Computer Oral History Collection, 1969-1973, 1977

Interviewee: Philip Morse
Interviewer: Richard R. Mertz
Date: December 16, 1970
Repository: Archives Center, National Museum of American History

MERTZ:

This is an interview conducted on the 16th of December 1970, Professor Philip Morse of MIT at his office in Cambridge. Professor Morse, would you describe your early or initial involvements with computing machines in your undergraduate work at Princeton?

MORSE:

It wasn't Princeton.

MERTZ:

Oh, excuse me: Case.

MORSE:

It was at Case--Case Institute. Well, it's a little hard to make a division between computing equipment as we think about it now and the usual "S" computers and, and various analog forerunners, but my bachelor's thesis--when I worked as an undergraduate, as a research assistant, as an undergraduate at Case--first involved the analysis of the data of Dayton C. Miller on ether drift .. which involved the Henrici harmonic analyzer. That work was done and then a similar work was done on star drifting, .. that's a way early forerunner of much work that's been done since on star movements .. around the sun using again the Henrici analyzer and this –

MERTZ:

Was this at Case or was this –

MORSE:

This was at Case. So this got me, to some extent, interested in the, in the use of equipment of one sort or another to analyze data and to work up theory, physics theory. Not much of that was done at Princeton during my graduate work as I was busy catching up on quantum mechanics and some of the newer

developments in physics, but it still was true that even there I was interested in getting numerical values to check against data and .. was interested in using what computational equipment there was then available.

[Interruption, recorder off]

After I got to MIT, I .. became .. familiar with the work of Vannevar Bush and the differential analyzer and it seemed to me right away that there were quite a number of things in physics that could be done with it; that couldn't be done otherwise. At the same time, I was interested in--and still am interested--in tabulation of standard mathematical functions that are of use in, in theoretical physics. And during the WPA days back in the early thirties, I had a very small WPA grant for the calculation of the various functions. And there were a number of tables that came out that are still of some use in physics.

MERTZ:

What were these tables calculated on?

MORSE:

Hand –

MERTZ:

Desk calculators?

MORSE:

Desk calculators, yes.

MERTZ:

During your graduate days at, at Princeton, ...were the computational problems which you worked on again in using digital hand calculating machines?

MORSE:

There weren't very many. And what there were straight hand calculating problems. Yeah, desk calculators. The things that I was catching up on was my graduate work, which was mainly the analysis, the mathematical analysis, rather than the numerical calculation. But, after I got up here, there were a number of things that we needed to go on for and get numerical values. There was a book that Stratton and I and Chu, C-h-u, got out on steroidal functions, which was a set of tables, a number of these.

MERTZ:

And those were based on desk calculators?

MORSE:

Most of those were desk calculations. Some of them were on the Bush differential analyzer, and there were a number of analyses, particularly one on the scattering electrons ..., which did use the Bush differential analyzer. It was perhaps one of the very first of the calculations of a non-separable equation involving more than one electron in an attempt to do an exact solution on the multi-electron problem. This was possible with the differential analyzer if one did some rather fancy programming--not exactly programming--you changed gears in the differential analyzer rather than programming.

MERTZ:

About when was it that you abandoned –

MORSE:

This was, oh, '36, '37, '38, something like that.

MERTZ:

And it was then not on the Rockefeller –

MORSE:

That's right. No, it was the early one with the threads and the gears and all the rest.

MERTZ:

Was the margin of error, the place accuracy be sufficient in the machine, was there a great problem of error in that office?

MORSE:

No, if the error was fairly large, it probably was not much more than a percent, but it was at least that. Nevertheless, this was the first solution of this non-separable equation that had been obtained at all, so that that kind of accuracy was pretty good. Enough to give us an idea of what was going on and it filled out some calculations that both Alice and I had made on a desk computer earlier on symbol scattering. Well, at the same time there was this work with the straight desk calculators in getting the tables of functions. Then during the war--there was first, of course, the period before we got into it where there was a fair amount of data to be maintained, but most of this was just again done on a straight desk calculator. When the Operations Research Group of the U.S. Navy was formed, very shortly after we got into the war, one of the very first things that we faced was this question of rapid collection and analysis of data, particularly on, on submarine sightings

and attacks.

MERTZ:

Excuse me. Had you been in the Naval Reserve?

MORSE:

No, no. I was, early in '38, '39, '40, '39 and ,40, I was doing work for the Bureau of Ships on underwater sound. Having written a book on sound, I was supposed to be a specialist in it and we had a fairly good-sized group up here reading measurements and the sound of everything from submarines to--I don't think there was a battleship that came up, but there were several full-sized cruisers came up and wandered around for us. So, when Pearl Harbor came and we began to lose a very large amount of shipping on the East Coast, underwater sound was a part of submarine problems, and I was asked to organize this group. It soon got way beyond underwater sound. A question of analysis of what actually happened and the use of all sorts of equipment and weapons--the usual standard operations-research problems. But, one of the crucial points was to keep really up to date, within 24 hours, on everything that happened in both oceans with regard to enemy submarines.

MERTZ:

This was ASW kind of problem?

MORSE:

This was to begin with, yes. And so I guess we were the first group that set up a, an IBM card program, one of the very early card programs –

MERTZ:

CPC?

MORSE:

Something like that. I forget. I don't think it was even called that then.

MERTZ:

Was it a ... tabulator?

MORSE:

Well, there was a tabulator and all the rest of the thing. Of course, you had to wire each problem.

MERTZ:

On a plug board, you mean?

MORSE:

Yeah. But it was the most up-to-date IBM had at that time, and we persuaded the, Admiral Kay to put that in as the data gatherer and analyzer. It bothered IBM because, of course, since this was in highly sensitive data they weren't allowed to get in to service the thing.

MERTZ:

Oh, they weren't. This is very unusual.

MORSE:

Yeah. And as a matter of fact, they had, every so often, they had to close the whole thing down and bring a man in to check it over. But we had, in the meantime, hired a man who was an IBM specialist who could do most of the minor servicing. So, we were able, for instance, every morning that top, to present to the top level command, the latest thing that had happened--the sightings, where they happened, what happened, all the rest. The records were all kept on punched cards. And this enabled us also, of course, then to analyze each of the attacks and the sightings to find out whether the Germans were doing anything new or whether our equipment was doing what it was supposed to do and the rest.

MERTZ:

And this then worked--there was some work that did involve, I think, a liaison with the Naval Security Group –

MORSE:

Well, the data on all these sightings was one of the more closely held things so that the whole business was inside the, the top secret enclave.

MERTZ:

I see.

MORSE:

And, as a matter of fact, only a certain restricted number of our group were allowed to go

in. We could ask for the data, but only those people could go in and get it.

MERTZ:

Which might account perhaps for the priority you got in getting the equipment because of this –

MORSE:

No, there wasn't any question [Laugh].

MERTZ:

It was pretty much in demand.

MORSE:

Yeah. That's right. But I think for a while this was the only piece of IBM equipment in the, in the Navy Department down in Washington. The old Navy Department on Constitution Avenue. .. Then about '43, I guess it was, early '43, when we set up a subsidiary group out at Pearl Harbor to service our own submariners, .. we got a duplicate of this installation, in out at Pearl Harbor. Again, very much with IBM's worry because, again, it was inside of a high security fence, but it kept the data on all of our submarine's sightings of everything going in Japan. So I began to get more and more acquainted with at least the beginnings of the digital field. Then ..

MERTZ:

Was there any related R&D activity so for as .. serial developments of the IBM equipment?

MORSE:

No, I was simply using it.

MERTZ:

I see. It was really a means to an end.

MORSE:

Just using it. Yeah. And soon we came back here for a short time after the war before I went down to Brookhaven. It got acquainted with what Forrester was doing and also--oh, the man at Harvard.

MERTZ:

Aiken? Howard Aiken?

MORSE:

Aiken, yeah, Howard Aiken. Although I didn't use, at that time, didn't use either of their equipment. Partly because they were both pretty--I don't know whether you knew either Forrester or Aiken --they were pretty individualistic and slightly prickly kinds of people, and at the time I hadn't got started on anything that needed that competition, although I was interested enough to keep aware of what they were doing.

MERTZ:

And did you follow the other activities, at the Moore School in Pennsylvania?

MORSE:

No.

MERTZ:

Princeton?

MORSE:

No. After cleaning up on my war work, I got involved in starting at Brookhaven and was the first director there, and that kept me busy for a while. While we were there, I did look in, again as an interested user, into these developments because it was quite obvious that the work that Brookhaven was going to be doing was going to need computers fairly quickly.

MERTZ:

Did you have any opportunity to visit the facility out at Los Alamos?

MORSE:

Yes. Yes. Didn't go into that part in any great detail, but was aware of what was--astronomy. Then, around '49 .. I was called again back to Washington to organize the ... Weapons Systems Analysis Group for the Joint Chiefs and, again, I was interested, again as a user, in seeing the development of computing in this kind of operations analysis, systems analysis. And by the time I closed out connection with that group, they already had a very good size piece of equipment.

MERTZ:

That was in the early fifties?

MORSE:

'49 or '50.

MERTZ:

By that time I guess they had a very large number of going digital machines, right?

MORSE:

Yes, yes, yes.

MERTZ:

By that time I guess they had a very large number of going digital machines, right?

MORSE:

Yes, yes, yes.

MERTZ:

Did, did--was that WSEG?

MORSE:

Yes.

MERTZ:

Did they have access to some of the .. related activities? Well, out on the West Coast there was SWAC, SEAC –

MORSE:

No, .. well, most of the work they were doing was so classified they couldn't very well take it out in view, on the outside. But very shortly, it was in the fifties, they had their own small machine that they were working on inside and I think that's developing now that IDA is taking over that computer.

MERTZ:

Was this WSEG in the Pentagon where they had their computing facilities? Do you recall what kind of computer?

MORSE:

It was IBM again. It was--I don't remember what--it, it changed from year to year as those things developed. Coming back here, in the early fifties, .. I got interested again in, in the computation business and was .. I was on an advisory committee to the Bureau of Standards .. division that was developing SEAC and SWAC and so forth, so that I kept up to date with what developments were going on there. And they also were interested--it was the same division that were developing numerical tables--and there was a long discussion as to whether computers would completely wipe out the need of function tables. And we had a, we had a conference here, it would be '56, '57, something like that, that people interested in the whole numerical table field had decided that while a large number of the specialized tables probably wouldn't be needed once large computers came along, nevertheless, there was a real need for a standard table, or set of tables of standard functions. And at our urging, the Bureau of Standards set up and developed this table of functions that you probably know and handled the mathematical functions, which I guess has been the biggest seller of the Government Printing Office. It's something in the order of half a million copies or something like that.

MERTZ:

At that time, was there any discussion of such things as the MARK I?

MORSE:

Oh yes, this was well after that had gotten underway, and while Aiken wasn't at the meeting--he was busy with something else--there were people from most of the, of the computing centers. In the meantime, I had gotten interested in, in Forrester's development of Whirlwind II, followed that fairly closely. And it was fairly obvious to me that what was needed in addition to the development work that Forrester was doing on hardware, .. we needed to start turning out students who were interested in software development, but also in using, in, in using the things like the Whirlwind in all sorts of different fields. So I went to the Navy and got some money over and above the Whirlwind money to .. use for assistantships anywhere in the Institute for students that would like to do a thesis in their own field using Whirlwind.

MERTZ:

Did they then work with Charles Adams' group?

MORSE:

Charlie Adams was one of the, one of the people that we supported.

MERTZ:

I see.

MORSE:

We had a certain fraction of Whirlwind time each day where these fellows could work.

MERTZ:

That was work with so-called scientific applications as distinct from defense.

MORSE:

Yeah, yeah, yeah. And the machine at that time was declassified and so forth. We got quite a few alumni around. Adams is one and, and [Corbateau] is another. Quite a number of people around the country that are fairly active, particularly in the software end, were in this program.

MERTZ:

If I might just go back a little bit in your own career. When you were at Brookhaven, .. did you participate in any of the decisions on the type or reach of computer facilities that you mentioned –

MORSE:

As director of the whole thing, most of those decisions were made by the department heads, and while I took an interest in them, I don't remember having been a crucial influence on any particular type. In fact, I'm not sure that there was any digital computer on the site while I was there, we were

the time when magnetic core memory was just being tested out and the idea of internal --stored program, stored programs was completely new. Some of the people that we supported up here on our program with Whirlwind were the ones that started FORTRAN, for instance, and so on. This was after, this was more in the fifties than in the forties.

MERTZ:

.. I was wondering if at that time, do you recall whether there was any particular emphasis or urging placed on the Atomic Energy Commission to develop in-house computer capability. This was the era of the sort of great impulse given to the, well it was the first generation after ENIAC --high speed electronic computers.

MORSE:

I certainly didn't take very much part in that. I was more interested in making sure that we had the basic reactors and high energy machines. And while it was pretty obvious to

anybody in, in the field that the labs, each of the labs would need computers, in the later forties, it wasn't clear that-- just how it would settle down. And what certainly wasn't clear was what policy AEC had. So that came later. Coming back to MIT. .. After about four or five years of using Whirlwind and getting a fair number of people started, it was pretty obvious that there needed to be more computer time available. You see, all the way through I have not been a developer of either hardware or software in the computer field. I've been a developer of the use of the machine and the training of people that would develop hardware and so forth. And from that point of view, I've always sort of operated from the outside and just shoved was going to grow out of Whirlwind. Whirlwind was beginning to get--you know it was one of the very early magnetic core machines, and was beginning to get overly expensive to maintain and so on, and we looked around quite a bit to see what was next. And in connection with some consulting outfit, some consulting committee that I happened to be on, I got acquainted with one of the IBM top executives. And did my usual raising of the arms that, that somehow or other, the computing companies would have to support the training of computer specialists or their field wouldn't develop as fast as it ought to. .. This was Hurd, H-u-r-d.

MERTZ:

Cuthbert Hurd.

MORSE:

Yeah. And he said, "What would be needed?" And I said, "Well, what you need would be to have the most up-to-date computer on the spot, plus a certain amount of funds to expend as assistant-ships to students on campus." "Well," he said, "would it be possible for IBM to do this?" And I said, "Of course." So, in the course of a couple of months of exchange back and forth, it was set up so that Tom Watson, Jr. came up and talked to Killian and things were set up so that this was just about the time this building over is the Information Center?

MORSE:

Well, no, not now. This is the Compton Building.

MERTZ:

Compton? Aha.

MORSE:

And the arrangement--building 26--the arrangement was that IBM would contribute to the building enough so that an additional fifth, the later half of the building, plus this excess out here would be put on. This meant that the building had to be redesigned after the foundations were getting first started. This bothered the architect a great deal. He didn't like the idea, but he finally got bullied into doing it. And the addition to the

building gave the computation - the new computation center enough office space plus this place for a 704 when it was installed. And so in 1957, something like that, the thing got started. They gave us the machine free and gave us additional monies to pay for a certain number of assistantships, not only here, but among the New England colleges. And while this certainly gave a considerable impetus to the interest on the part of the students and indirectly to the faculty in the use of the computers, we were very careful to always give a certain number of assistantships to those departments that hadn't started to use computers yet--psychology and economics and things like that.

MERTZ:

Proselytizing a little bit.

MORSE:

Yeah, there were some very interesting economics, simulating-- very early simulations done on the machine here. And, of course, this was the easiest and best way of getting the faculty acquainted. You get a graduate student to do the dirty work and a faculty man had to supervise the thesis and a lot of the knowledge rubbed off. .. So this went on for about 10 years, until things got overdrawn, what IBM could afford. And also it became quite apparent that it wasn't the right way to finance a computation center to give the machine rent free because this meant that they couldn't charge the projects who had a lot of money for machine rental. And so it took a couple or three years' struggle to finagle things around so that MIT now pays rental on the machine but IBM then makes a grant for research in computer science. And that grant can be allocated in the way MIT sees fit. But since on the books they are paying rental, the projects have had to have support.

MERTZ:

It implies somewhat more perhaps efficient, or at least –

MORSE:

Well, it means that –

MERTZ:

careful examination of the utilization of time.

MORSE:

Yeah, for the time and also –

MERTZ:

Is this related to time sharing?

MORSE:

Well, this was done after the time sharing got started. But, several of the people who had been aboard. And in the meantime, we'd gotten some money from NSF for the development of software. Time sharing was sort of in the wind, so we decided we'd get started. It was a big argument for about a year as to whether the important thing was software development or hardware development. And the staff of the center down here almost blew up because of the arguments back and forth. I finally had to step in and say, "OK, it's software." And [Corbateau] with his team, was the one who developed, I think, the first workable time sharing system, with the 7040 by that time. And then the 7090. I think we had a workable time sharing system on the air almost before anybody else. The 7090 was not a particular efficient machine to do it in, but it was the one we had and [Corbateau] was able to set things up so that it would work.

MERTZ:

You have much contact with the people out at Lakeland? We have kept in touch with them. .. Sometimes more, sometimes less depending on--At any rate, let's see, about five years ago, it was obvious that the need for straight computing service was getting great enough that it was about time to separate the software-hardware development work from the service outfit. And Project Mac was set up to do the development work. [Corbateau] and his group went over there and what was left was essentially a service organization, which is now developed, which is now moved in the ICP over here. And about that time since I was getting ready to shuck off some administrative things anyway, game in general. So I'm not too much up to date inter-relationships with Lincoln, for instance, right now. to go back just a little bit in terms of teaching in the line of, did--well, in the field of operations analysis, this sort of acted as a kind of extracurricular stimulant to promote which kind of render ... computational techniques. , this particular instance was at the beginning. But, from my point of view, the two activities that I was engaged in at the time were somewhat separate. There was the advancing of the, of the arts and science of computing. As director of the computation center, the main job was to make sure that students from all the different disciplines around got a chance to find out what could be done. Machines were important and the students from center, right from the beginning, used this machine, but here the urge was to get the applied science and operations research recognized as a y good discipline in the university, and to get enough students from all different departments and schools to go into them.

MERTZ:

Well, I was going to ask, isn't, in one sense operations research, maybe I'm mis-defining it, but when it comes to the problem of formulation of computers ... computational techniques very much the same as what is based on a lot of policy ... and someone who is a graduate student who has a problem and wants to see if he can make a mathematical… but almost any science or engineering branch operations research. was just thinking that those models looked, in a sense, predate the computer.

MORSE:

Yeah, but now you have these systems where you, where the data is automatically taken by the com- you get your analyzed results at the other end. Many of the publishing group ... cosmic ray data collection, which the computer is an integral part of it together. I wouldn't say that this is operations research. It isn't. Probably true, I'm not sure. I'm not sure whether operations research uses a computer to a larger extent than, say, a modern civil engineer.

MERTZ:

I was thinking more in terms of the aspect of operations research and problem formulation.

MORSE:

Well, there is a lot of that, but there's a lot of that in ... certainly, in economics. I

MERTZ:

Yeah, this is way I was thinking that conceivably they're being terribly different things.

MORSE:

Except that operations research deals with operations. Economics is not necessarily an operation.

MERTZ:

MORSE:

No, and it's not economics. My definition of operations research is the research on operations. And an operation is a combination of equipment and men doing an assigned job--automobile traffic, anti-submarine warfare, or police surveillance of a region. Any of these things are operations.

MERTZ:

The production of an automobile in an automated factory could be a problem in which ... –

MORSE:

Yeah. That's part of an operation, yeah. Inventories is the maintenance and the running of an operation.

MERTZ:

Flow studies and traces –

MORSE:

So you study these as just a physicist studies an electron. Take data, you form theories, and you make predictions. And some of the operations are complex enough so that you can't do your prediction on the back of an envelope, so you have to use a computer. That's true in physics, too.

MERTZ:

So you tend to view these - I was wondering whether there was any sort of mutual reinforcement at the same time as development of research capability.

MORSE:

It's true of my interest in physics, too. And certainly a good many of us who are now in the development of computers came from their interest in physics. And I don't know whether it's any different now than it was then. It's just that whenever you get quantitative, nowadays you are dealing with things complicated enough so that you need a good sized computer to help you. Whether it's physics or operations research or almost anything else.

MERTZ:

There was a time, however, when we probably might experience some reluctance with a number of academic departments to think in terms of the computer.

MORSE:

Yeah. There are always--at least here at MIT --there are always enough younger fellows on the faculty and graduate students who are interested in the quantitative stuff so that if you could get to them enough support, you could get things started. And once, once these things show what they can do, then it was hard to keep up with the demands.

MERTZ:

And this, fairly decisive in this was the commit-

MORSE:

Well, this made it possible to really open things up for a while because, for a while, it made sense to provide time free and, therefore, a department that hadn't been using it at

all --such as economics or even history--wouldn't be banging up against the problem of raising money before they tried out something that was completely unknown to them. So, for the first five or seven years, it would make sense to drop the economic aspect of the business and make computing time free. Then, of course, was the headache of turning things around so that people really did have to see "is this worth it or not?" And this was quite a struggle.

MERTZ:

In the, in the teaching of--I understand that there had been an early, a fairly early course in the early fifties on programming, and that a number of people associated with Whirlwind offered in the summer to people who came through MIT.

MORSE:

We started, as soon as this center was set up, we had a two-week course before the opening of school, not only to anybody enrolled at MIT or the faculty at MIT, but also any associated universities in New England that could come in. Usually, oh, 80 or 90 from MIT and another 60 from the other schools came in and took two weeks to really pro-gram. And then usually during the year, there would be, oh, a series of --what do you call them --courses, lectures and demonstrations after 4 o'clock for students who would want to get started. We never found that it was necessary to give a full term course in programming for anybody's machine, the EE department very soon had courses in the general field of computer design and computer service. But for the students to get on the machine right now, for instance, it's simple enough so that most of them learn and soak it up by themselves in their freshman year.

MERTZ:

How about the role of some kind of guidance to assist them?

MORSE:

There are. The computation center has advisors available and there are short courses. A couple of afternoons a week, or something like that that kids can go to, but I don't know, they seem to just soak it up. I, several times, have had some of >x various subjects--physics or operations research --and when I suggest "let's do a simulation" or let's do a computation," there are always two or three in the group that know how to do it and go down and do it. I would say, probably more than 95 percent of the undergraduates now just get it somehow.

MERTZ:

That was probably not the case fifteen years ago.

MORSE:

No, of course not. Because programming was in machine language. Nowadays, programming is quite simple. I mean one has to learn a very small vocabulary- you don't know logic, you'd better not be at MIT. Are your visions in future teaching, lecturing, at least in the computer application of ... operations research ... kind of problems?

MORSE:

Well, just more--some of this operations research, I think, is the same, particularly in the large scale simulation. Simulation has been badly over-done and it's dangerous if you don't know how to use it. There's a need for a lot of it. It isn't a substitute for actual observation of data gathering. But once you've got the data, put it together and see what it means, you can see that simulations are pretty important. Then there are quite a number of systems that are complex enough, even a thing like 360/50 even 65 would be hard put to do the simulation. So, there are quite a number of our problems just as there are in any field I mention.

MERTZ:

Do these problems relate directly to the possible future developments in hardware or are they –

MORSE:

Well, some problems are just waiting until there is more hardware to do it. Much of the development of course. As far as the needs around a place like MIT goes, we've got time sharing, but it's pitifully small. I forgot what it was--a year or so ago--something like Compton 20 console were around a thousand. They ought to be linked up with operating programs where a student is assigned to take a sequence much more than the CAI concepts of prism. A lot more flexibly. Then when the software is developed, one can take a large number--particularly engineering courses--a large number of routine things which you can simply tell a student "go ahead and set up and get that program and sit down with it at the console".

MERTZ:

You did do that is a--there are some, some individuals fell that small individual ... time sharing on a larger machine.

[End of Side 1]

[Start Side 2]

MORSE:

Well, anybody who looks at the economics of hardware couldn't help but see that if you try to duplicate by completely separate individual units around a place like this or a place like New England you'd ' just be spending a hell of a lot more money than if you had a few larger machines handing out conversational consoles. If, if people can afford it, of course, it's nice to have your own nice little machine. Terrific. But any of these smaller colleges or any of the departments around here that have their own small machine, you'll find, on the average, that two-thirds of the time they're idle. This is not a good way around the road. They can afford it so nobody can kick too much. But when you start looking around the places that can use computers but can't afford it, you wonder whether this makes sense. And when you begin to get systems like the new control data STAR, way beyond anything that IBM has, that can handle a thousand conversational consoles plus a couple of dozen remote batch things, and do it flexibly by taking what they need of the core memory and using it for a time and then turning it over to somebody else. It seems to me that this is the way it's got to go. Of old-timers. In the first place, they're kind of bothered about only having a little piece of equipment under their control, but would be tickled to death to have their own computer sitting in the back room. But I just don't see that that can possibly be economical.

MERTZ:

.. One item that I'm interested, and that is among the individuals that you have known over the years that have been concerned with computers and problems of computation; who do you think, comes to your mind, who have made contributions to this program in history?

MORSE:

I'm sure you will or have already talked to Jay Forrester, and I would hope that you would talk to Van Bush.

MERTZ:

Well, he has contributed many hours of taped recordings, answers for his recent book.

MORSE:

Perhaps you can get from that, but there may be some questions he would be willing to talk about, because I'm sure there's some interesting early reminiscences in the differential analyzer that didn't get to the final edition of the book. If you haven't talked to him, certainly [Corbateau] In the meantime, of course, there are a large number of old-timers. In the first place, they're kind of bothered about only having a little piece of