

Of course, it does. However, it was a tremendous fight to get this installed because editing--You see, editing was something we couldn't cope with mechanically. If a format was followed rigidly why we were in good shape. If the format had been deviated from we were helpless. We had no way of automatically editing any of that. We should have been able to lick that, and we didn't; and I don't think we tried hard enough.

So as the War progressed we were principally relying on card equipment, adapted business machines. We did build a number of special devices which would do some of these special enciphering functions for us. Now the people who worked on these were good engineers and who did a good job, and who found it, I think, very educational, because they were people who went into the computing business right after the War. But we did not find a means of recording information data storage. We had rolls of paper tape and decks of cards, and those were essentially what we had. Well, we did have some of these things on the photographic medium that Eastman Kodak had given us, but they... it was not really a storage thing. That was a processing thing. Incidentally it was storage, but we never put anything on film just to keep it, except, of course, microfilm; we microfilmed documents sometimes.

MERTZ:

Was there much interest in the development of such things as the Williams tube and—

CAMPAIGNE:

Well, the Williams tube was later. That was after the War. Yes. When the War terminated in '45, the ENIAC, of course, was ready to sort of show--it had just got to the stage where it could begin to do things.

MERTZ:

Had you all more or less been interested in it or following the activities?

CAMPAIGNE:

No. No. We were completely ignorant of what was going on at Aberdeen, which was kind of a different world. But Von Neumann, of course, was working with them, and he recognized this as an important development, and he gave it a lot of publicity, called the attention of people. Well, I guess maybe Bush did too. And some other people.

The Moore School at the University of Pennsylvania had been, of course, very influential

in the ENIAC. They had built it. And the Moore School organized a course in the summer of 1946 which would be for the purpose of indoctrinating people on this. We sent a man up there, a Navy officer named Pendergrass. And Pendergrass came back with knowledge of what computers can do, and we discussed "what can a computer do? What are its limitations?" "Well, it can do anything." "Well, if it can do anything, it can do cryptanalysis." "Well, you know, can it?" That was a question. So we spent--even before he finished the course he came home on a week-end and told us about it. We were interested in what are the possibilities of this. And we became quite interested. In fact, within a month or two we had determined that we had to have one of these devices, and we started planning one. Of course, other people had done the same thing. MIT had some plans well along for Whirlwind, and I don't remember the differences between Hurricane and Whirlwind, but it was Hurricane was also...

MERTZ:

Raytheon Corporation was in it.

CAMPAIGNE:

Was it? I don't remember.

MERTZ:

There had been some.

CAMPAIGNE:

But, anyway, we studied these plans, and we read and listened to all the plans we could. And we were quite influenced by Whirlwind. But we came up with a design, and we managed to get some money. There were some advocates of sitting back and waiting, you see. You know: "It's coming along. In a year or two there are going to be computers, and you don't have to do anything to get computers. Why should you spend a nickel?" There was a man in the Bureau of Ships, a senior man, who sort of stood in our way quite a while on that. But we eventually let a contract with ERA, who at that time was manned largely with people who had been with us during the war, people we knew like Larry Steinhardt and John Howard and John Coombs, Bill Norris, and others, and we gave them a contract to build this.

Now that was sort of their first indoctrination to this because although they were familiar with digital circuits, they had built plenty of digital circuits for us, recognition circuits, they had never, of course, built anything as complex as a computer, and there was an awful lot of circuitry in it. But they undertook to build it, and, in fact, it was delivered in sort of December of '51. They gave it the designation 1101, which is the binary form of Project 13, which was the [contract task] under which it was built.

MERTZ:

[Laugh].

CAMPAIGNE:

Of course, by that time there had--there was really quite a lot going on. There were very few computers of the new style actually operating, but there were a lot of them maturing, including the UNIVAC which we had studied closely and decided that because it was decimal coded it was not useful to us. You see, we so often had peculiar things. We had adding letters according to tables, and UNIVAC wouldn't do that, not readily. Well, a binary machine was much more flexible for that reason.

MERTZ:

Was there any particular interest or concern about the nature of the... whether the machine was serial or parallel?

CAMPAIGNE:

Yes. Yes. There was quite a lot of study on that. We, in fact, some of our people were fascinated with the SEAC, and we did undertake to build a SEAC of our own. And that was a serial machine with mercury delay line storage. And this started just shortly after we let the contract to build the 1101, or maybe I shouldn't call it the 1101. That was a subsequent designation. We called it Atlas. There was a comic strip at the time which had somebody called Atlas, the mental giant, in it. So Atlas was the term we applied to it. The--of course, the computer looked awfully big and expensive at the time, and we were looking for economy. And so—

MERTZ:

Is this--excuse me a minute--the immediate post-war,

CAMPAIGNE:

Yeah.

MERTZ:

Let’s say, pre-Korea, period?

CAMPAIGNE:

Yeah, yeah.

MERTZ:

You know, there were fairly sharp cut-backs in research expenditures on the part of a number of groups.

CAMPAIGNE:

Well, yeah; yeah, we--well, it wasn't only money. It was a matter of getting into something which might be a maintenance headache if it was too complex. And it might take too long to construct.

So we built around the magnetic drum memory, which--we had had a drum in an interesting fashion. One of our people had suggested that if we wanted to look at a tape over and over the way to do it was to paste it on a drum. So we had pasted it on a drum. And this particular drum was unable to--it had to write at a tape reader speed. You had readers which ran at ten characters a second, and so the tape to load the drum was advanced at that rate with a worm drive. And then it was driven at a much higher rate to read it. In fact, you couldn't read it slow because you don't get enough magnetic flux. You have to run it fast. But we did want it to go fast. It circulated at four revolutions a second or some such speed. This was a great big thing like three feet in diameter. And that's so that it would accommodate enough tape around the periphery.

Anyhow, we were familiar with drums. ERA had already pointed out that it was simpler to put the magnetic oxide right on the drum than it was to put it on a base and then paste it on a drum. And so they had done some things. And they built--they did build several drums for us before the Atlas drum, which we began using. The storage medium became clearer. It was a useful thing. Of course, the drum is not very fast.

MERTZ:

Now this was about the time, well, certainly the Williams tube was in existence.

CAMPAIGNE:

Yes. Yeah, that's correct. Williams tube--Williams, I suppose, must have done his first ... tube about '46. But I remember his being over here in '47, and some people trying to use them. Americans had quite a time at first. They just couldn't make 'em work. Began to wonder if it was the climate or what it was that wouldn't-- And, of course, when they did work they weren't terribly reliable.

MERTZ:

Well, Von Neumann did, I believe, manage to use them in his Institute computer.

CAMPAIGNE:

Yes. We also--before Atlas had got into metal, you know, they were still just building bread brass boards and things, we started a second design which we called Atlas II. And this was built around Williams tubes. But it didn't mature, of course, until about 1953.

The magnetic drum, of course, was a kind of terrible thing to use as the basic memory of a computer because you'd have to wait a whole drum [revolution]-- a half a drum revolution on the average for information. And that wouldn't be very fast, even if the drum was pushed hard.

MERTZ:

Of course, with the acoustic delay lines I don't know—

CAMPAIGNE:

It wasn't much better.

MERTZ:

if you'd do all that much better at all.

CAMPAIGNE:

That's right. Yeah. Well, that's quite true. They're very similar. They're recirculating memories, both of them. Well, we tried to do things about this. One of the things, I devised a scheme we called Octoplex in which, whenever you wrote something on the drum, you took a whole drum revolution and you wrote it on eight times, eight different places, but when you wanted to read it you just took the first one that came up. And so you saved a factor of eight on every reading, and you only lost a factor of two on every writing. And since readings are much more frequent than writings why this looked like it would be a significant saving.

However, before that was done, I came up with another scheme which we called linear programming actually, and it was based on this, that when you want some information it isn't a random matter to get it. You know when you're going to want it, so put it so that it will be there right when you need it. And we started spreading out the instructions, separating them widely on the drum and then putting the data that we needed in between. And we altered the program counters so that instead of looking at the very next place on the drum for the next instruction it would be eight or sixteen words farther on. And this would give the machine time to execute this instruction before the next one came up. So instead of doing one instruction per drum revolution, we were now in a position to do two or three hundred instructions per drum revolution. ... Usually the data you needed could be put nearby, you could scatter [the data] around the same way, so you didn't have to wait for data.

MERTZ:

But wasn't there one premise in this, though, and that is that you have no conditional instructions?

CAMPAIGNE:

That's correct. But you can afford to take a loss on conditional instructions usually because they don't come up so often.

MERTZ:

Right.

CAMPAIGNE:

And, in fact, you can even do that. On the basis of this idea, I showed how you could do a table look-up in one revolution. This was the scheme where you look halfway down the table and decide whether it's a first half or second half, and then you look in the middle of that half to see whether it's the next quarter or the following quarter, and you just keep doing that. And if you put the table on the drum, not in table order but in this order, that is, the middle word is the first thing you put down, and the--the first quartile, and the last quartile are the next two words you put down. If you do that then you can run through the whole table in one drum revolution.

And I remember that when this was explained to Ida Rhodes she said "now, why don't you interpolate?" And, of course, we with our digital things were quite taken aback at that idea of interpolating. Nothing that we had was interpolable... interpolatable.

Anyhow this idea knocked out the octoplex which was mechanically much more difficult to do. The idea of spreading the things out was quite easy to do mechanically. There was nothing to it. All you had to do was interchange a couple of wires on the address registry. You could do it in a minute.

MERTZ:

One other question in passing. Was there much interest in particular in Aiken's work up at Harvard?

CAMPAIGNE:

We visited Harvard to see what they were doing. Let's see, at the time they only had Mark I running, and Mark II was under design. The Mark I, of course, was relatively useless [to us]. It wasn't much better than a Friden at doing our operations. But, of

course, Aiken had some bright people there who were learning programming and programming methods which was very important, but not to us.

MERTZ:

I meant to ask you in that connection that there were a number of Navy officers I believe who were _____ with Aiken and maybe with IBM.

CAMPAIGNE:

Yes. _____ was a close friend of mine, and Hubert Arnold, too. I guess he was officer in charge up there for a while. No, we didn't really get much from the Aiken operation. I think we were more influenced by Whirlwind at MIT than anything else.

MERTZ:

And ERA

CAMPAIGNE:

Well, of course, ERA was working for us. They certainly supplied lots of ideas, but they followed our leadership actually.

MERTZ:

In that regard, this is the same era as the Princeton machine.

CAMPAIGNE:

That's right.

MERTZ:

The Von Neumann machine which perhaps was not an engineering masterpiece but at least was an extremely influential machine in a number of ways. One way at least was in stimulating interest among a number of physicists and mathematicians in computer problems who might not

CAMPAIGNE:

Yes. I guess that's right. We got Von Neumann in as a consultant and member of our Scientific Advisory Board toward the latter part of Atlas, I guess about 1950. And we told him this idea we had of distributing the information around the drum, but, of course, by that time the Williams tubes were coming along so well that there wasn't too much interest in it any more.

We got delivery of our Atlas in December of '51, and we began to get very good use out of it. In the meantime the Atlas II was coming along. Now Atlas II was more parallel. The words were... there were two address systems instead of one address. We had found it was worth avoiding some of these economies. Atlas I was a terrible machine in one respect, and that was we had economized in input-output stuff by using the quotient register as the input-output register, too, which meant it was absolutely impossible to do anything while you were loading and unloading, which by modern standards was very backward. The Atlas II had Williams tubes on it, and, of course, had a drum as well. The drum was now secondary storage.

MERTZ:

I was going to ask you, was this intended like Whirlwind to be, except for the external memory, be a fully synchronous machine?

CAMPAIGNE:

Yes. It ran by a clock.

MERTZ:

With a parallel…

CAMPAIGNE:

Yes. That's correct.

MERTZ:

Although, as you mentioned you were interested in serial.

CAMPAIGNE:

We had this second machine which we called Abner. Abner was like SEAC except it had some special functions in addition to the arithmetic. We put on quite a number of things which would help search the memory and it was quit complicated. And, in fact, it was running before SEAC did. You know, like a few weeks before. We bought the memory, the mercury memories from Technitrol in Philadelphia. And I guess they were the same ones that the Bureau of Standards got, but we always had trouble with them. They were never quite as reliable as we'd like.

We, in fact, built a second one of those. I think we had two of them before we were through. But there wasn't any follow-on. We gave up on the delay-line memories. You see, by the time we had finished our second Abner the cores were already coming along.

They were at least on the horizon.

MERTZ:

Well, they started to be introduced into the decision to go using the cores were made in '53.

CAMPAIGNE:

Right. It was in '53 sometime that our Atlas II was delivered with its Williams tubes. And then we had a second model of that one. We had two of the Atlas I's, too. And we ordered a second of the Atlas II's, and this second had core memory on it, which came along only about twelve to fifteen months later. And the Williams tubes, of course, had to be tuned up every little while. I think we were unable to run twenty-four hours without stopping to sort of tune them up.

MERTZ:

I was wondering if you used any kinds of techniques in preventive maintenance associated with Whirlwind in marginal checking approach to reduce the amount of down time by preventive inducing failures.

CAMPAIGNE:

We had marginal checking on all the Atlases, I believe. But we only lowered the voltage. The two Atlas I's stood face to face, and, of course, they were great big monstrous things, great big bottle tubes, you know, and long wires. There must have been cables 36 feet long.

MERTZ:

Are there any pieces of these machines around still?

CAMPAIGNE:

Well, yes I think so. Small pieces.

MERTZ:

What I was thinking of in this connection was about [preserving samples for posterity].

CAMPAIGNE:

Yes. Well, one of these two machines was less reliable than the other.

MERTZ:

They were identical?

CAMPAIGNE:

They were identical. There were certain problems. One problem was notorious because it would run on one machine and not on the other, not reliably anyway. Come to find out eventually that one of these machines had its voltage set a little higher than it should have been, so that on the marginal testing you turned down the voltage then it was in the range where it worked better than ever. Consequently it didn't respond to the preventive maintenance the way we were expecting. After that we learned to have marginal checking in both directions, raising voltages as well as lowering.

MERTZ:

One other question is involved with such things as tube reliability. MIT as you perhaps may recall went through a great deal of pain and effort to raise the quality of tubes used in the machine, with Sylvania and others. ...

CAMPAIGNE:

We did a lot of worrying about that. There were predictions, of course, that this gadget wouldn't run more than twenty minutes at a time because you'd have a tube failure every twenty minutes. And that turned out to be false, the reason being that the tubes don't fail independently. They tend to fail on Monday.

MERTZ:

Did you work out fairly... At least if I recall correctly the Whirlwind machine had a reasonably elaborate turn-on [algorithm].

CAMPAIGNE:

We did, too. I believe that's correct. We did have to have pretty careful turn-on procedures. And we avoided those by just leaving it on. We didn't turn it off very often. In fact, when we subsequently came to transistors we, our first experience in turning the device off over the week-end cost us s o much that I think we never turned any of them off thereafter. Because apparently it was a warm humid week-end when they were turned off, and something like a thousand of them had to be replaced come the next week. Took nearly all week to get it running again.

MERTZ:

They had fairly close control ... initially at MIT of the environment for the machines.

CAMPAIGNE:

We had controlled environment, too, but on the week-end... I think what happened there was not only did they turn it down, which was regarded subsequently as a mistake, but somebody came through and turned off the air conditioning. You know, there was air conditioning going on the week-end, and they turned it off. That was not intended. That was a mistake.

MERTZ:

That can really do a lot of damage.

CAMPAIGNE:

That's right. Well, it did. It did a lot. And, of course, in those days the transistors weren't encapsulated. They were much less resistant to humidity than they are now.

MERTZ:

About when did you go into fully transistorized [circuits]?

CAMPAIGNE:

About '56 - '57 time frame.

MERTZ:

It might be early. Actually, you just might be one of the earlier....

CAMPAIGNE:

Well, we didn't really succeed in being early, but we were making efforts early. Let's see, the first fully transistorized computer we had was the Philco 1000. The Philco came up with this direct coupled circuitry which looked awfully good as an approach The first attempts to use transistors were to substitute them instead of vacuum tubes, and that was not a good way to use them. Nobody had good success with them.

But then Philco came up with these circuits, and we supported and bought a machine from them, the 1000. That was the first transistorized one.

MERTZ:

Excuse me, let me backtrack a little. Did you do trial and error with transistors as substitutes to drive.

CAMPAIGNE:

That's correct. We didn't try to make a whole computer out of them, but we did have transistor circuit.

MERTZ:

Was that fairly early on?

CAMPAIGNE:

Well, I suppose '55 - '56.

MERTZ:

Did you also follow the activities of Sperry Rand people, the UNIVAC people in their work?

CAMPAIGNE:

Yes. They made a fully transistorized 1101 which followed the complete logic of the 1101 and I believe they were paid to do that by ONR who was trying to encourage transistors, but we never did get one. It was probably not too good an idea.

MERTZ:

Of the generation of computers that emerged after the say '53 when we find ... the SQ 7 which was used in the SAGE system, and the like were you at all interested in particular computers at this time or did you...

CAMPAIGNE:

Well, our experience with the Atlas was very favorable. We were able to do things that we hadn't been able to do before. And so that we became very computer minded. We not only began ordering these other machines, like Atlas II, when 701 became available we bought 701's. Let's see, 650. I guess we got a 650. I don't remember for sure. 650 had a modest capacity. And there was something earlier than that called a calculating punch which we had--CPC. I don't remember whether we had that or not. But we did get in a line of IBM 700s computers as soon as they were available. 701, 702, 703.

MERTZ:

Did you have them all at the same time?

CAMPAIGNE:

Oh, yes.

MERTZ:

Kind of a collection of computers. How about some of the other lines such as the UNIVAC or Burroughs

CAMPAIGNE:

Well, the UNIVAC because of its decimal arithmetic wasn't very useful. Burroughs, I don't remember that they had anything until later. No, we didn't get any of those. But you see, ERA started making commercially available machines and, of course, the 1103 was our Atlas II, a version of our Atlas II, and that was commercially quite a successful machine. We didn't get any of their others until we got an 1108, and that is much more recent.

MERTZ:

Roughly how many high speed electronic digital machines in the pre-transistor era--you must have had quite a good sampling of them, of the total number produced.

CAMPAIGNE:

Yes. We did. I don't remember. We had seven--along about '56 we had seven or eight. Going back a bit, there was one little bit of thing which was of considerable interest. In '48 we had Atlas planning, and we were reading, of course, about Whirlwind which was planned and EDVAC which was planned, and EDSAC which was also under development.

And a lot of these ideas going on. And we very much felt as though, you know, we were a skier without snow, we couldn't do things. So we planned, we made a little relay model which was the exact analog of the 1101 except that it worked at relay speeds. And this was thrown together in three or four months by some of our engineers there, and we called it ABEL. And this gave both the engineers and the programmers a chance to really try things out. For example, I remember when we tried to do some triple precision arithmetic for the first time it caused the programmers quite a bit of trouble because [of the complex algorithms], but we were able to actually do it and show that it worked and so on. As a training device it was great. Of course, it was unable to do any real calculation. It was too small. Once the 1101 was there, of course, Abel became much less interesting. But it had about two years of life before Atlas arrived. We subsequently gave this to the logistics research project here at GW. They had it for a while and then they gave it away. The last I heard it was at the Albert Einstein High School out in Maryland. So it lasted a long time and did yeoman work for many, many years. As an

educational device it was quite good.

MERTZ:

A similar story applies to one of Stibitz's relay machines that went to Wayne State University for a while, and now it is in I believe Madras, India. I think it's Model 5.

To get back to another thread in this story of digital machines for the development of relay equipment and switching equipment by Bell and the like, I imagine that this, the No. 5 crossbar, and then its later application to Stibitz's machine had some impact in this field, although it might not have been in the Navy's...

CAMPAIGNE:

We had some relay devices we built in the latter days of the War. In fact, we had one big and quite successful one whose name I've forgotten. We gave pet names to all these things. And it had a lot of relays in it. It must have weighed an awful lot. But it was quite good. Of course, it wasn't fast enough by present standards. It would be much too slow.

MERTZ:

Did Von Neumann play any particular role in influencing decisions on types of computers or characteristics of computers that would be most useful?

CAMPAIGNE:

Well, Von Neumann laid down some general principles which were very [abstruse and] which we followed. Of course, one was that you should use a common store for data and for instructions, and we followed that. Another was that the computer should be able to read its own output which we followed. And, let's see, did he have some others? I don't remember now. Yes, he was quite influential that way.

MERTZ:

He was also, I think in at least a number of cases a fairly strong advocate of binary arithmetic.

CAMPAIGNE:

I believe that's right, although I don't know that he influenced us because we had arrived at our conclusion that binary was for us. Now, in the early fifties when we began sort of getting every computer we could we were kind of big in the computer business. There weren't too many--I don't know what pro portion we represent, but it was pretty big. Our insistence on binary I think influenced the whole industry. I remember the IBM people

used to come down and they would give us arguments about binary coding. They wanted to be persuaded, maybe. But eventually they decided on policy, that they would go binary. I think maybe if it hadn't been for us they might not have done that at that time.

MERTZ:

But there was a pull the other way. UNIVAC developed.

CAMPAIGNE:

Yes, there was indeed. In fact, there were advocates for using decimal arithmetic. Don't bother translating. Make this thing do it your way. But we so often had elements which weren't decimal. There were arithmetic's that were all sorts of radices. And binary, of course, was one of them. Because all of the teletype enciphering devices are binary. So we would have had somehow or other to simulate binary if we were working on decimal machines. It was terribly wasteful of resources to do that. You know, you take a decimal machine and use one word for each bit. ... So, yes, we very early decided that binary was for us, and nothing else would do. And we pretty much stuck to that. We've had very little exception. There were, I believe, some of the IBM sorting devices, the 702 and the 704 or 705 were kind of exceptions to that.

MERTZ:

Which raises another question. In connection with both acquiring personnel and sending people back out into the field itself, there are a number of groups have been quite influential either as training grounds for people in computer technology or as having stimulated others to train and produce say engineers who are familiar with more elaborate flip flop circuitry and the like, or any one variety of the storage tube problem. MIT was an absorber of some of the lore, so to speak, of the Moore School in Pennsylvania, and it later, because of its summer courses and programs, particularly in Illinois among other institutions influenced people in England and elsewhere who went through the courses. How would NSA fit into that? If it had so many machines one would think that actually it would...

CAMPAIGNE:

Yes, I think it's true that it was... Well, Tom Cheatham, for instance, was a man who was introduced to computers at our place. He is now head of this Computer Associates in Boston. And there were a lot of people who had their first exposure to computers in our place who went out and subsequently found that there were skills that were saleable.

We had a difficult time keeping programmers for a while. The only way we could get them was to train our own, and then they would immediately get a good job elsewhere.

MERTZ:

Did you have--did you find there were any particular institutions that proved to be more useful to you in recruiting your personnel in the fields of either engineering or mathematics than others by virtue of their experience in the computer...? For example, did you find MIT particularly...?

CAMPAIGNE:

Yes, I think MIT was [influential] because we used to send people there. We would give them fellowships or assign them up there for a year at a time. So we had people through MIT regularly. Let's see. I don't know that any of the others were. I don't remember that they were. Of course, we've sent a lot, in recent years we've sent a lot of people in computer science any number of places--University of Maryland, Johns Hopkins, University of Iowa.

MERTZ:

But that is not... that mushroomed.

CAMPAIGNE:

Right. But back in the era '53 or even '51 through '59 there were almost no training places available. Of course, many of the commercial [organizations] have now set up training schools, but in those days there was very little training available. And we just trained people on the job that was the main thing.

MERTZ:

Well, fairly early on MIT did develop a course, a regular term course in programming and then a special summer program.

CAMPAIGNE:

That's right. I don't think we got very many of those.

MERTZ:

Well, thank you very much, Dr. Campaigne.

CAMPAIGNE:

Yes. Right.

[End of interview]