

An Interview with

ROBERT HAWKINS

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Conducted by William Aspray

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Robert Hawkins Interview  
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Abstract

Hawkins discusses the computer projects he worked on at Harvard University as a technician. In 1940 he joined the Mark I project, a collaboration between Harvard and IBM. When the Mark I was placed in operation in 1943, Hawkins assumed a leading role in its maintenance. He describes the method for locating problems with the Mark I relays and identifies improvements made in the relay contacts enabling the machine to be run more reliably. He mentions project director Howard Aiken's dissatisfaction with the off-the-shelf components, counters, relays, card keys, and card punches, supplied by IBM. Hawkins also discusses the personality of Howard Aiken and his expectations of his staff.

ROBERT HAWKINS INTERVIEW

DATE: 20 February 1984

INTERVIEWER: William Aspray

LOCATION: Barnstable, MA.

ASPRAY: Mr. Hawkins, would you tell us something about your early education and home life, for instance? When were you born, where, and what kinds of schools you went to?

HAWKINS: Well, I was born in New Hampshire in a place called Antrim. I went through grade school, high school, and then after graduating from high school I went down to Boston and went to Wentworth for a couple of years.

ASPRAY: For the purpose of those in our audience who don't know about Wentworth, why don't you describe the school?

HAWKINS: Well, I would call it a glorified vocational school.

ASPRAY: What did you study there?

HAWKINS: I took a course they called "Electrical Construction", which was supposed to be on the electrical engineering idea. But the school itself was very versatile. It had mechanical and steam machine work, electrical work. You could take most anything you wanted.

ASPRAY: What sorts of courses did you take?

HAWKINS: I just took the one course which included a lot of the things that I mentioned.

ASPRAY: What year would this be?

HAWKINS: I graduated in 1934.

ASPRAY: 1934. So at that time when one talked about Electrical Engineering in any way one was usually talking about Power Engineering?

HAWKINS: Right.

ASPRAY: Was there any kind of control or communication engineering courses?

HAWKINS: There was, but it wasn't too well known at that time. I was primarily interested in transmission - electrical transmission.

ASPRAY: What did you do when you graduated from Wentworth?

HAWKINS: Well, that was at the time when everybody was looking for work. So I answered a lot of ads. I went to Waltham and back to Harvard and asked around. Of course at that time everybody asked what experience you had and of course just out of college you don't have experience. If you don't have experience well, they're not really interested. So finally, I went back to Harvard and - rather than stay on the street - I asked if I could just stay there and work and get experience. And that's what I did. I worked in the Physics Labs and stayed there and eventually they hired me.

ASPRAY: Who did you work for in the Physics Lab?

HAWKINS: I worked for G.W. Pierce who was the Director of the lab - Physics Lab. I was in the machine shop where they were building equipment for the labs.

ASPRAY: What sorts of equipment? What kinds of projects?

HAWKINS: Well, amplifiers and power supplies. There were special tube ovens and things of that sort. It was really a machine shop. They gave you everything to do; so I fit in there alright.

ASPRAY: What happened then?

HAWKINS: Well, about 1940, I think it was - at that time Professor Pierce had died and Professor Chaffee had taken over - I got a little itchy and I wanted to go on and do better myself. He came down and offered me a position at IBM. He said that IBM was building a computer for Harvard and asked would I be interested. Of course I was. So they sent me out there.

ASPRAY: So you went to Endicott?

HAWKINS: Yes, Endicott. I stayed there a year and a half and then came back here. When the machine was ready they shipped it to Harvard.

ASPRAY: What did you do in Endicott?

HAWKINS: Well, most of it was studying the construction, finding out where various pieces go, and how the machine performed and so forth.

ASPRAY: Was that done through any kind of formal classes that they offered "in-house", or through actually doing some of the construction, or just talking with people?

HAWKINS: This was during the war, and this project didn't have any priority. So if they could find some material to put in the machine they'd do it. And it would build up very slowly. Everything had to be on priorities during that time.

ASPRAY: Who was responsible for overseeing your work at IBM, or was anybody?

HAWKINS: Well, in this particular division there was a fellow by the name of Lake.

ASPRAY: Yes, C.D. Lake.

HAWKINS: C.D. Lake - he was the head man, and Ben Durtee was one of the designers. And Hamilton. I believe there was another fellow by the name of Piatt. And of course there were all the workmen there. This was just a laboratory, you know.

ASPRAY: Were you actually involved in putting things together as they came in? Did you work with them?

HAWKINS: No. Well, I wasn't allowed to do that - at least I didn't think I was. I went in there to see what was going on and saw how it was put together.

ASPRAY: Then you came back to Harvard. This would be in 1941?

HAWKINS: No, I came back in 1943 I think it was. 1942 or 1943.

ASPRAY: The machine was being shipped at this time?

HAWKINS: No. Harvard wanted me to work on a war project, which was one of those hush-hush things. I was sworn to secrecy. So I worked on that for nine months or a year. In the mean time, they had tested the machine out there and packed it up and shipped it down. They had to break it down. If you had seen it...

ASPRAY: I've seen the pictures of it being installed.

HAWKINS: So it's quite involved - there was a lot of wiring - a lot of connections and so forth. So that came down in 1943 I believe, August of 1943.

ASPRAY: By the time that you left Endicott had the machine essentially been finished except for testing?

HAWKINS: When I left it wasn't finished. No, they had quite a bit more to do. There were some finer things. You know - dress it up and so forth. They had only tested parts of it. But when it came down I guess everything was tested. But of course you have to redo everything because there was so much involved.

ASPRAY: I just wonder how much feeling you had for the overall system, by the time you had left IBM. I guess you had seen plans for the design.

HAWKINS: I had plans and I had write-ups on it. Believe me, I was scared along with everybody else when I first saw the machine, wondering whether you would be able to fulfill all the liabilities and so forth that you're supposed to be doing.

ASPRAY: So you came back in 1943 and worked on this other project for awhile, and then came back to working on the computation. When you came back, was this your first experience working with Howard Aiken?

HAWKINS: Yes. He was over in one of the other laboratories as an instructor, I believe. I hadn't had any contact with him.

ASPRAY: Was he responsible for hiring you to come back? Or was it just a shift of duties with money coming out of the same place? How did that work?

HAWKINS: No. I worked for this Professor Chaffee for Cruft. And the machine was being sent to Cruft, so it was his

responsibility. Howard Aiken knew of me and, I presume, he got reports from IBM as to my progress. Bob Campbell was his liaison. So between the two of them I guess they figured it was all right.

ASPRAY: So what, then, when you came back onto the project, were your duties?

HAWKINS: Mainly to keep the thing going. It was a seven day, twenty-four-hour position. I had to take care of the people that were working there and see that everything ran smoothly.

ASPRAY: Now when you say you had to take care of the people that were working there - that is you ...

HAWKINS: Well, he gave me a fellow by the name of Roche - Jack Roche - who helped me. And Jack and myself would do the testing and maintain the relays and counters and everything that would go bad. Typewriters, feed, card feed and card punch - they do break down. So we had to see what we could do to keep things going.

ASPRAY: What sorts of preventative maintenance was done on the equipment on a regular basis?

HAWKINS: He would allot us - I don't know how much time - but he did give us some time. Whether it was half a day - I'm not sure. But we would run all the tests to see that the machines were functioning properly. In the early stages we had nothing to test the cam contacts, which we later found out were one of our weak points.

ASPRAY: They were involved in the timing?

HAWKINS: Right, very much so. Then we had to devise tests to check out some of the counters because the counters had a weakness we had to find out about as we ran the machine. The little brushes on the counters (it's a rotary commutative type counter) and the little wires that they use for brushes would wear down. Some of them would make contact in both places so that we would get shorts. So we had to devise all sorts of tests.



ASPRAY: What kinds of tests would these be as best you can remember?

HAWKINS: I can't tell you. We would run counters - take a number, and run it through the series of counters. Start from say counter one and go down to counter two and then transfer it that way. In between - each time it did that you would check the original number, and if it didn't coincide with it the machine would stop. Then we would be able to find out where the error developed. That was for just the storage counters. To multiply, that was something else again. You'd have to stop the machine in various cycles and find out where the number had changed or whether it had failed. Lots of times we'd have to crank the machine by hand - in other words, slow it down.

ASPRAY: If I remember correctly, there's a common drive shaft on the Mark I. Is that right?

HAWKINS: There was a ratchet drive on the motor that we could ratchet the main shaft around. But normally it would go about 200 rpm - that's about three-tenths for every cycle. At the time we didn't have any way of checking it other than cranking it slowly to see what happened. Just visual location of errors.

ASPRAY: There wasn't any special test equipment ?

HAWKINS: None at that time, but we developed it. Oh yes, we developed cam testing and made provisions for special type-outs and things like that.

ASPRAY: Can you describe some of those?

HAWKINS: Not really. They're pretty involved.

ASPRAY: I just don't have a very good feeling yet for all your job would involve. How frustrating it might be seeing this massive machine when you knew the problem was maybe in one area or another. How would you go about attacking it? What tools you would use? What techniques would you use?

HAWKINS: Just your head and the logic lists. Of course, you would have the facilities of some mathematician around. You'd get them in on it and they would provide you with some figures to run through that would be able to pick up this error a little easier than what you might have.

ASPRAY: You'd get a mathematician to give you a worst possible case or a characteristic case of some sort?

HAWKINS: And we found it was possible to reduce the DC voltage. In other words, you would make the condition much worse. Instead of running it at 50 volts (that's what its supposed to be running at) we'd reduce to 40 or 35 and we found that the errors would be easier to pick up that way.

ASPRAY: Can you explain the physics behind that to me?

HAWKINS: Mainly because of resistive contacts. Originally the relay points were steel and the contacts were brass. Now steel and brass as a rule don't make a very good connection. So then they developed a silver wire and silver contacts in their relays. That improved the thing a great deal.

ASPRAY: When were these implemented?

HAWKINS: These were implemented after the machine was installed down here. This is some more research on IBM's part. They replaced all the relays.

ASPRAY: They replaced the entire set of relays in the machine?

HAWKINS: They did it in steps. I don't know what the finances were - whether they did it gratis or whether the government had to pay for it. I don't know. That part I didn't worry about.

ASPRAY: Naturally enough. Do you know when that might have been? Can you date it?

HAWKINS: No, I can't date it. It's the early stages - have to be 1945 - somewhere in there maybe.

ASPRAY: You mentioned the cam contacts as being one of the worst problems - what other sorts of problems were there? When I was reading some notes that Bob Campbell had written describing the Mark I, he said that the initial problem was with the number of components and didn't say anything more specific than that.

HAWKINS: Well, we've already mentioned cam contacts. The counters - the little brushes that go on the counters - would give us a problem. They used paper tape as you probably have seen and continually feeding the tape (going round and round). The tape has a little problem, if there's a hole there, it will go through; if there's not, it just hits the tape. After a while the paper gets weak and sometimes it would make it through anyway. So that's one of the things you have to find.

ASPRAY: How was that remedied?

HAWKINS: Well, you duplicate the tape.

ASPRAY: I see. So you just use it for a certain amount of time.

HAWKINS: And when you find out you have an error and your error is on the tape the first thing you do is put a piece of scotch tape over it. You've got to have scotch tape to run a machine like that. You plug the hole up with a piece of scotch tape and then you duplicate the tape and start off again.

ASPRAY: Was there any way of running a tape and its duplicate to see if they matched?

HAWKINS: Yes. We made a little test for that too.

ASPRAY: So you think that in duplicating these there would be all sorts of possible problems?

HAWKINS: We'd check this one with that one and stop the machine if there was a difference.

ASPRAY: What about any other components - were there problems with some of the other components initially?

HAWKINS: Well, they didn't fail very often. The other components would be switches...

ASPRAY: Relays?

HAWKINS: The counter drives with the mechanical knock-offs. I think they had very little trouble with the gearing. They do wear. One of the things you had to do every day was to check to see that each gearbox had oil in it. Of course the card feeds had the same problem as the counters. They had these little wire brushes. They would wear so you would get false readings. And the card punch. Well, its like any other mechanical-electrical thing - they do go bad. You have to maintain them, clean, oil them.

ASPRAY: Can you give me some estimates on how reliable the machine was? How often it was down - what percentage of time might have been?

HAWKINS: I don't know why, but it seemed to be different at different times of the year. We were in a good 80% - maybe better than that. I don't know who would have that record other than Bob Burns or somebody. He was the Chief Operator.

ASPRAY: I know Bob.

HAWKINS: He's a nice fellow.

ASPRAY: Were you more or less on call any time there was a problem?

HAWKINS: Twenty-four hours a day, seven days a week.

ASPRAY: That must have been...

HAWKINS: It was terrible.

ASPRAY: I see. Can you remember any particularly difficult situations that you had to resolve?

HAWKINS: Yes, one time we had very bad trouble. It went on for about three days. And I stayed there - I don't know how long - but I just couldn't keep my eyes open anymore. I just told the boss, "I'm going home - I don't care!" And that was it. He told me to calm down. But we did shut the place down until we all got rested and then it was nothing. We fixed it right away. If you work and work and work and work and you don't let up, you're just hitting your head against the wall. You're not progressing at all. But that was the worst time - it was a series of things that happened.

ASPRAY: Well, I imagine if you have more than one thing happen at once its particularly difficult.

HAWKINS: It's not as easy as a single thing.

ASPRAY: Bob Campbell also mentioned, in his description of the Mark I, that a certain number of enhancements were made later on for Mark I. He mentioned an electromechanical relay multiplier, a plug board sub-routine unit and perhaps some more storage units. Can you tell me a little more about those? I don't really know anything about them and how they enhanced the machine.

HAWKINS: Well, the way they enhanced the machine was they sped it up tremendously. Because, take a multiplier for instance with - I don't know how many sockets there were...

ASPRAY: I see. There wasn't a multiplier on there before. It was repeated addition?

HAWKINS: That's right. And the divider was a subtraction - it was comparisons and so forth. Now as for this relay multiplier, I got in on a little of the original, but at that time Mark IV was being installed and they shipped me over there. So I don't know too much about the multiplier itself. We had a pluggable sequence - which is a series of step switches where we could plug in the various codes, and do what we want. So if we had a routine that was a repeat, we could just plug it into that. You would have the machine call the sub sequence, it would go through that routine, then call back the main machine and then carry on.

ASPRAY: So it really was like a standard sub-routine then?

HAWKINS: Yes, that was what it was. We called them a sub-sequence. I couldn't think of the word for them. And with that we had this glorified cam tester which we were quite proud of. With a series of switches we could check every cam on the machine under load - very nice. Find out when the cam was breaking - when it was giving you a solid contact, or whether it was marginal.

ASPRAY: Who developed that device?

HAWKINS: Well, I was in on it, Jack and the boss...

ASPRAY: Jack?

HAWKINS: Roche.

ASPRAY: Jack Roche and Aiken?

HAWKINS: Oh, yes. And of course the machine shop helped us out.

ASPRAY: You used the Cruft Lab machine shop or...

HAWKINS: No, this time we were over on our own. We had a beautiful machine shop. That's where we did a lot of our fundamental research.

ASPRAY: On the subsequent machines?

HAWKINS: Not only that, but Mark III, Mark IV. Because the big things, like the big drums - they had to be farmed out. That was precision stuff.

ASPRAY: As I understand it the Mark I was..

HAWKINS: Just electromechanical that's all.

ASPRAY: Yes. It was designed using standard IBM components for the most part.

HAWKINS: The standard counters, the standard relays, the card keys, the card punch. The only things that was special was the interpolation tape and the sequence tape. They were special.

ASPRAY: Did Aiken have higher demands on the performance of these components than IBM had for their more standard uses for them? Was that a problem?

HAWKINS: Well, maybe, yes. Because they had to be reliable. All this information that we were computing was

going to the government.

ASPRAY: The problem isn't entirely analogous, but now when I think about the engineering design for the ENIAC later on, which is [of course] electrical, rather than electromechanical. Taking off-the-shelf tubes they had to devise a variety of special ways of using them because they just didn't have the performance ratings that would be required of the electronic calculator. I assume though that electromechanical devices were already fairly well-developed. They'd been in use for a couple of years and they were already quite reliable. And the uses by Harvard were not so much out of character with the other kinds of uses that IBM had for them. I mean a counter is a counter whether it is involved in this.

TAPE 1/SIDE 2

ASPRAY: You taxed them by using them so much.

HAWKINS: Well, seven days a week, twenty-four hours a day you're really pushing it. It's like giving an endurance test. And you can see that the original relays weren't really reliable enough. So, IBM did a little research on them and improved on them. It not only helped us, but it helped them with their future equipment.

ASPRAY: Was there a problem with heat dissipation in the machine?

HAWKINS: Not with that one, no.

ASPRAY: It's clear there's going to be a serious problem once you go to an electronic machine.

HAWKINS: True.

ASPRAY: But I've never questioned whether there had been one with an electromechanical.



HAWKINS: Well, we used to open doors once in a while to let a little of the heat out. But it really wasn't that serious, no. Relays take so much current, counters take so much current, but they're all pulsed. And the motor was an oversized motor, but it was the only motor that they had at the time.

ASPRAY: That didn't come from IBM, did it?

HAWKINS: Yes. They got it out of the junk pile. It was a 5hp motor. I think about 2 or 3 was all that was necessary. That's all right. I mean beggars can't be choosers.

ASPRAY: How did you like working for Howard Aiken?

HAWKINS: I got along with him fine. He was a hard man: "You do your part and you won't have any problems."

ASPRAY: Was he quite clear about what he wanted, what he expected you to do?

HAWKINS: Definitely. He knew what he wanted and he got what he wanted most of the time.

ASPRAY: Who else did you work closely with at the laboratory?

HAWKINS: I was only responsible to him - that's all.

ASPRAY: As I understood the way things worked, though - for example when he had graduate students, he'd really want them to get hands-on experience in a wide range - both the actual use of the machine to solve scientific problems but also to understand the workings of the machine. It was almost an apprenticeship program in many ways - more than a formal educational program. I could see that he could easily send out word that students would seek you out to learn more about the internal workings of the machine. Did you have close communication with some

of the other workers or students that were coming through the Lab?

HAWKINS: I don't recall too much of that. We did have fellows come and ask us questions. I think, primarily, that they were mainly interested in results.

ASPRAY: Well, that was very much Aiken's attitude I guess, more so than any other designers of the machines at that time. He wanted to use the machines rather than build them.

HAWKINS: No, he wanted to use Mark I and keep that running and get the reputation and so forth. But he loved scientific problems on the side - believe me, yes.

ASPRAY: Moving from Mark I to your experience with some of the other machines, can you tell me what kind of input you had in helping the group decide what was going to happen? For example, did Aiken take into consideration the kinds of experiences of his staff members in the design?

HAWKINS: Oh, definitely. The boss would very often have these little get togethers or seminars when some new project was being proposed. And he would talk to ? , the machinist, or he would talk to us if there was something we could help out with. Or he would talk to the mathematicians to see if there was any way that they could propose their problems to the machine - that is to facilitate easier computation and so forth.

ASPRAY: Can you give me some examples of the kinds of things that he might have asked you from your experiences?

HAWKINS: Mainly I can remember on Mark II. He was interested in what I had to say about the sequencing of the tapes, the contacts and so forth. So I proposed a method to read the tape. They worked on it and I guess they got it going. He got us all together on the relays - the type of relays that they were using. They got what they called the Aiken relays which were more reliable. It was a heavy duty type of relay, had heavy duty contacts and so forth. I

think that was what Mark II was about; everything was relay, of course. Mark III was a little of each. It had a drum and tapes and the relays. Mark IV was, of course, electronic with the drum.

ASPRAY: How much did you know about what was going on at other computer facilities at the time? Did you hear much about, say, what was going on at Bell Labs or later on, when Mark IV was going on, what was going on at ENIAC?

HAWKINS: I got in on none of that.

ASPRAY: Do you think that their problems would have been helpful to you in some way, or that their experiences would have been helpful to you?

HAWKINS: Possibly. But I had my little kingdom right there and that was about as far as I got. I stayed there for about sixteen years. Then IBM took over.

ASPRAY: IBM took over?

HAWKINS: Yes, they had their own machine.

ASPRAY: I see. They went to commercial machines.

HAWKINS: Yes. ASPRAY: What did you do after your career...?

HAWKINS: I went back over in the Physics Lab. No, wait a minute - they established an electronic design center. They built and designed special equipment for various departments in the college that didn't have the facilities. So that was very educational, as far as I'm concerned. I liked it.

ASPRAY: I'm sure your experience in the computation laboratory was quite useful in that.

HAWKINS: It helped; but of course it was entirely different. Electronics, solid state and all that - I had none of that experience. It was a good learning experience.

END OF INTERVIEW