Computer Oral History Collection, 1969-1973, 1977

Interviewee: Grace Murray Hopper (1906-1992)
Interviewer: Uta C. Merzbach
Date: July 1968
Repository: Archives Center, National Museum of American History

[The interview begins with a discussion of natural division points in Hopper's biography.]

HOPPER:

Before the Navy and after the Navy.

MERZBACH:

Before the Navy and after the Navy? All right, so that—

HOPPER:

But, I can divide the earlier period as before I went to college and after I went to college. There's an actual division there; that would be about 1924, you see, when I went to college.

MERZBACH:

Pre-Navy and then pre-…

HOPPER:

That breaks at 1940, 1943, so it goes up to 1924 and '24 to '43 and '43— then it breaks there—the time at Harvard '43 to '49 and then '49 we're beginning to learn the programming. You see by '51 I'm beginning to work on our first compiler, so I get right—fairly rapidly to—How does that compare with what you had in mind?

MERZBACH:

That's fine, I had—well the difference here is I had put the break a little later. I guess I didn't make the college break, but the—

HOPPER:

I don't think the college break is really necessary, because to me in thinking, it breaks at the point at which I entered the Navy. It's before that and after that in my mind.

MERZBACH:

All right, very good, why don't we—in other words, we'll think of it, if it turns out that the pre-Navy—we may simply as a matter of convenience and time and energy break it there.

HOPPER:

See, that goes so quickly now because it's essentially irrelevant and unimportant. It's funny how time can collapse and that's all collapsed—strain up.

MERZBACH:

Well, that's interesting of course; the question is the key and importance as you view the significance of the work. The only question is we look at you as an historical figure. We always wonder where are those things that explain. So, there is one question, I suppose: what would you—without having thought about it too closely right now—if you were just throwing out influences from the top of your head now, what comes to your mind?

HOPPER:

From early years or middle years or what?

MERZBACH:

Well, let's do all—let's start with the early years.

HOPPER:

Well, influence of family, with ancestors who had been scientists and engineers, and my mother's very great interest in mathematics and my father's, a house full of books, a constant interest in learning, an early interest in reading, an insatiable curiosity; those were all developed in those early years and are a primary influence all the way along, and there were a good many of those to mention.

MERZBACH:

What about—well, this would be, I think, one of the things we'd want to [?] here. Also one of the questions that I would like to get into are just data concerning your family, you know, names—just the standard things, names, dates and places of birth, deaths, occupations, etc. and then there is the question we have of standard family members that

we consider; but of course there is always the question whether aside from the mother, the father, the grandparents—did you have brothers and sisters?

HOPPER:

Oh, yes. I have a sister and a brother.

MERZBACH:

You have both, ah! The question then is whether aside from those there might have been a particular uncle—[interruption]

HOPPER:

Yes, you see, to some extent there was some influence of ancestors whom I never knew, but some I knew about.

MERZBACH:

Well, this would be one of the things we'd want to run through.

HOPPER:

Are you concerned with pictures?

MERZBACH:

Very much so, and you know we haven't got <u>anything</u> on you, of you, about you.

HOPPER:

Early pictures, late pictures or what?

MERZBACH:

Yes, the works. And, again—

HOPPER:

Lucky I'm going home this weekend.

MERZBACH:

I was going to ask you—I think one thing that would be helpful would be before the next session if you have a chance to rummage around largely as you look over things, things will probably come to mind and then perhaps we can look at the material as we talk.

HOPPER:

There are not too many things I have with me, but I'll be going home to Philadelphia this weekend to get some. Now, some aren't there; some are in New Hampshire and it'll take me time to get them.

MERZBACH:

Yes, you mentioned that before. Well, we can always— I think anyway what we can do is—

HOPPER:

Whether I'll get there this summer or not, I don't know, but I do have some in Philadelphia.

MERZBACH:

Fine, well, why don't we start with that and then as you get back to—

HOPPER:

Besides which my early childhood pictures are marvelous. In all of them I look startled and scared and this has been a permanent influence on my life, I think.

MERZBACH:

All right, we have the question of the data in the family, getting back to the influences, farther on what would you list as major categories or individuals or—?

HOPPER:

Well, the major interesting contacts of course would be—I mean who led me on in mathematics would first be Henry Seely White, professor at Vassar, and had been trained at Goettingen, and then later James Pierpont at Yale would be, and then finally, I guess, Courant.

MERZBACH:

Well, that would.

HOPPER:

And, of course, back at Vassar, Miss Smith, Gertrude Smith who was my math professor and also head of the dormitory I lived in. Then, of course, you get a different—the Navy influence goes back to again great-grandfather and I'll send you an article about him. Then the first prime influence of course is Howard Aiken and then John Mauchly and then there were others to come along after that but those two come first.

MERZBACH:

You would put those in a group by themselves?

HOPPER:

Yes, very definitely.

MERZBACH:

Yes, Mauchly dropped in very unexpectedly a couple of weeks ago and we had a marvelous— I wish I had had that thing there, because we chatted for over five hours; we had lunch and—

HOPPER:

Did you get the tapes from the ACM Meeting?

MERZBACH:

No, I still haven't. I've been talking to Rosenthal but he said they were re-taping them and cutting them and editing and what not and I still don't have them on hand, but I'd be interested in both versions, because you had that meeting and then the first one—

HOPPER:

And then as you come along there would be a double line of influences, the Navy influences and the computer influences—a double line for recent years.

MERZBACH:

Well, on that would you like to go out? This is mainly …Of course, right now this is really more to help me to than anything else.

HOPPER:

One curious thing that seems to have always happened and I don't know quite how it happened but every time I'd get into a blank wall in industry somehow or other by some accident the Navy would send for me to do something and somehow enabled me to get out and get loose again and then come back into things again - sort of every time I hit a blank wall, I'd somehow seem to get a lift from the Navy and usually I'd go in training duty or something would happen and they'd open another door for me just as they had in the very beginning. And, it's just a series of coincidences and yet it seems to have happened.

MERZBACH:

One of these days we'll return to the …

HOPPER:

One of these days that'll come down here permanently, but in the meantime, I need it for …You'll know where it is in case you need it anyway.

MERZBACH:

Right. Well, what we did of course, we had it on exhibit …

HOPPER:

Haven't you been able to find a copy?

MERZBACH:

You know we still don't have what we did. We had it on exhibit and then we Xeroxed now of course we borrowed the Library of Congress copy, we haven't Xeroxed all of it but some of the sections that we were interested in primarily this is what that's like. I forgot that that too was in a blue folder that's what created the confusion, so that … No, but we still don't have that - don't have …

HOPPER:

A permanent one - well, this one will come eventually.

MERZBACH:

Well, we'll just hold off then. Well, let's see - Oh, I have a few more - Oh, I know there were a few more specific things that I thought I should get down—simple things such as schools you attended, grade school, high school—this kind of thing, we have it. Let me tell you what we've got to make sure that little bit is accurate: December 9. 1906, New

York, New York, and there's one question that puzzles me: you refer to New Hampshire as home; where does New York come in?

HOPPER:

We lived in New York, permanent home, and actually I was born at 53 West 69th Street in a real old-fashioned New York brownstone, but then in a few weeks later I was moved to my parent's home which was very new then in apartment buildings. 316 West 95th Street that was our home. However, at the end of school every year, we went to Wolfeboro, New Hampshire and didn't come home until school opened after Labor Day. So, actually I grew up in two homes. The first time I got to New Hampshire I was just about six months old.

MERZBACH:

That takes care of that question. Let's see - oh, the other thing: when you are sent questionnaires and things of that sort what do you consider yourself?

HOPPER:

Mathematician. A rather degraded one now, because I deal with actual digits instead of letters and formulas. That was my basic training and that's what gets my basic thinking. I've been called an engineer, a programmer, systems analyst and everything under the sun but I still think my basic training is mathematics.

MERZBACH:

The other thing, and I was wondering - one of the things that struck me in going through some of these standard references such as Men of Science, which is indicative too, that in listing your career and your title, the only …You're referred to as you say, a scientist, an engineer, a programmer, and it's only during the period at the Eckert-Mauchly Corp. that you're listed as senior mathematician, formally. Is there significance is that?

HOPPER:

No, that is really a job grade.

MERZBACH:

Well, yes, but apparently this is the only group that called you mathematician and mathematician is what you …

HOPPER:

Well, all the way through my teaching through is mathematics. Well, no, what happened there was that the titles for programmers and things hadn't been developed; they didn't exist and senior mathematician then was sort of a combination of senior programmer and consulting mathematician but they just landed on … At one point we were called systems engineers, programming engineers. It was the feeling in the early days of personnel departments feeling around to get titles for these bugs that they had.

MERZBACH:

Let me see that …

HOPPER:

And, I think that was what was really invented so that I'd have a job title that matched my salary. It sounded impressive enough to match the salary.

MERZBACH:

I've mentioned names of early schools, we have that here … There is one question that …

HOPPER:

That has to go all the way back to the Graham School.

MERZBACH:

Yes, yes. Well, did you go to kindergarten or did you start in first grade?

HOPPER:

No, I started at Graham's School, the Misses Graham School, though I think it eventually came to be called the Graham School.

MERZBACH:

Well, we'll get the details. You spent the year, according to record, at NYU on a faculty fellowship from Vassar.

HOPPER:

That's right.

MERZBACH:

Was that a research fellowship or teaching?

HOPPER:

They don't have what you might call leave of absence at Vassar. What you do is you apply for a faculty fellowship. And, when I was there you could get one for one semester or you could take half time for two semesters, and I elected to take half time for two semesters, and spend it studying in school. And, what the fellowship amounted to in dollars was half of your salary. You weren't working, but were given time to go and study; it meant you stayed on full salary and spent half your time studying.

MERZBACH:

Well, essentially what would otherwise be called possibly a sabbatical equivalent to one semester …?

HOPPER:

Except that you did go and study and they called them formally faculty fellowships. You had to study and you had to enroll and have an actual project.

MERZBACH:

Well, what … In looking—planning for this session on this early period what things do you think I should listen to get at what you might consider significant things? It's just another question - a way of asking what you think of …

HOPPER:

I think there were three influences there which can be a little bit located: one is the home and school in New York City and one is the surrounding family which takes in Philadelphia and Plainfield, New Jersey and grandparents and great-grandparents and the other is Wolfeboro, New Hampshire in the summers and [?] there and lots of different people wandering in and out, of course.

MERZBACH:

I'm wondering, as far as actually scheduling, when would you be likely?

HOPPER:

How long do you think you want to spend?

MERZBACH:

Well, this is, I would say, largely up to you as to how we break it. I'd like to …

HOPPER:

And, what we have to set a start and find out how far it goes?

MERZBACH:

You mean all together now?

HOPPER:

Yes.

MERZBACH:

Well, I had thought of a set of approximately six sessions, six to eight depending if we run into some things that we'd find we'd want edited and then in other words covering your career, as well as your comments on state of affairs or work of others, and so on, and then what I would like to do, if you're agreeable, would be to follow up periodically, particularly as we talk to other people, have a get-together every few months or so perhaps for just one session getting your reaction to things that others have said and problems that we didn't think of and so on. And, really as far as the length of the sessions go, I think it will depend somewhat on … We should keep it slightly tentative because some days are —it depends on your schedule and also I think it makes a difference: some days one might be a little more up to this kind of thing and remembers more than others. At least I find there are days that I can keep on talking for four hours and others …

HOPPER:

Well, it depends on what days and what's happened over at the Pentagon.

MERZBACH:

Right, right.

HOPPER:

Well, next Thursday would be a good time to start then, in fact, most Thursdays. How are they for you?

MERZBACH:

Thursdays, that's fine.

HOPPER:

I could come over here at 9:30 on Thursdays, is that …?

MERZBACH:

This would be a—I don't have a calendar here.

HOPPER:

I can make that right from the 25 and then it would be 1, 8, 15 and 22 of August.

MERZBACH:

Right, now—one problem is 8, 15 I'll be out, I'm going over to Edinburgh and I'll be talking with the people over there. But, I will be back on the 22nd.

HOPPER:

All right, let's say the 25th …

MERZBACH:

Twenty-fifth, first, twenty-second.

HOPPER:

The 15th you'll be out—8 and 15 you'll be out.

MERZBACH:

8 and 15 I'll be out, right.

HOPPER:

Now, I'll probably be out the 29th—out at ACM. That's August—now September: that's fairly clear, I can keep them clear. Let me see, that gives us one, two, three, and the 5th will give us four. I will want to get back at some point to Philadelphia on one of these times to probably free more things after I find out what we need. I may have to cancel one of these dates, but I'll hold it down through 12 September anyway. That will be: one, two, three, four, five through 9/15 and I'll just put them on my schedule and hold them.

MERZBACH:

Fine.

HOPPER:

Then we can verify them depending on your and my schedules. That's 9:30 in the morning?

MERZBACH:

9:30.

HOPPER:

That gives me time to get a little bit organized.

MERZBACH:

I think the next three we'll have where we are right now, and then my office situation should be straightened out by the time I get back, and

HOPPER:

That will be the 25th of July and the 1st of August?

MERZBACH:

Right. There is one—I was wondering—if you think you might be getting some material you mentioned next weekend …

HOPPER:

Just early material, huh?

MERZBACH:

Yes, early material. Do you think I could get a look at it before we talk?

HOPPER:

Now, I'll get back here Monday night and I won't be able to get over here before Thursday morning.

MERZBACH:

No, of course. What I was wondering was perhaps if I could stop by and maybe just look at the things in your office … mainly, if it is the material that would cover the period we'll be talking about.

HOPPER:

Mostly what it would be, what I can pick up would be, the stuff about ancestors and pictures of places and people.

MERZBACH:

I see. Well, let's leave it and it may be the kind of thing that would lend itself naturally to development as we talk.

HOPPER:

As we talk I'll be identifying the people and telling … And, it would come right along that way, and I'll bring my baby book down. Most people don't have those now. You'll find out that I started out by being scared and sleepy. They kept me awake when I was a baby and I never recovered from it.

MERZBACH:

Well, then, good. We'll get a bibliography from your office, right?

HOPPER:

Yes, and I'll bring the pictures.

MERZBACH:

And, the dates, the relevant … well, we'll be going over the family.

HOPPER:

The dates, I filled out. Clearance papers, the background investigation and I had to check every date when I did that, so I'll bring a copy of those too. That's the best way to find those out.

MERZBACH:

Good, fine. Well, I think that should - depending how much … If we start at 9:30 - depending on how much time you have. We'll see how far we get …why don't we leave that open?

HOPPER:

I'll try to leave that clear fairly well through the morning. I think—because I have a staff meeting Friday morning. I won't get back here until Monday night and I have a meeting the 24th and a staff meeting the 26th, the 25th is clear and I'll try to keep it that way. And I have … They take me out (?) in China Lake and I'll have to spend the 29th to cut back,

2½ hours, you don't want that kind of story. Then, on the 30th I have to go up to Social Security and give a (?) debriefing and the 2nd, I have one for DCA; after that I'm clear. So, if we get started those first two sessions before you go away, then I'll have two weeks to find things and think of things before we go on from there.

MERZBACH:

Well, that will be actually - that will be good because that's when you get to the period that you were primarily fine.

HOPPER:

MERZBACH:

I have - we're working trying to round up material particularly on the relay computers this term. You know we've gotten …

HOPPER:

You mean Mark II or earlier? Stibitz computers?

MERZBACH:

The Stibitz computer, Mark I and Mark II - some of the European things such as the

HOPPER:

The only one I really had material on was Mark I and Mark II except as I read about them here.

MERZBACH:

No, this is not to ask, this is just to let you know what we are doing. Of course, you had some reference material to that Mark II, diagrams and so forth. No, we've gotten to be a little more systematic about all those things since I last talked to you—thanks to the AFIPS grant. So, we'll … As a matter of fact, if you have just a little time, I'd like to show you the vastly expanded files, for one thing.

HOPPER:

We can stop on the way.

MERZBACH:

We're working up a bibliography and as I say aside from incorporating material generally, we're trying to concentrate on the relay stage in the logical science this year and the mechanical and differential analyzer just to have a little priority there—priority set up.

HOPPER:

At some point in time I will get the stuff from storage. I may be getting a new apartment this year so maybe we'll get that stuff from the storage in Philadelphia and also a storage company in New Hampshire. Sooner or later I'll produce that, sometime in the next few years but I don't know when.

MERZBACH:

Well, as you know—as I said before—I'm more concerned now about the things that we don't know about. I know that your things are safe—that you are not going to start a fire one of these days.

HOPPER:

No, no. Definitely not!

MERZBACH:

Yes, I'm thinking … Is there anything else we should hash out before next time, but, I don't …

HOPPER:

See, I'm already beginning a list of things I should look for.

MERZBACH:

Very good, right.

[End of First Taped Interview with Dr. Hopper]

[Second Interview, Part II]

HOPPER:

I guess the thing is that we got me grown up in a happy family and through college, and graduate school and teaching though I may come back to some of those as they influence later things and landed me in the Navy, didn't we?

MERZBACH:

Well, we hadn't gotten to the Navy yet.

HOPPER:

Where were we?

MERZBACH:

You were just beginning to get into teaching. I asked you some general questions; you gave a few general comments on teaching, but we really hadn't …

HOPPER:

Well, there are some things then I should have said. Because, I went back as an assistant instructor at first and very, very happy to get $800 a year in 1931. Jobs were awful scare and I was—When I look at these youngsters now-a-days I can never catch up with them, because I got $800 that first year and $900 the next year and I was delighted with a hundred-dollar-a-year raise but that's where I started and of course started with all the courses nobody else wanted to teach such as mechanical drawing and architectural drawing and shade shadows and perspective and carried on all of the technical drawing activity. And then of course I had basic trig and calculus where there were large sections the youngest always got one of the sections and gradually worked into some courses of my own—mostly because for instance nobody wanted to teach finite differences. I didn't know anything about finite differences but I learned it one jump ahead of the students and taught it. And that was one of the things you see that eventually sent me to computers— sheer accident. The other thing was that nobody wanted to teach the probability and I'd had one course in probability at Yale. So I picked up the probability and eventually built it into a basic theory of probability in advanced and [?]. And there it was all a background for operations research and game theory. I couldn't have anticipated it.

And another thing during the teaching was that faculty members at Vassar were permitted to attend any other course as auditors at any time. And, I always took two courses a year and what I did was fill in my background in all of the other sciences and where I had had for instance no astronomy as an undergraduate, I took the basic astronomy course and then went on and even took statistical astronomy and began to learn all about giants and dwarves and everything else, and galaxies. So that I began to develop a whole background—I wasn't an astronomer but developed a background which enabled me to read in astronomy and understand it and that of course when space came along, I had all of that available, if you will. And I'd been interested in geology work and that of course

has been background for all of the oceanology work that's been coming along. And I took philosophy; I'd only had one course as an undergraduate and I went on and took—let's see what was it—not theories of learning but something like that. Can't remember the title of it. Anyhow and then the background history of scientific thought and all those—all that background for the philosophical side of it and then I also got off into bacteriology, biology, zoology, plant horticulture, I took more chemistry and more physics and I took some architecture and that background has been of inestimable value as I got into the computers because I could talk to the people who wanted to use them, because there are dialects and there are vocabularies and unless you can understand what a person's saying to you, you can't really make the—And in those early days you were trying to explain to the people how they could use the computer and they were trying to tell you what their problem was and there was no language, no nothing; you were trying to communicate across gaps.

And I think that was one of the reasons for the slowness of the computers going into some of the sciences and things. Because where the mathematicians and physicists and chemists were talking the same language with the same symbols, this was not true in the geology, the biomedicine and all of those areas. And it wasn't 'til we could begin to communicate with them and find out what their problems were and what the mathematical computer people could hope to do for them and you needed people with more vocabularies. And this slanted me. Those years were learning about all of the sciences and some of the arts, you see, and getting that tremendous background which I would not have had otherwise. Even with intelligent, grown-up reading without a basic course which gives you concepts, a way of thinking, the way they attack and handle problems, what the major problems are, the problem areas, where then could see the future coming, all of that you don't get from reading. Nobody could read enough to get what is encapsulated in a course. And that gave me more of a feeling when the time came of where computers could go. So that when I got into the computers later my slant became one not just toward the computers themselves but how all these other people could use the computers and how it could be made easy for then to use it which was of course the thing you see that landed me in the software and into the languages and compilers and everything. And I think that came about because of the broad background I had been acquiring all those years of going after all those subjects and meeting those people and knowing them and knowing how they yearned to get into weather prediction, earthquake prediction, all these things that they wanted to know and wanted to get into and then the beginning to feel when I met the computers finally that it would provide tools. So that my drive was more not to exploit the computer itself but to make it useful to people that had problems. And of course in the economics I went on and took—as an undergraduate I had concentrated on the financial side of economics, public finance, money, and banking, business cycles, all that sort of thing. I didn't take economic theory and the social side of things like I finally took one course in ideology, which went across everything from communism to Nazism and back again. I didn't get to that side of it. I took these courses while I was teaching. And I think that without the discipline of taking the courses, much as I read I would not have gotten the background without all those courses. So, I'd never like to be in an environment where I can't take a course. And

almost any course that builds on something I've had before will give me something and they are relational for me at any rate.

MERZBACH:

At that—well, of course, this covers quite a period.

HOPPER:

This covers '31 to '43 you see.

MERZBACH:

What was you teaching role while you were doing all this?

HOPPER:

I was usually teaching five courses or sometimes six: the three drawing courses, the mechanical drawing and architectural drawing and shade shadows and perspective were listed as two-point courses instead of three but they had these long labs in the drawing room so that that took quite a bit of time. One of the most amusing things I had to go through in that was the first time I got a left-handed student. Because I was perfectly used to hitting a "T"-square with my right hand and holding my triangle with my left hand, I mean holding my triangles with my right hand, drawing with my right hand everything and I had to completely reverse everything. I used to go over there at night to figure out how to use the stuff in reverse so that I could cope with the left-handed students. And I had always been partially ambidextrous and that brought that back again and reconfirmed it so that I again could use my left hand almost as well as my right. I always had those and after having built them up and made them interesting, I brought in a lot of new texts and new material. They had gotten into terrible doldrums and I brought in new texts and new materials and above all I brought in new applications. And again, this was part of the influence of these other courses. Because when it came to mapping, having been over with geology and economics, I began doing maps that are based on population rather than—different kinds of maps based on different kinds of projections and everything where they had just done ordinary mapping. Then from the astronomy and everything I began to get into the polar mapping long before they started having it for the missiles and everything. I tucked this stuff both into the solid geometry course and into the mechanical drawing. It was about then somewhere along there that the first Snow White and the Seven Dwarfs came out and I got the bright idea that we could do something about some of our curves and things and so there is a project that when you are in the mechanical drawing class each girl made a drawing and we took the Cartesians the [?].and cardioids and each girl made a drawing. They were in quite large classes by then. Then we took one drawing board and we pinned these things up on it and snapped a couple of feet of one of the girls on movie camera. And we made them grow from [?] into cardioids and everything you see. We made them by drawing the rolling circles. And we made a movie

which actually generated all these you know the different cardioids has … well, you have a … there are a whole bunch of forms of it. One has just a knob of it and finally you get it with a loop and then the loop breaks off and goes inside and everything and they're in the whole family and we made them generate all through the whole family and made a movie of it. So that … You see the outside influences kept hitting all along the way. That was because we had seen Walt Disney's animated cartoon. Alright let's make our curves come alive and we did some of the same things with some of the mapping giving the impression of moving across the pole and so on. Long before they started really doing it in advertising and space and everything. But because it was fun to bring these new things in because that mechanical drawing had been deadly. They'd been doing the same three-dimensional objects you know from three points of view with the same lettering on it for the past 50 years I think. And while they had to do that kind of drawing they also I thought should learn something more so I tied together you see the theory of equations course and the mechanical drawing and then I tied in the tie from the solid geometry and projected geometry both of which was still taught in those days. We didn't have so much knowledge; people took more time to learn things and particularly in perspective you see. And we were taking all these different kinds of projections and everything. And then instead of just studying projections I made then do maps and project the maps which was lots of fun and we invented a whole mythical country with cities and stuff and we kept projecting it by [?] all the things and we gave it a population and this began to tie into economics and that made the drawing courses a very different thing from what they'd been and we began to get students from all different majors coming to take it. We also went into graphing—using the height of something since the [?].goes as well you can give people a mistaken impression of what's happening and leaving off base zero and so on and so forth and I put that all in the drawing because all of it was practice in handling their instruments which was what the laboratory was for and once you'd learned the principle of three projections, autographic projections and learned a little bit about isometric wasn't much more to do except do more and more and more of the same thing. And so I tried to drag in from all the other parts of the different courses and everything and things that they were meeting in the outside world like animated cartoons, the graphs which were beginning to appear in all the papers and everything they weren't so current before that. Much of this developed in those years between, oh, I guess the end of World War I and the beginning of World War II. A lot of this was growing and developing then and I kept trying to pull them into these courses and of course solid geometry had been dying for years. We began to get a little projection into it and then began to look at it from a different point of view. I began dumping a little non-Euclidean into the solid so they could begin to understand the new concepts of space. See all of that was new then—all the Einstein stuff was brand new and exciting and it was fun to try and bring it into the courses. Then my own taking of these courses was to keep bringing me new applications and new things which would feed into what I was doing.

MERZBACH:

How large were those classes?

HOPPER:

Those drawing classes ended up by being around 75 students total before we got through. They started from about 10 students each. But as we began to go through all these different adventures into it we began to get students. You see a two-point course they could take in addition to their regular course. It was reasonable that they could and lots of them took it just for the fun of it because they knew they'd have a good time. And it built up to a very large group of students. And also led me into more exploring you see and into all sorts of fields and what was going on in those fields which I might not have been aware of had I stuck to straight-away teaching of trade and [?] and calculus and advanced calculus and theory of equations and on into my probability theory and finite differences, I might never have gotten into all this. It was the fact that I myself was taking these outside courses and being hit by these new techniques that were appearing into all kinds of different things that began to feed in. And I began to get awfully tired of the books and when they had … We were still filling cisterns as badly as you do in school you know. We still had boiler rushing at different rates and we were still taking pressure at different depths and so on and so forth and I kept turning those things into submarines and when I had to cope with cisterns I turned them into traffic arteries and put in cloverleaf's and things like this and tried to get them to study flow and when … and probability and so on began to study and you have a street so long and cars so long. and somebody parks here—how many more can you park and then if they leave at a certain rate and come at a certain rate, how many cars can you put in there and all this is calculus but there were no calculus books that had any of this. And we kept trying to invent new problems which we didn't know the answers to and piled up quite a pile of those too. and in those areas and then you know the standard calculus book the standard [?] they do have one ballistic problem. There was just beginning to be rockets you see. They were just coming before World War II; they were just beginning to mention rockets. So I had to put rockets in instead of just bullets. Then from astronomy I carried over the orbital work and see all these things criss crossed all over the place into the different courses and I'm afraid I kept changing all the courses all the time. And then I had some students to prepare for actuarial exams which I flunked beautifully. And so I began dragging some of the actuarial stuff into the regular courses instead of leaving it all in the finite differences. Brought back some of the … and the probability from the actuarial work that was practical; I brought that over into the probability course. So there was a continuing tendency throughout all those years of not just pure mathematics—they learned their pure mathematics all right but also I kept bringing in applications of it and uses of it. And when one year I taught—what was it I taught—not finite differences but the finite differential calculus. And of course at that time there was no application of it at all. And my prediction then was that the mathematics always got there first and then eventually somebody found the use for it, and that there'd be a use for that in a due course of time. But in troubling for instances these were the days when we first talked about fourth dimension and sure there was mathematics in multi-dimensional, vectors but the concept of a multi-dimensional vector and we invented all sorts of things like tables that existed in a certain place and a certain temperature and then you moved it to another room through space and time and it swelled up of course because there was dampness and

became a different table and began to get some concepts of these multi-dimensional vectors actually had a meaning which was not true in math courses in those days. That's not the way it was taught at all.

MERZBACH:

How did your colleagues in the mathematics department react to this?

HOPPER:

Professor White who was head of the department still when I first went back loved it. He thought it was just wonderful; he was crazy about it. And Professor Gertrude Smith who had been my calculus teacher and then I'd lived in the dormitory she was head of—she died just last year, 80 something, 90 something—was completely entranced by it. She was probably the most old-fashioned of the lot; she taught the best calculus anybody ever taught; she had a master's degree but no doctorate and she was also a head of a dormitory and she was a perfectly charming lady, quite pretty. She just viewed her child's adventures with delight so to speak. She wasn't quite sure it was orthodox but it delighted her. But then the younger group—older than I was but younger still—they disapproved of practically everything I did because I wasn't doing the right things, and I was going off into things which were not mathematics. And I had more than one battle but they usually fell out on my side because Professor White or Gert Smith would back me up on it. So I was allowed to keep going on and in fact encouraged. And of course the dean who had once told me that she didn't think I'd ever finish college was delighted by it. Because, well I guess one reason—same reason Professor White—was they were getting many more students into the math classes and of course the economics department was delighted they'd send people over into my classes because the probability and statistics were always background and they'd send people over. The architecture department sent people over into mechanical drawing because they were getting more than just mechanical drawing, and were experimenting with things and geology even used to send people over into mechanical drawing, and were experimenting with things and geology even used to send people over which had never been done before and so the dean liked that because it was interdisciplinary which was just beginning to be talked about too you see. And here was the math department which they had thought of as the most isolated of all beginning to draw people from the other departments and inter-relate the work, so they liked that too. But all of it you see was beautiful preparation to meet a computer with. It couldn't have been predicted so that it was almost a natural that I'd fall into it easily when it came.

MERZBACH:

Now this was also the period that you were quite interested in the history of [?] numerology.

HOPPER:

Yes, because when, I finished my doctorate, my husband was getting his doctorate at Columbia and he elected to study number symbolism and as we discovered when we tripped over number symbolism there's a long and very fascinating history of it. And to understand it as it was in the middle ages you cannot help going back to every document and piece .f paper, or stone or anything else that you can find because it seems to have traveled not along in documents and in history and everything but by word of mouth. It's a sort of folklore thing, if you will. And when you can find a great big rock in which Sargon can say that he's going to conquer some other king, I've forgotten … I've got the reference to that some where but he's going to conquer some other king because he knows his number and as soon as he knows his number he has power over him. And any day in the week you can say, oh, I've got your number and the same phraseology even has come down—not written down—but has just come down from people. Well, this happens all through this number theory business because when you say I want a square meal and the same thing is true of a square deal. And that's why you have 4 bases in a baseball game. These things are all over everywhere, everything we do constantly and to try and track back where the concept appears earliest and where the probable and possible derivations and then to track them down through literature was really quite a job and one of the things I did was I read through all 200 volumes of the pater slatner (?) and then part of the pater_____ and I read most of the books on all the heresies and read through the Egyptian Book of the Dead and read through the Epic of [?] and many of the related texts that were available from the Syrian, Babylon and Egypt, Greece, Rome down to the Middle Ages.

MERZBACH:

I gather by that time you had overcome your language obstacle.

HOPPER:

Well, I never did until I started reading those things. And then what did it was … Well, it started when I was in graduate school when I had to read things in German and there was nothing for us but sit down and read the darned book with a dictionary beside me and I suddenly found that I could read the stuff. And all the formal training in learning vocabularies, in learning grammar had done me no good. But when I got a book and when I tried to [?] a sentence I'd look the word up in the dictionary I suddenly found myself learning the language. And when I got into this broad reading I picked up Greek of course I'd had Latin but I'd never read it easily and I could soon read Latin just as well as I could English—early and medieval Latin and I picked up early Italian and I finally was reading things in Spanish which I'd flunked at college and French of course became very easy and I just began reading and each case I had a good dictionary, and I just started reading. What I didn't do and of course the reason I can't to this day is speak the grammatical language or write one is I made no attempt to study grammar; I just put the words together, and used the endings not so much from a grammar point of view as you would an equation or plus signs or minus signs to relate things and from that point of view I was perfectly alright with languages. But it was not the way they had been trying

to teach me. So something was wrong there in that I didn't get the way they were trying to teach me languages. Because when the time came and I started just picking them up myself I began to be able to read them with perfect ease. And I can to this day read most of them. As long as I have a dictionary around for a new word. But I can't speak them and until this day when I speak French practically all of my verbs are infinitives and when I speak German I still speak the way I do to a computer, I put the verb first which I shouldn't do and I don't mod … I have no declensions or no verb modifications, no noun modifications or anything but I can spit out a sentence so to speak. But I can't write it or anything though I can comprehend and I can read with no difficulty.

MERZBACH:

What were you doing in your spare time in those days? Now, that was the period that you did your …

HOPPER:

We …well let's see, I got back to Vassar in '31, and in '32 with the last … We had been given some money. We were married in '30—we'd been given some money as wedding gifts which we put away, and we found up on a back road in New Hampshire a very old farm and the house was there with 60 acres of land and the last dollars we had was $450 and we bought it. We finally persuaded them to sell it to us for that because that was all we had. They were asking I think $700. We got them down to $450. Remember that was the Depression. The house was beginning to - two windows and their frames had been stolen from it and so on, so that it would have deteriorated and they did sell it to us. And we started working on that in summers and we did much of the carpenter work on that ourselves, taking down ceilings and plastering ceilings and painting and cleaning paint off old woodwork and everything like that and a good part of our summertime went in on that. And then of course Vincent's thesis took us a great deal of time—all this reading. And we played badminton regularly. There was a faculty badminton club so that was part of the activities. Once in a while we played golf and the rest of the time I was hooking rugs for the farm and knitting things for people which I've always had to do and I've always done and once in a while getting a little painting done. They were very, very busy years, extremely busy years plus all the extra courses I was taking besides the one I was teaching and getting more and more students with more and more papers and exams to correct. I don't think there was much spare time.

MERZBACH:

Which brings us perhaps to talk about events leading up to the Navy.

HOPPER:

Well, this all goes on fairly smooth and continuous right up to December 7, 1941 you see. And, I can remember being in my office. Well, I did have there the … That year I was on

half-time and I studied with <u>Courant</u> at New York University and that's where I met all the soap bubbles, and also started to try and using all the drawing techniques making pictures of all those things and getting fascinated with making contours and things like that which again later got into the computers and wanting to make the computer draw the contours for me which we did at first with letters. But I did have that year…I was on half-time and I can still remember December 7th. The two of us were up in our study. We had a great double desk and we each had a window and solid books all around but there was a little radio up in the shop and I can remember the announcement of Pearl Harbor

Part of the work with <u>Courant</u> had also been one of the first defense training courses and that was the course on finite differences and solutions to partial differential equations. It was beginning to be important, you see?

MERZBACH:

You were there on one of the [?]_

HOPPER:

I was there on a Vassar faculty fellowship which permitted me to teach half-time in Poughkeepsie and half-time I was in New York.

MERZBACH:

And this would have been in the academic year '41, '42?

HOPPER:

Yes, it started in September "41, two semesters I was there. And one of the courses I took …I took a regular graduate program—course I couldn't get another degree but I took a regular graduate program most of it under <u>Courant</u> and then took his course in method of solutions in partial differential equations which involved finite differences. But very few of us … and that one was sponsored by the government which again was one of the things which showed up on my punch card and sent me to the computers, you see which I couldn't have dreamed of. And I finished that year and then of course when we were in the thick of it, my brother and my husband and everyone wanted in. My husband was then 30—let's see, he was born in 1906 also so how old was he 37—no 25. 1906 to 1941 is what, 35. Anyway he was over age and he tried to get a commission and he kept getting turned down mostly on his eyes. He had always worn glasses. And he finally found that he could get in by volunteering under the draft, and he volunteered under the draft and went in as a private. My brother got his doctorate that winter and then he started to try and get in. He has a blind area—he can see everything before it and everything after it but there is one area just about the level of a normal blackboard—he wears glasses too. He tried every which way too and he had two things: his eyes wouldn't pass and his weight wouldn't pass; he was skinny like I was. But he finally volunteered under the draft

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and got in. Meantime, all my cousins and everybody else were all going in and there was more and more need for mathematicians to the summer of '42 since they were all gone, I accepted an appointment at Barnard and taught there in the accelerated summer school for training mathematicians for the war effort and I was there that summer at Barnard. And while I was at Barnard, the midshipmen from the training ship down at the river kept marching by that dormitory every day and the more they went by the more I wanted to be in the Navy also. So I started to argue with Vassar as to whether I could join the Navy or not. You see, our whole family was in—everybody except my sister who had small children and wasn't acceptable. You see the summer of 1942 they organized the WAVES and one cousin was a nurse and another one had gone in the WACS and the girls were beginning to go too and I wanted in. But they classified… Mathematicians were an essential industry and you could not leave your job to go in the services without permission. You couldn't even transfer jobs without permission. If you didn't get permission what you was when women first went in a big way out into all those plants. And I was beginning to fell pretty isolated sitting up there, the comfortable college professor—all I was doing was more teaching, and I wanted very badly to get in and so I finally gave Vassar an ultimatum that if they wouldn't release me I <u>would</u> stay out of work for six months because I was going into the Navy period. And I did join in December of '43. I finally got things so I could go in and I reported to midshipmen's school in April of '44 and right in the class with the students I'd just been teaching and the ones I had just taught and the ones that I was about to teach almost. And of course I was definitely older than most of them. And I had not been studying for exams and had all the difficulties of someone who has not been memorizing, 'cause I had one course in the organization of the Navy and I could figure out anything that derived itself logically, but that wasn't logical—you just memorized it and tried to put it together. Maybe if you could learn a little history you might be able to put it together that way but it wasn't logical, and I had a terrible time learning those things and I was …

MERZBACH:

What type of training was involved?

HOPPER:

One course was the Organization of the Navy. We were new still and part of our being accepted by the officers of the Navy was that we were to be Navy. And we had one course in the Traditions and Customs of the Navy. We had to have good enough sense to talk about the deck and the overhead and not the floor and the ceiling and we had to talk about bulkheads and try and make these old crusty admirals happy and we were very well brought up on protocol and the proper demeanor and what you did and I had the darndest time trying to let admirals to go through doors ahead of me and they tried to treat me like a lady and get me through the door first and we usually ended up going through together which was bad. But there was Organization in the Navy, then Traditions and Customs, Naval History, there was one on Ships and Aircraft which we had to learn to recognize the ships and aircraft. That was the only one I really shone in I guess because that again

was all my drawing and space specialization was not too difficult except I still mixed up things that were hulled out and then naval correspondence, how to write naval letters and naval reports and all that sort of thing because most of us landed in supposedly were going to land in that type of work—personnel, training, all those things stateside work because we didn't go overseas then. And there was one other course I'm trying to think what that was. I'll have my records here in a little while and I'll be able to find out what it was. That was two months; the first month we were seamen and the second month we were midshipmen. And I can remember when we first got there wearing those heavy clodhopper shoes and we had cotton stockings. See nylons had just come and it was all being channeled into parachutes and defense efforts so we had to back away. They wouldn't let us wear silk so we had to wear those horrible Lyle stockings. I've still got a pair somewhere, I think. I kept it as a souvenir. And I can remember the first…when we first got there we had to pack up all of our civilian clothes and ship them home. We had been warned not to bring too much. And then all we had at first we kept some dresses and a coat and then we had these Lyle stockings and those heavy black navy shoes and we had caps and gloves and bit by bit we were uniformed and that were fitted and we got uniformed and got into classes. But the thing I enjoyed the most there was very curious— it was the drill because it was just like dancing as far as I was concerned and I'd always loved dancing and I turned out to be very good at drill and landed up as the battalion commander. But the youngsters who came in had a rough time. To me, when I got there I'd been teaching all these courses, doing all this outside work, running back and forth from New York to Poughkeepsie and teaching Barnard and Vassar and umpteen other things trying to take courses, write stuff doing all sorts of stuff, very busy and constantly having to assign priorities and by then I was one of the guidance counselors for freshmen, and I was on the marking committee and a whole bunch of faculty committees and things as you do at the end of that many years. And all of a sudden I didn't have to decide anything, it was all settled. I didn't even have to bother to decide what I was going to wear in the morning, it was there. I just picked it up and put it on. So for me all of a sudden I was relieved of all minor decisions. All the minor stuff was gone. I didn't even have to figure out what I was going to cook for dinner, or see that I shopped for it and that I had the proper number of rationing points and everything and housekeeping had gotten to be quite a chore by then to figure out how much meat you could have and could you give dad some sugar 'cause he loved it and you might have some extra points. That's when I learned to drink most of my drinks without any sugar in them so that dad could have it. And we had very little gasoline and we had to have a car and you had to plan every trip very carefully. Well, all of a sudden I'm in midshipmen's school and all of a sudden you don't have to do any of it. It's all gone, and I just reveled in it; I had the most complete freedom I'd ever had and the amount of studying. I should have studied a little harder but it wasn't that much that weighed you down and I just promptly relaxed into it like a featherbed and gained weight and had a perfectly heavenly time whereas the youngsters were very busy rebelling against the uniforms and the regulations and having to eat what was put in front of them and everything and I was just tickled to pieces by that time to have a beautiful meal put in front of me and I'd eat it. I didn't have to do anything about it, particularly since we were in New England and meat was short of course and so right there at Northampton they fed us lobster all of the time. I was the

happiest …every Sunday night was lobster dinner, and delicious fish all through you see because we were near the coast. And they didn't ship the meat into New England. Well, I just loved that, so I didn't rebel against the meals. Once I got over the cotton stockings, why the uniforms were comfortable and I was perfectly happy and I didn't have to decide which I was going to wear. Only thing I had trouble with was making my bed - bunk. Just as I managed to get that tight enough so it'd bounce a nickel I threw a quarter on it and it didn't bounce but I had a very good time at midshipmen's school where many of the kids had difficulties.

MERZBACH:

How long did that …

HOPPER:

Two months, one month as a seaman when we learned to take orders, and then one month as a midshipman when we gave orders to the seamen and then on your way. And when I had joined, when I was at Yale one of my professors had been …oh, what was his name …I'll think of it in a minute, Engstrom had been one of my instructors in Yale Graduate School. And he had joined …he'd been in the Naval Reserve and by that time was a captain and he was down here running what was called the Communications Annex, actually it was the bunch that did all of the cryptographic work and were beginning to devise machines to break codes. And in the last year before I got in the Navy, the Navy had sent out correspondence courses for civilians who wanted to plan to be of help and I had taken a course in crypt analysis. They sent them out to the math departments and about four of us took it. I thought I was … this was the direction I'd be going in with my mathematics, the crypt analysis course and Engstrom. And I had talked to Engstrom and so far as I knew it was set up that I would be assigned to Communications Annex. I didn't know then that they were building computers to do this because that was <u>highly</u> classified. But, that was where I thought I was headed. However, in the meantime while … just before I went to midshipmen's school the request went out. The Mark I computer had been finished by IBM and had been brought in March to Harvard, and Harvard had decided to loan it to the Navy and it was in April that they had asked for it and Aiken had specified the crew he wanted. And among other things you see he'd specified the finite differences and a lot of those things. So that when they went through the punch cards in (?)View Perce, mine matched it, and instead of being ordered to Communications Annex, I was ordered to Harvard and my orders were changed during the time I was at Midshipmen's School; I didn't know that at the time. The interesting thing is that Engstrom, when he finished his time in the Navy, together with his administrative officer then a commander, Cdr. Norris …when they got out of the Navy went on to St. Paul and set up a company known as Engineering Research Associates and I went on off to Harvard you see. And of course eventually just to jump a bit when I was ready to leave Harvard I had job offers then of course from Engstrom and ERA and Mauchly and Eckert-Mauchly and eventually we all ended up together anyhow except that Norris broke off and formed CDC so that even that far back I knew the people who were

eventually going to become computer people. Because, you see, the whole heart of UNIVAC for instance to this day is that original Communications Annex. You see MacDonald who is now president of UNIVAC was then a lieutenant out there. And the vice presidents …and so on, the whole structure …I'll have to get it—we'll have to look it up some day and figure it out is derived from that original Navy Communications Annex and they are all Navy. It's just amazing. So having got me into Midshipmen's School is that a good time to stop today.

MERZBACH:

I think so.

HOPPER:

I'm on my way to get to Harvard.

MERZBACH:

We might just take a couple of minutes … Say, you mentioned Courant—could you comment a little bit about your impressions of him?

HOPPER:

Well, I had worked, you remember, with Henry Seely White who had been at Gottingen and with Smith at Yale who was in the Gottingen tradition and when I got to Courant it was like coming home again. Courant other than being a researcher and everything else was a teacher. He was a terrific teacher…was; he's still alive. But I mean being with him…I was just in sheer pleasure again working. That's of course, why I wanted to go there because Courant was there and 'cause I had heard of him. But the sheer delight and inspiration of a teacher like that was fascinating and I had not only the partial differential equations but also the calculus of variations I got there and several others; I forgot…well something on one-Euclidean or in the area of differential geometry there. He had one trick though; he gave the lectures and then you had to write up his notes for him. And then, it was his students' notes that went together to make those books. But he's just one of the most delightful people to study with I've ever known in my life. I had a perfectly gorgeous year. Of course, he scolded me at intervals, just as all of the others did because I kept doing unorthodox things and wanting to tackle unorthodox problems. I enjoyed that year tremendously. He is a topnotch lecturer, cute accent, but you never went to sleep in his classes; there was always something going on. You were learning something—it was sheer pleasure.

[End of Part II]

[Part III: Taped Interview with Dr. Hopper]

HOPPER:

Today is the July 27, 1968.

MERZBACH:

We had you in Midshipmen's School and you'd received your call to Harvard. Do you want to take it from there?

HOPPER:

Well, when I got to Cambridge, the first thing I had to do was find out where I was going to report. My orders read Navy Liaison Office which we finally found in the basement of one of the Harvard buildings. There was another girl also reporting there. Then they told me I was to go over to an installation in Cruft Laboratory. That's all they told me, and gave me directions of how to find Cruft. And I got down in the … and got the guard on the door and he took me downstairs and I was introduced to Cdr. Aiken, Howard Hathaway and he found out who I was and he said "Where have you been?" And I was a little bewildered and at that point of course thoroughly scared of a commander and I said I'd just come from Midshipmen's School and he said: "I told them you didn't need to do that," which of course was sort of an abrupt greeting and he said: "Have you got a place to live," and I said "no," and he said: "Well, get to work and you can get a place to live tomorrow." Meantime there was this large mass of machinery out there making a lot of racket 'cause it did not have the case on it then. It was all bare—all open—it was a very noisy computer. And he took me around the door and into the machine room and said, "That is a computing machine." All I could do was look at it, I couldn't think of anything to say at that point. And he then gave me a rundown on it and introduced me to two ensigns, one of whom was Robert van Dyne(?) Campbell who had helped him with the design of Mark I and the other was Richard Milton Bloch. And they were the ones that taught me programming, particularly Dick Bloch. I later found out that they'd been selling each other … trying to bribe each other as to which one would have the desk next to me. Because they'd heard this grey-haired old school teacher was coming and neither one of them wanted the desk next to me and they were trying to bribe each other to see which one would get it. Aiken explained what the machine was for and particularly the interpolators and then said he wanted me to program a tape which would calculate our tangent functions and gave me a code book, a little …a few pages. I think I gave you my copy of that or if not I should've, and that was it! And then he gave me a week to do it in—to learn how to program the beast and to get a program running. And I think I also gave you some of the coding for that itself—some of the actual coding—some of the stuff from my notebook.

MERZBACH:

I have some Xerox copies of it here. This is the sine.

HOPPER:

I think the arc tangents may be in there too.

MERZBACH:

Here it is.

HOPPER:

Yeah. Well that was my first sufferings and if it hadn't been for the whole crew, I assure you it would have never gotten done.

MERZBACH:

Now is this the one that you used?

HOPPER:

Yes, that's the coding manual as it stood, yes. Some of my notes are on it and additions of things we put in later.

MERZBACH:

This is what he handed you …

HOPPER:

That's right, that's it—now coded, and that was all the crew there was at the time. There were the enlisted men who were operating the computer and there was still at that time several of the IBM engineers around, because it had not been completely debugged yet.

MERZBACH:

Now what precisely was that date again?

HOPPER:

I reported on the 2nd of July, 1944. It was quite a while ago, and we plunged right into it. Then later there were other additions to the crew who joined us. One other WAVE joined us, Brendel, and we started right off with assignments from … We were then on …from the very beginning we were under the Bureau of Ships but it was very shortly taken over by the Bureau of Ordnance and put on ordnance jobs. We did not know that we did some of the atomic energy computations until after the first atom bomb had been detonated. But von Neumann was up there and all of those people from Princeton where there at

intervals. And during that first year I think we saw anybody, everybody and met everybody that was at all concerned with computing anyway. It was fascinating. It was a hotbed of ideas and concepts and dreams and everything under the sun.

MERZBACH:

During the first year do you recall what were the main problems that were dealt with?

HOPPER:

One was a classified problem, a very big one which was run by Dick Bloch. Most of the things that I ran were fairly small. We did that one on …we were towing a dipole behind a ship and what was the strength of the magnetic field and three dimensions around it. And of course that was the point at which they said they wanted the numbers every foot and we figured out we'd deliver a cord of paper and we finally explained to them that the way the curve had attenuated they only needed it about every 25 or 50 feet, and finally told them they only wanted it every time it changed, and we cut it down to two volumes. I did quite a lot of smaller programs for different special jobs. I don't remember anything in particular …measures and partial differential equations and things of that sort. The big job was the job that Dick Block did. Bob Campbell was mainly working … by then we shifted to design the beginnings of design for MARK II, very definitely. And of course part-way through that first year though the date on the manual is much later, Aiken walked up to my desk one day and says you are going to write a book. And, I said I can't write a book; I've never written a book and he said, well you are in the Navy now. And, I started work on the manual which was the first of the publications in that series.

MERZBACH:

Could you talk a bit more about this? How did …

HOPPER:

There are some rather interesting things about that manual. One, I don't know how long it's going to last because of the wartime paper. Did you notice that?

MERZBACH:

Uh huh.

HOPPER:

There's another thing that most people don't know about this manual, and that is that the headings for the chapters were very carefully chosen. And you will find, for instance, I selected this for Aiken. I suggested that (MERZBACH: Chapter one) and you will notice that it more or less refers directly to Aiken and when you come over here to the chapter

on coding (see if I can find it). I like this bit because he chose this one for me and it has my name on it, of course, because I was in charge of the programmers by then. And these were rather carefully selected and, oh well …let's say half a secret or half amusement of the crew that put them in here. I think the one on the (let's see if I can find it), I think the one of the plug boards is rather good, if I remember correctly. This was really a job putting this together. There was one section there on the Division … I think this is rather cute on plug wires; one deviates to the right, another to the left—varies the same one sees it in different ways. That's real bug-hunting for you…We took a long time to find that one. We had a lot of fun finding those. There was a very happy crew. This historical introduction was rough because not being able to travel all I had was the Harvard Library, and I just dug out everything I could find in the Harvard Library. Nobody had done this before to look up development and history of computers has never been put together. The math history has told us a little about the abacus but they completely neglected to mention any _____ I guess they put in Pascal and Leibnitz and that was all. And finding out about the rest of these things was quite fun trying to find them. And I think anybody who does get into computers at some time … we should make it available … there should be a reprinting of the original Babbage things because they are delightful to read. And they would be reread and there are still some ideas in them that we haven't implemented. The job of writing out and designing all these circuit drawings were fantastic and we had to even invent this type of drawing, these timed drawings, the timings and the circuit diagrams that correspond to them. Those were a new type of drawing to show how it worked … to try and explain it to people. Because back in those days you really had to know every relay and how they were working or you couldn't debug a program. Because you never knew whether it was a relay or your program. And you did need to know these timings because _____could slip, the timing on them could slip and the bug could come from the fact that this one held too long—didn't drop out at the right time or it didn't pick up soon enough so this one didn't get picked up, and things like that. It was a very different world from the present-day computers. But all-in-all that computer ran <u>amazingly</u> well.

MERZBACH:

Who handled the drawing _____?

HOPPER:

Oh, I drew those.

MERZBACH:

You drew those.

HOPPER:

Oh, yes I drew all those circuits; this was my job. This was again … these this listing of the relays and the sequencing of operations of what the relays did. That was a new… these were …this was done much of it so we could run the computer. We needed to know that these things were. If this relay wasn't working, what did it do? Well, it picked up this and held it and so on.

MERZBACH:

How was the work divided, particularly say in the first year or so? I mean who did what?

HOPPER:

Well I was working on this and trying to get the material for it together. Much of this existed in notebooks and stuff before it was actually written up so that we could run the computer and I was also more or less governing the programmers. The …now where is the list of the crew and I can go down it and tell you. Aiken, of course, was running the outfit and also was working with Washington on the beginnings and everything for MARK II and working on the contract and specs and everything like that. Goheen… Harry Goheen came in later. He came from a research group and he handled run-of-the-mill computations as they came in. And I was handling … more or less keeping track of the junior programmers and writing this manual. Dick Bloch of course was on the big classified computations particularly the work for von Neumann. Bob Campbell was working with a commander on the design of MARK II, on the work for MARK II. Brooks and Lockhart as the same as me were running the general run of problems and they came in they were assigned to different people. I may still have a list of those assignments; I'll have to find out if I have it. There is one person missing that we may find in the next one—one officer missing—Arnold, Arnold.

MERZBACH:

Well I was going to ask you who was the _____

HOPPER:

Arnold never should …Well I can't say it that way. He wasn't really a naval officer; he was still a college professor, I guess. He was the one who was a real mathematician and absolutely refused to admit that there could be both a positive and negative zero. As far as he was concerned zero was positive and that was it. There couldn't be a positive and negative zero and since the test register tested on positive zero and went the other way if it was negative zero every time his programs didn't run he'd get on the computer, it wouldn't run, and it'd blow up and everything. The commander would come storming into my office and say find out what's wrong with Arnold's routine? And I'd get out there and the first thing I'd always look to see if there was a negative zero around because he'd probably ignored it again. He'd never, never, never, never learned that. He was also slightly a health faddist and I can remember the day the commander found him eating

raw liver, which had disgusted all the rest of us, we'd left and the commander told him to throw it out. He also came in … he had another spell when he was drinking carrot juice. And by then we were the crew … He'd been made executive officer and the crew was getting a little bit restive and we stole all of his cans of carrot juice (we borrowed them) and hid them in the commander's bookcase, while the commander was in Washington. Then the commander came back and found the carrot juice in his bookcase and threw it all in the wastebasket. Then Arnold came in about then and said that the crew had been insubordinate while the commander was away and the commander said well if you can't manage them you aren't a lieutenant commander and there was quite a session.. Anyhow about then he assigned to Arnold the job of developing the bibliography which is in the back of this. So Arnold went over and spent his time in the Widener Library.

MERZBACH:

Well I was wondering … was he primarily responsible for that bibliography?

HOPPER:

Yes, he did the whole bibliography, mainly I think the commander wanted him out of the laboratory because the crew was insubordinate to the executive officer … I'll admit it, we were. We played all kinds of tricks on him. We were insubordinate, I guess, except he'd just asked for it, I swear he did. So, he went over and retired in the Widener library in a period only to get the stuff typed. However that is another first I think. I think that is the first attempt to pull together a bibliography of all the computing techniques and everything else that would be useful to people who had computers.

MERZBACH:

Yes, it's a very extensive …

HOPPER:

He did a very good job on it, and this was where he belonged—in the library.

Chief Porter was back from the Pacific and he was a chief—a typical chief. He never did manage to learn anything much about how to run the computer. But he was a real good electrician, and he was real good on bugs and he tried to keep the crew in order but that didn't work very well either because the officers didn't help him.

Frank Verdonck, the yeoman, was a very bright youngster. He is now at MIT in the purchasing department, I think. He did all, or a good part …he and Ruth Knowlton did most of the typing on getting this book out.

Delo Calvin, Hugh Livingston, Mahoney—John Mahoney, Whiz White, Gary Huntsberger and Hourihan all of them were …the first four of them anyway were ex-IBM.

And at present Delo is back with IBM in Poughkeepsie—Delo Calvin and is in charge of publications and things for training. I don't know what became of Mahoney. I don't know where he went later. And Whiz White is back at IBM and he's at IBM Poughkeepsie.

Huntsberger and Hourihan were not basically computer people. They were electricians. You see they were machinists' mates and they dealt with the … they were maintenance personnel. Joe Harrison had his Ph.D. and I'm surprised that he isn't shown here as being a Navy officer because he was a Navy officer, and is now a commander in the reserves. He's now out at NBS directly under what's his name … Herb Grosch … he's directly under Herb Grosch and of course has his doctorate in math.

Bob Hawkins is still at Harvard. He was from IBM and joined the Harvard crew and he was the one that really kept that machine running, he was terrific. He and John Roche were the ones that really kept things going, kept the thing running. They were both maintenance.

Fred Miller was also a Navy officer and I'm surprised he isn't shown on this list as a Navy officer. He is now up at Honeywell. He was at that time a lieutenant. I don't know what he was when he got out, but he was a Navy officer. I'm very much surprised that he isn't shown on this list as a Navy officer. I don't understand that as a matter of fact because both Harrison and Miller came in there as Navy officers.

There's one person who came in a little after this was finished and will show up in one of the next books and that's Ed Berkeley. And, he came up on special assignment from Dahlgren and he was part of that original crew. That's the Ed Berkeley that's published all the books.

MERZBACH:

Oh, I see.

HOPPER:

Yes, he was a lieutenant commander. He was a lieutenant commander and he was there but on special assignment TAD from Dahlgren, from the Naval Proving Grounds at Dahlgren and he was a consultant on the building of MARK II.

Miller eventually became the engineer in charge of building the MARK II.

Joe Harrison of course after he got out of the Navy spent some time at UNIVAC, and then went to JPL and from there he went to a classified activity and then finally he's come out into the open again out at NBS.

Fred Miller I saw at Atlantic City last year at the ACM meeting. He's still at Honeywell and _____.

Bob Wilkins became one of the design engineers on MARK II and MARK III and then eventually went to Honeywell. When Dick Bloch went to Honeywell to build …what's the name of that computer, it went to Point Margo—the first Honeywell computer—it went to Point Margo. I'll think of it eventually. Bloch was the design engineer on that. Wilkins designed all the peripherals and the mechanical gear for it and Miller went with him also to Honeywell at that time and a new crew came in and built MARK III. Does that account for most of the people here?

MERZBACH:

Yes. I've had some questions… One thing I don't understand in looking through … Do the lists contain people who may have been involved with the particular projects say outside …

HOPPER:

It's supposed to be the whole crew that was on board at the time.

MERZBACH:

Well, now this is the volume on the _____conference, and I notice … which … actually I think it appeared the year before in '45, would these …

HOPPER:

This was the crew at that time and this is a later crew.

MERZBACH:

So this in fact was permanent …

HOPPER:

This precedes that.

MERZBACH:

Yes, it does, it does. These people were regular.

Computer Oral History Collection, 1969-1973, 1977
Grace Murray Hopper Interview, July 1968, Archives Center, National Museum of American History

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HOPPER:

Chuck Bissel incidentally that operator I'm afraid was disciplined eventually and removed from the crew. You notice here's Robert Rex Siebert. He was there as a civilian; he is now at IBM in Poughkeepsie and he was a doctor, a Ph.D. too. He was there as a mathematician. Wendell Ferry was a consultant on the work done in this particular book. That's right he was a consultant that's why he is marked separate. Dave Wheatland was an administrator for Harvard. He was the liaison administrator for Harvard.

MERZBACH:

Yeah, I was curious what he was …

HOPPER:

In each case these were the on-board people at the time the book was published, regardless of whether they were concerned with the particular book or not. The idea was that the whole crew—those who ran the computer and maintained it and did the typing and kept the whole place going. All really shared in any job that was done so that everyone was put in.