

An Interview with  
ARTHUR GRAD  
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Conducted by William Aspray  
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Ardsley, NY

Charles Babbage Institute  
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Arthur Grad Interview  
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Abstract

Grad describes his work in mathematics at the Office of Naval Research and discusses the reasons for his move to the National Science Foundation (NSF). He recalls his early funding of computer science out of the mathematics program and the types of grant support provided to computer science research by NSF and the various military agencies.

ARTHUR GRAD INTERVIEW

DATE: 29 October 1990

INTERVIEWER: William Aspray

LOCATION: Ardsley, NY

ASPRA Y: This interview is part of the NSF Computing History oral interviews. The location is Ardsley, New York. I would like to begin by asking you some questions about your own background before you came to the Foundation, what you did before, maybe starting with your formal education.

GRAD: I got a bachelor's degree in mathematics at the City College here in New York and then a master's degree at Columbia. During the war I worked as a mathematician with the U.S. Coast and Geodetic Survey for about five years predicting tides. Then at the end of the war, about 1946, I went to Stanford, got my Ph.D. And then in 1948 I went to the Office of Naval Research in the mathematics branch, but shortly thereafter it became a division.

Now, the ONR supported the design and construction of computing machines. At that time it wasn't clear anyone could get them to work. Probably the largest project we had was at MIT - Project Whirlwind. I believe that originated with an idea by a man named Perry Crawford whose notion was that we could have computers controlling hundreds of aircraft in battle. But before you could do anything like that you had to have a computer capable of it. So, in fact, the project became exclusively the engineering research... a big computer that ran to about a million dollars a year and was classified for no really good reason, but I guess because of the military origins. Now, in addition, the ONR supported design of machines at the Bureau of Standards that was...

ASPRA Y: SEAC.

GRAD: ... the SEAC and the SWAC. And there were various others. They were in on the design of most of the big computers and there was also a program to support numerical analysis. And, oh, algorithms for doing arithmetical calculations on computers - fast data and that sort of thing. And then in 1959 I came to the Science Foundation.

ASPRAY: Excuse me for one moment. At ONR what was your position?

GRAD: I started off in the mathematics branch when I got there in 1946 Mina Rees was head of it. And then there was Joe Wyle, another mathematician, Fred Rigby, also a mathematician, who, when the branch became a division, headed up what was called the Logistics Branch. And there were two men named Smith - C.V.L. and A.E. Now, C.V.L. has died, and I have no idea what happened to A.E.

ASPRAY: I believe he did too, because one of his nephews or some... worked for me at one time.

GRAD: Oh, I see, so he's dead too?

ASPRAY: I believe so.

GRAD: They're dropping like flies. They became the computer branch - the two Smiths. When I first got there it was all one branch. It later became a division but it was closely knit. So we tended to know what the others were doing. I left for a year in 1953, came to the Courant Institute in New York and went back in 1954 as head of the mathematics branch where I stayed until I went to NSF. That was I guess January of 1959.

ASPRAY: What was the attraction to go to NSF?

GRAD: It's hard to remember. I guess principally not being attached to a military organization in support of basic research. When I think back I am not sure I really remember. Now, when I went to NSF I was mathematics; there was no one else there. So for several months until... I don't remember quite how long it was before I managed to hire one other person. I had to do everything. Now, there the computing was part of the mathematics. I guess it remained so certainly as long as I was there. When I got there the budget for computing was about 3 million dollars. That included both the mathematical and numerical analysis aspects and the program for helping universities buy computers.

ASPRAY: Was there anything besides numerical analysis that was being supported at the research level?

GRAD: There wasn't anything to speak of in the engineering design that I can recall. I wouldn't stake my life on my memory there, but I dare say you probably could go through the records of grants made to check on that.

ASPRAY: I have a list of the awards and it seems to me that there were some small grants awarded during that period for automata theory studies. For example, Arthur Burks at...

GRAD: Yes, there might have been. Now, we had an advisory committee that met, I believe it was only once a year, that decided on the large awards for purchase of computers.

ASPRAY: You didn't use that structure for individual research grants, though?

GRAD: No.

ASPRAY: And was the reason because of the difference in the amounts of the awards?

GRAD: Not necessarily, because some of the awards for computers were fairly small. Now, as I look back, most of the awards tended to be for the small IBM machine - I have forgotten the number now. Was it a 401?

ASPRAY: There was a 1401.

GRAD: 1401.

ASPRAY: That was a small machine.

GRAD: About 30,000 or thereabouts. And we would make awards anywhere from several thousand up to the full amount, depending on the circumstances.

ASPRAY: What were you looking for when you made these awards? What would convince you to fund a proposal?

GRAD: What they were going to do with it. How they were going to integrate it into the academic program. And I guess partially the quality of the institution, but in a sense there was pressure to have a fairly wide geographical distribution of the NSF funds, though it really didn't matter that much. The money didn't all go to the big research institutions. Besides, they tended to want larger machines. The grants would go up to several hundred thousand dollars for the big ones.

ASPRAY: Did the Foundation anticipate that the machines would be used for research purposes, or educational purposes, or both?

GRAD: Both.

ASPRAY: And education at that time meant graduate education?

GRAD: Not necessarily, although the typical college curriculum didn't integrate computing to any substantial extent.

ASPRAY: My colleague on this project has said, looking through some of the records of the late 1950s of the Foundation, that he noticed that different divisions of the Foundation would use advisory committees in different ways - that biology seemed to rely very heavily on them; physics seemed to be less so.

GRAD: Yes, that was a tradition. You see, the original staff of the Foundation came almost exclusively from ONR, certainly in the life sciences area there was a big migration to NSF when it was founded. Was it 1950?

ASPRAY: A little bit later, but not much - when Waterman came over...

GRAD: Yes. In ONR the biologists had used advisory committees for making their awards; they were accustomed to it. In mathematics we hadn't. And I don't think physicists or chemists or engineers had either.

ASPRAY: Does that mean in any way that you had a freer hand than the biologist had?

GRAD: I suspect yes.

ASPRAY: But there didn't seem to be any problem with that at the senior level of administration in the Foundation.

GRAD: No. Now, we did use reviewers, which is something we had not done in ONR. Typically we would send out two or three proposals to three reviewers. Ordinarily if you wanted to support a project it wasn't that difficult to find reviewers who would review it favorably; you would just pick people who were closely in the field. At least you knew they thought the field was worth supporting.

ASPRAY: And did the program officers do a lot of that to shape the program that got supported?

GRAD: Not really. Well, for one thing, it was not an easy job getting a proposal reviewed. We were getting hundreds of proposals, and if you wanted at least three reviewers for each proposal, you had to use a lot of people. You had to keep records to make sure you weren't overburdening any particular individual; they weren't paid. And sometimes there was a problem trying to decide who was competent in a particular field, who was qualified. It wasn't that difficult in computing and mathematics. The areas of specialty tend to be fairly narrow in some disciplines.

ASPRAY: People don't have that wide cross-view.

GRAD: I guess it's been almost a hundred years, since there have been mathematicians who knew everything in

mathematics, which is impossible.

ASPRAY: Had there been a previous person in charge of mathematics before you came to the Foundation?

GRAD: Leon Cohen had been in charge for five years before I got there. Let's see, 1959, 1954. As I recall, Bill Duran of Tulane had been there for about a year. Who else?

ASPRAY: I was particularly concerned about the earlier period with regard to computing. The first grant was given in 1954 to von Neumann for a conference and then soon after that - 1955 or 1956 - they started giving facilities grants. And I was curious to know what you knew of the start up of those programs, or the continuation of those programs. Have you seen files that you carry... or programs you carry forward after you arrived?

GRAD: The bulk of the money, as I recall, went for procurement of equipment, and those tended not to be continuing grants. So you gave them \$20,000 to help them buy a 1401. They bought it and that was it.

ASPRAY: I guess what I meant was continuing the program, not continuing an individual grant. Do you know what the rationale was for starting this program, for continuing this program?

GRAD: I don't really; I would have to guess. It seemed to be certainly sensible to help universities acquire the machines. For the most part, they wouldn't have gotten them if there weren't this incentive of the government contribution. And, well, it seemed clear that this is something eventually the university couldn't do without. It could be useful, but in an academic program where... As far as the large grants, concern for the bigger machines, that was a matter of the various research workers not being able to get on with what they were doing. Oh, in some areas of chemistry, for example, and crystallography, we just couldn't get along without them.

ASPRAY: It was during your time in mathematics at the Foundation that a separate program in computer sciences was established. Can you tell me about that?



GRAD: I am not sure I recall. If something like that happened I suspect it was purely administrative. I doubt that it altered the nature of the program in any way.

ASPRAY: Well, I had the impression that the number of individual research grants was starting to grow during the very late 1950s and early 1960s. It would be a natural administrative step to consolidate those into a program once they had gotten to a larger size.

GRAD: Well, it always was a separate program because it had a separate budget.

ASPRAY: It had a separate line budget?

GRAD: Because when I arrived the budget for computing was three million dollars.

ASPRAY: Do you know how it grew during that time?

GRAD: When I left it was five. It didn't grow nearly as rapidly as mathematics did. As I recall, that was one and a half and it ended up when I left - 9.8.

ASPRAY: Having these separate budget lines, did that mean that the traditional mathematicians were less nervous or worried about computing?

GRAD: I don't recall then that that was ever an issue. Well, for one thing, during my tenure there the mathematics budget never increased by less than 40%. There was always enough money.

ASPRAY: One doesn't start asking you these questions until one comes up against tightening of budgets. Was it during your time that the work was begun on the Rosser report?

GRAD: Yes, it must have been about a 200 page report - the Academy of Science. That all started with Phil Morse at MIT. They needed a bigger computer. They estimated they would need about ten million dollars. And I told them, well, there wasn't much I could do about it since my entire budget was only five. And I suggested to him that probably the best thing he could do was to have a National Academy study done pointing out the need for more money for computers. So the Academy duly appointed the committee to make those studies. But they botched the job. It was my opinion at the time that the... Well, I calculated that by then... You see, the government had supported computing for some years, but I would say that the total investment couldn't have been more than \$10 million - well, maybe somewhat more, but on that order. I mean, including the money the Bureau of Ordnance had put in designing machines. And that investment now accounted for a discipline which added up to... I believe I figured it must have been something like one half of one percent of the total gross national product. It seemed to me that was the kind of talk that any congressman would understand and appreciate. Now, instead, Barclay did this... Well, we had, I don't know how many people submitting reports, and eventually it was distilled into 200 pages of highly technical language - completely mystifying to any legislator. And I don't think anything ever came of it. But it all started from Phil Morse's need for a big computer.

ASPRAY: What was the Foundation's role in the report? Did you have representatives on the committee?

GRAD: Well, I attended all of them.

ASPRAY: You attended them. Were there areas in computing which the Foundation has tried to give special attention to or direction to during your period?

GRAD: No, I can't recall slanting the program in any way. We took whatever came in the way of proposals. We had an open mind.

ASPRAY: You weren't proactive in any particular way?

GRAD: No, I had a tendency in mathematics and computing both to send a proposal out for review to people who were working in that field, so in a sense that's a bias in favor of the proposal, but that was in favor of any proposal that came in.

ASPRAY: So everybody was playing by the same rules? The competition was fair?

GRAD: Yes. It was my impression, however, that some disciplines did better than others. Mathematics, for example, did a lot better than chemistry. Chemists, it was my feeling, were very hard on themselves, and they tended to give away money in very small amounts. Well, I mean, for example, when I arrived, Waterman was still signing personally every grant. Well, at the time the Foundation budget was still below the \$50 million statutory limit. \$5000 grants might have made sense, but when the budget got to be a lot larger, if you kept giving the money away in nickels and dimes he would have to spend a 40 hour week just signing proposals. It didn't make sense. But the chemists kept giving it away in very small amounts. Maybe that's the nature of research in chemistry, but on the other hand it is a laboratory science; they work in large groups.

ASPRAY: What was the attitude of the senior Foundation administration towards computing, if you remember them having one?

GRAD: I don't recall that they reacted to them at all. Well, what it amounts to is that I have no idea what their feeling was.

ASPRAY: You certainly don't remember any occasions on which they initiated an effort in one direction or another?

GRAD: No. Any such efforts would have initiated within the program. You see, you might think that something like this Academy study that Arthur chaired might have aroused their interest. But I never noticed that. That doesn't say it wasn't there. It just wasn't visible to me.

ASPRAY: One of the areas that comes to mind in terms of support during your period at the Foundation was some of the initial work in time sharing, and Phil Morse again and the MIT people getting started at NSF but then they moved over to DARPA, with all that money coming from DARPA. Was that seen as a particular for success at the time?

GRAD: No, it was a difficult problem. That is, when you see how they operate now, I would have to say it succeeded beyond anybody's expectations. There was some work in that direction. It tended to be just cycling. You would sample each terminal, maybe it's a fraction of a second or whatever it turned out to be. But I don't think anyone really had a firm grip on that.

ASPRAY: Are there any people's work or any projects, any technical areas within computing that stand out in your mind from that period as being ones that you thought were quite successful or notable in some way, or representative of the kind of support that the Foundation gives?

GRAD: I just don't remember. Certainly, the pilot program, which involved just buying computers for universities - it would have been difficult to access how well that worked. The presumption was they bought the machines and used them. [laugh] It would have taken some years before anything of consequence might have arisen from that. As far as the actual research projects were concerned I don't recall anything particularly significant.

ASPRAY: Who handled the day-to-day work on computing in mathematics during this period?

GRAD: I guess I was. I don't recall that we had anybody, any real expert. I get confused at this late date between ONR and NSF because the programs were so similar. Now, there was Bob Owens, but I believe he was at ONR. Yes, he was in computing. He ended up as head of the computing center at Virginia. I think it wasn't until after I left that they hired anybody who was a specialist in computing.

ASPRAY: A little later, Milton Groves, for example, took over. At the time that you were at the Foundation there was

still continuing support for the mathematical sciences in ONR and also support work, and that would include some computing, at least numerical analysis. There was also support coming out of the AEC for some computing.

GRAD: Yes. They offered me that job. I turned it down. I guess eventually Charlie Smith took that.

ASPRAY: I was wondering if there was either cooperation, communication with these other offices about supporting various kinds of projects, or if you saw yourselves as having different roles, and so you'd support something and they might support something else.

GRAD: The emphasis tended to be different, but I think we looked on each other as more or less parallel organizations doing the same sorts of things. Certainly, as far as AFOSR and AROD were concerned, they were just copies of that ONR modeled and NSF. I mean, all four of the agencies did more or less the same thing. The AEC, I think, emphasized computing much more. I mean, I would say certainly there was Charlie Smith and I guess John Pasta followed. I mean, they were specialists. They knew what they were doing.

ASPRAY: Do you recall conversations that you might have had with the program officer at ONR or AFOSR about a particular computing project or your initiatives in computing?

GRAD: I am sure it happened, although I can't recall any specific instance, because we were always talking to each other.

ASPRAY: Can you recall any areas in which you decided not to give support because you knew they were being supported by one of these other organizations?

GRAD: No. On occasion we might have decided to go in on something together because neither one of us wanted to put in the whole amount. It might have been too large to put into one pot. But even that didn't happen too often that I can recall. Mostly, that sort of thing would be, oh, with regard to support of things like conferences, or maybe

a journal.

ASPRAY: Was the Foundation the only organization supporting graduate students?

GRAD: All of them supported graduate students. As a matter of fact, in my opinion, that was the greatest accomplishment of all those programs - supporting graduate students. The research would have been done certainly in mathematics the research would have been done anyway. In the laboratory sciences some of them might not have been able to proceed without money for equipment. But, I mean, these people weren't going to stop their research because the money wasn't coming.

ASPRAY: Did you notice any changes in the nature of the kinds of proposals that were coming in in numerical analysis during this time because of the directions set by the computers?

GRAD: I didn't pay too much attention to that, but I am sure it happened. Certainly as people got more sophisticated the algorithms got more complicated. It tends to speed up the machine. It became more successful. Well, the more computing you did, the bigger machines you had, the more advanced the numerical analysis became. As I recall, in the early computers you had to... Well, for the input-output facilities there's always a pack of cards. Just about every machine had an hour a day of scheduled maintenance. A machine could be down for several hours; it could be down for a few days quite frequently. And this had to affect what you would consider to be a feasible calculation. But as time went on it became feasible to do a lot bigger, more complicated calculations.

ASPRAY: Also, there were new areas that were open. You could do Monte Carlo techniques; if you needed new methods for partial differential equations you didn't worry so much about truncation methods, consider iteration methods, or that sort of thing. Are there other things you can tell me about computing at the Foundation during your period there?

GRAD: I have to admit that computing was a secondary interest, because the program in mathematics was a lot

bigger. Unfortunately, I have a very poor memory for that sort of thing. I have difficulty remembering things that happened a year or two ago.

ASPRAY: Licklider, who went to DARPA as their head of computing about the end of your term of rotation, had told me a year or two ago that at that time he was running regular meetings of all the people from government agencies supporting computing to be a representative of each of the area agencies? Did you attend any of those?

GRAD: I don't recall. I don't recall ever having met Licklider, although I might have, but I don't remember.

ASPRAY: In trying to write about computing, and the Foundation's impact on it, what sorts of themes would you like to see emphasized in the book? Anything come to mind?

GRAD: I try to assess what we accomplished. Certainly, the largest impact must have been making it possible for so many colleges and universities to acquire a computer, because without them the field wouldn't have exploded quite as rapidly. I mean, after all, for the field to grow you have got to keep...

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GRAD: ... you have a voracious user of programmers, and where were you going to get them if the colleges didn't produce them? Of course, it was more complicated in those days, because you were programming machine language. So it was hard to predict what would be most useful in a good programmer who could program in three or four languages.

ASPRAY: I guess it was only 1957 that the first high level programming language was written anyway. FORTRAN was written in 1957. Was it your sense that computing was supposed to be a facility support tool for the other sciences?

GRAD: Primarily.

ASPRAY: There wasn't much of a concern about building up a science of computing then?

GRAD: We certainly supported some of that, but we weren't beating the drums trying to proselytize, get more people into the field. That is not the Foundation as such. Presumably the workers in the field were doing that sort of thing. We did have a tendency to support large groups more than some of the other programs. Large centers, like MIT, Stanford, Illinois.

ASPRAY: Do you remember any people you called upon for expert advice? People you put on your advisory board who you'd call on as reviewers when you had an important proposal to look at?

GRAD: Let's see. I try to think of who was on the advisory board. I dare say, you have a record of the names.

ASPRAY: I am not sure we do, surprisingly enough. We haven't been able to find that. Undoubtedly, there was a paper trail once, but lots of the records are missing.

GRAD: Oh, that's unfortunate. You mean, you don't have the minutes of the meetings of the advisory board?

ASPRAY: No, we don't.

GRAD: I believe Phil Morse was; Herb Simon was; I think Alan Perlis was. The names are all pretty obvious.

ASPRAY: What was the attitude towards the industrial sector at the Foundation? Was it appropriate for somebody from an IBM to apply for a research grant?

GRAD: Well, he could have, but I wasn't very receptive. They were in it for the money, and if they didn't think they



could make money on it they wouldn't do it in the first place. And if they could make money on it there was no reason why we should support them. Well, certainly, at the very beginning IBM didn't have a very progressive attitude. Let's see, the first big machine was the 701, I think it was, that was originally called the Defense Computer, and they wouldn't put any money into that. There was not a dime of IBM money in there. I forget who it was at IBM who was convinced that the electronic computer would never replace punch cards.

ASPRAY: All right, anything else you would like to add?

GRAD: No, I am sorry. I suspect there should have been a lot more that I could have remembered, but I have to admit my primary interest was the mathematics program. I was strictly ONR. I would have to say that the more interesting programs were at ONR, because they were supporting the engineering, the design, the development of the machines themselves. And that was where the more interesting work was done, where it made the most progress. Well, I must say, I am astonished at what they have done in the interim.

END OF INTERVIEW