ORAL HISTORY: Charles Harper

About Charles Harper

Charles Harper was born in Ridgeley, West Virginia in 1926, and raised in Western Maryland. In 1945, he began attending Johns Hopkins University on a senatorial scholarship, studying chemical engineering with an interest in plastics. After receiving his degree in 1949, Harper went to work for the Glidden Chemical Company in a research lab before taking a two year tour of duty in the Army, which he served mostly in Germany. When he completed his military service, Harper wanted to get into plastics and went to work for Western Electric building cable terminals. After a few years, Westinghouse opened a facility in Baltimore, and Harper was hired as a senior engineer by the Materials and Process Engineering Department to work on plastics and electronics. Harper quickly became a supervisor. He later advanced to program manager, department manager in the early 1970s, and technologies manager. During his career at Westinghouse, Harper was involved in many important projects – like Aero 13 and VHSIC – as well in as the progress of electronic packaging and plastic through developments in such things as transfer molding, soldering, and materials. He published his first book on electronic packaging in 1960, and he remained a very active writer throughout his career, publishing many books and articles, and later serving as a McGraw-Hill series editor and series editor-in-chief. Harper was also involved in professional groups such as the International Electronics Packaging Society (IEPS) which began in the early-1970s. Harper served as the first president, later helping to combine it with the ISHM to form the International Microelectronics and Packaging Society (IMAPS). He was also involved in the IEEE, working with the EI Journal and EI conferences, as well as involvement with the reliability group. Harper also taught at the Westinghouse School of Applied Engineering Science and various evening schools around Baltimore. In about 1985 he was the co-founder of Technology Seminar, Incorporated which gave public, onsite and university seminars on electronic packaging. After retiring from Westinghouse in 1987, Harper began teaching internationally as well as seminars at Johns Hopkins, the University of Maryland and the University of Dayton.

In this interview, Harper talks about his education and career, but focuses mainly on his years at Westinghouse. His time at Johns Hopkins is discussed, including his initial difficulties coming from the counties into the city, his positive interactions with GI Bill students, and studying chemical engineering. Harper's interest in working in plastics and electronic packaging is covered throughout the interview, as well as how chemical engineering fits into electronics. The structure of the Materials and Process Engineering

Department is also talked about, particularly how the engineers in that department worked on multiple projects at once, rather than one single project over a long period of time. Issues and developments in electronic packaging are discussed, including advancements – and sometimes failures – in chip technology and circuit boards, and how original designs were at times changed as they moved forward into manufacture and production phases. Harper's interests in teaching and writing are also covered, as well as his involvement with McGraw-Hill and professional groups. He also talks about his management style and the family-like atmosphere at Westinghouse.

About the Interview

CHARLES HARPER: An Interview Conducted by Sheldon Hochheiser, IEEE History Center, 13 October 2010

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Interview

Interview: Charles Harper

Interviewer: Sheldon Hochheiser

Date: 13 October 2010

Location: The National Electronics Museum, Baltimore, Maryland

Background, Hopkins and Teaching

Hochheiser:

It is October 13th, 2010. I'm Sheldon Hochheiser of the IEEE History Center, and I am here at the National Electronics Museum in Maryland with Charles Harper to listen to him talk about his career.

Harper:

Thank you.

Hochheiser:

Good afternoon.

Harper:

Good afternoon.

Hochheiser:

If we could start with a little background, where were you born?

Harper:

I was born in Ridgeley, West Virginia, right across the river from Cumberland. I was raised in Western Maryland, the Cumberland-Frostburg area.

Hochheiser:

Very good. And when were you born?

Harper:

1926.

Hochheiser:

What did you parents do?

Harper:

My father was a miner who worked in the coal mines in Western Maryland. Eventually he left that and bought a large farm which he owned and ran for a number of years. My mother was a housekeeper, a housewife.

Hochheiser:

Were you interested in technology and science as a youth?

Harper:

Yes, I was. I was just generally interested in anything academic or scientific. I didn't browse into any particular area at that early age, but I was interested in science and math and the right kind of subjects for getting into technology eventually.

Hochheiser:

And what led you to Johns Hopkins University for college?

Harper:

Well, I was led there by fortunately being awarded a senatorial scholarship by then senator, from Maryland, who was Senator [James Glenn] Beall.

Hochheiser:

Was this the state senator from your part of the state?

Harper:

Yes. He was the senator from Western Maryland. Each senator, including the one from Maryland, Senator Beall, could award one scholarship to Hopkins for each county. And I was awarded the scholarship for Allegany County which is where Frostburg is located. My high school was Beall High School, which was named for the Beall family, of course. And he had a son who later also became a senator. So there were two senator Bealls. And the young Senator Beall was in my class. He and I were classmates up until the eighth grade. And at that point his father who was the elder Senator Beall sent him, appropriately, to a prep school of some type because he wanted him to also be a senator which he did become.

Hochheiser:

Right.

Harper:

The younger Senator Beall who was in my classes up until the eighth grade died just within the past three or four years. But the Beall family and the senatorial scholarship by Senator Beall was what got me into engineering and into Johns Hopkins. Sometimes I ask myself what were the things which got me the scholarship by Senator Beall and I think it was not only the academics in which I was always interested, but also the extensive extra-curricular activities. Freshman Hopkins was difficult since in the counties the quality of the teachers is no match for the quality in cities, like no way could we match up to the [Baltimore] Poly graduates for instance. And going into Hopkins, there were a lot of Poly graduates which made the first year for people like me a little tough keeping up with them.

Hochheiser:

Right.

Harper:

Of course you catch you up in a year or so. Fortunately I had a very good math teacher in high school, an outstanding math teacher, in a subject I was always interested in. And scientific subjects. Plus, I was always very active in extracurricular activities, I wasn't large enough and strong enough to be in sports so my extracurricular activities were academic. For instance I was the president of the student council and in the senior year,

the City of Frostburg always had a day run by the students of Beall High School. I was the Mayor that day. And other things like that. And so I fortunately was awarded this scholarship which got me through my years at Hopkins.

Hochheiser:

So did you enter Hopkins with a particular course of study in mind?

Harper:

No. It was an engineering scholarship and the first year was fairly general. I could have gone in any direction. But I switched into chemical because that seemed to be of considerable interest to me at that time. So I switched into chemical engineering. And my academic career at Hopkins and my degree were in chemical engineering.

Hochheiser:

What was the curriculum at Hopkins like when you were there?

Harper:

Well, it was very interesting. It was a very strong academic curriculum of course. The year when I was a freshman at Hopkins which was 1945, I graduated from Beall High School and went into Hopkins in the fall of '45. And the fall of '45 was the end of the war which meant that the first large wave of veterans coming in on the GI Bill came in and were fellow students. So I had what I considered the good fortune of being a fellow student with all of these veterans who were three, four, five years older than me and therefore a lot more mature than me. It was really great working with these guys because while they had the advantage of having the GI Bill, they had the disadvantage of having been off fighting a war for three or four years and getting a little bit rusty in their math. So here I was fresh out of high school with math. So I worked with some of these guys and would work with them on the math subjects helping bring them up. Most of them were married, and they would have me home for dinner and I got a free dinner out of it. It wound up being a pretty good deal all around.

The math and the science subjects were strong of course. I more and more got to like chemistry and the chemical subjects and eventually leaned into - while there are many branches of chemical engineering and chemistry - I found myself leaning in the direction of plastics which was the up and coming thing in those days. Plastics were always there but the real advances were starting to be made in the late 40's and 50's.

Most of my initial work in the industry was with plastics. That was my specialty. But eventually I got into a lot of other things as you would imagine working with the electrical engineers and mechanical engineers.

Hochheiser:

Right and we will certainly get to those.

Harper:

Right, in fact it was interesting that I wound up after many years of being in industry, teaching at Hopkins. That was very interesting having graduated from there and to teach there. I might get into this more later, but it happened that there was a new branch of materials and chemistry coming into play in the field of electronic packaging and in the field of electronic manufacturing and so forth. I was right in the middle of all this in my work career with Westinghouse. And being into the middle of that plus a couple of other interests that I always had, which were teaching and writing, that played a major role in my whole career. I taught in the Westinghouse School of Applied Engineering Science, and also taught many years in the evening schools in the Baltimore area. The Baltimore City evening schools and Poly and City College, and Patterson Park were some of them. These were mainly adult education, of course, people finishing up their adult education. So that led eventually to Hopkins needing someone to teach some courses in the area in chemistry and chemical engineering related to electronics which my background and experience in the industry led me into, so I wound up teaching at Hopkins for three or four years in the late 80's, early 90's.

Glidden, Army, Western Electric

Hochheiser:

Circling back around - so in '49 you get your degree from Hopkins.

Harper:

Yes, I got my degree from Hopkins in '49 in chemical engineering.

Hochheiser:

Right. And what led you from there to Western Electric rather than some other opportunity?

Harper:

Well, actually right before getting into Western Electric I had just a shorter career ahead of that, not a large one, but when I graduated from Hopkins in '49, it was a year when jobs were tough to get. A lot of the engineers were having a hard time getting jobs because they just weren't available at that point. Well I had the good fortune, I guess you would say, of being active in extracurricular activities as I was in high school. Hopkins, like a lot of other colleges, had a student chapter of the American Institute of Chemical Engineers. I was the program chairman for that association at Hopkins, and that meant that it was my job to find speakers and to invite them. So I made friends among people in the chemical industry in the Baltimore area. One of them was the research director from the Glidden Chemical Company. While all the other people had trouble getting jobs, he hired me right away because I had worked with him so it was just a fortunate coincidence for me. That was just research, in a research laboratory and it was only for about a year and a half because I had to do a tour in the military. I had a two year tour of duty. And so I then after about a year and a half with Glidden, I did serve a two year tour of duty in the Army which was primarily in the occupation army in Germany. The war was over by that time. And then after coming out of the Army, rather than going back to Glidden, I really wanted to get into something where I was leaning towards plastics which was my specialty and towards chemical engineering. And at that particular time Westinghouse didn't have a facility in Baltimore yet, so I didn't know Westinghouse. But Western Electric did have a job for me in this area.

Hochheiser:

Right. Western's got a large plant in Baltimore.

Harper:

Yes, down at Point Breeze.

Hochheiser:

Right.

Harper:

When I got out of the Army, I was hired by Western Electric. My work there was strictly in plastics, in building cable terminals. The cable terminals in the telephone industry are

all some kind of terminations or conductors separated by plastics. They wound up being molded in plastics. The particular plastic used primarily was a polyester resin. So I got very, very familiar with polyester resins and with polymers in general. I worked for them for a couple of years actually.

Westinghouse, Aero 13, Miniaturization, Transfer Molding
Then Westinghouse opened their facility here in Baltimore and Westinghouse, being in the advanced electronics industry much more than Western Electric, appealed to me. So I applied to Westinghouse and was hired immediately and went back into the plastics and electronics field. One of the major programs at Westinghouse at that time was the Aero 13.

Hochheiser:

Right.

Harper:

I was heavily involved with the Aero 13 because the Aero 13 had a lot of electronic modules. And these electronic modules had in them some miniature tubes, capacitors, resistors, various types of sub-size electronic components. The semiconductor era wasn't here yet so it was tubes and resistors and capacitors. These components were mounted into little blocks and they had to be molded with the plastic. When I joined Westinghouse the plastic being used was polyester with which I'd had a lot of experience at Western Electric. The polyesters created a lot of problems in being used to mold modules in the electronics industry because the shrinkage of polyesters was fairly high and this would break subminiature tubes and break some of the fine leads which were no problem in say the telephone industry because there were none of these fine components, but in the electronics industry polyesters were a problem. So my first job was to get rid of polyesters and move into epoxies which had much lower shrinkage and much better adhesion, a lot of better properties in the electronics industry. And so my first job was moving from polyesters to epoxy. My first two or three or four years was precisely that.

Hochheiser:

And now is this in the Aero 13 project or did that then spread to other projects?

Harper:

The Aero 13, then spread to the other AWG-10's and Q-72's and a variety of those other electronic systems. We used epoxies in these modules for a fair number of years, but eventually we started using another form of module known as the cordwood module. And in this cordwood module, these were considerably smaller than the modules in Aero 13 in which there were a variety of sizes but they might be like three inches by five inches by an inch and a half. But as we went further and further towards miniaturization, the task was to pack the components in smaller configurations, and so we started building the components in what was known as a cordwood fashion, like stacking up the components in a cordwood style except they weren't touching one another but they were close together. And these small cordwood modules were perhaps more like, one inch by three inch by one inch or something like that, considerably smaller than the Aero 13 module.

Hochheiser:

Yes.

Harper:

So we had to find other methods of manufacturing those. Coming into the industry at that time was a technology - and this is where the chemistry and chemical engineering all come together because you now need equipment to do this - but coming into the industry was a plastic molding process known as transfer molding. The key feature was that you could mold electronic components at a much lower pressure than with all of the other molding processes. Most of the common molding processes for plastics were high pressure processes. This would break these electronic components, break the fine wires, etc., and so the chemical industry, and all the chemists in the chemical companies, plastic companies, started working on low temperature and low pressure moldable epoxies as opposed to the longer cycle curing epoxies in the Aero 13.

Hochheiser:

About when was this transition?

Harper:

This transition was probably in the early to mid 60's. It became industry wide - in fact, it's interesting just re-tracking a little bit, sometimes people would wonder what does a chemical engineer or a chemist have to do in the electronics industry. It doesn't seem to match at all because of course there are a lot of electrical engineers and a lot of

mechanical engineers in the industry. But when you think about it, everything in the world is made of materials, and materials are chemicals. Processing those chemicals into a product is a process and this then becomes engineering. So chemicals and chemistry and chemical engineering fit very strongly into electronics whereas on the surface it doesn't appear that they might. But they do.

Hochheiser:

What was Aero 13?

Harper:

Aero 13 was a radar system fitting in the nose of airplanes, I think an F-4 Phantom for instance, in some of those early airplanes. So if you would look at the system, there's an antenna in the front of the system and then behind that are all the electronics. And the electronic bays are loaded with these electronic modules which, as I say, were made initially with polyesters which were a big problem. But with epoxies they worked fine. The only thing is with the epoxies at that time, they were all long processing cycles. In other words, if you molded these modules they would have to go through an oven for a couple of hours or something like that. That's a long cycle. And when transfer molding came along and the low pressure molding with transfer molding, the cycle was minutes, a couple of minutes. And you could simultaneously mold a number of these small cordwood modules - remember I mentioned they were considerably smaller.

Hochheiser:

Right.

Harper:

So you could simultaneously mold a large number, maybe a dozen or more of these modules in a couple of minutes. So the result was tremendously improved efficiency, time efficiency, in using this. Every time I give a presentation on this I have to give some credit, great credit, to a company which developed this transfer molding technology. It was the Hull Corporation located in the Philadelphia area. A guy named John Hull ran that so I worked very closely with him. His equipment and this process became internationally used. Today they are still used everywhere. The modules today are even much smaller yet.

Hochheiser:

Oh sure.

Chip Technology, Technological Progress

Harper:

Today's components are chip-sized components. And you have chips which are directly molded. When we got into the chip technology, there was a new set of problems, both chemical and material and engineering and every other way, because the chips are bonded together or wired together with very fine wire like one mil wires instead of the larger wires that we used in the larger modules. And these very fine wires and the semiconductor chips break very easily. And they are very sensitive chemically to even plastics. So here came another leap in plastics technology to get higher purity low pressure moldable plastics. The plastics industry did develop these I can recall when the industry got into semiconductor technology and molding of chips.

Hochheiser:

Okay so we're talking now into the 70's?

Harper:

Yes. And the first chips could not be molded. They were too sensitive to impurities in the plastics and to the pressures of the molding and breaking the wires. The first chips, as everyone in the industry will recall, were chips mounted in containers. The first ones were the so-called T-O cans which were metal containers, little metal containers - T-O meaning transistor outline - and there would be one transistor mounted in this little maybe less than a half an inch, quarter inch sized diameter little can and the wires coming out of the bottom of the can through an insulating ceramic. Now another area of chemicals and electronics, ceramics, became more and more important. While that worked great, a bunch of transistor cans on a circuit board took up a lot of space. And then comes the question how could we get rid of those cans and mold the chips directly. This gets into the developments on higher purity plastics and lower molding pressures and so forth, which require a combination of both the electronics and the mechanical, on one hand, and the materials and chemicals on the other hand.

Hochheiser:

Who did you report to at Westinghouse during your early years, both as a person and as an organization within the organization?

Harper:

When the Westinghouse plant opened, one of their departments was the Materials and Process Engineering Department.

Hochheiser:

And where was this?

Harper:

It was at the Air Arm Plant right here at the airport facility. The guy who hired me was the manager of that department. I eventually moved up the chain and took his place. But Al Hamill was his name. He is dead now. I worked for him for a fair number of years, and it was very interesting. Just as a sort of a humorous side issue, in my early years of working for him he attended a conference on these new moldable plastics. He got the Proceedings and gave it to me to review and to return to him for his files. Well somehow or other I never did get it returned. And so something like five years ago - he wasn't dead yet - I found it. And I sent it to him with a little note - I'm finished with your Proceedings from 30 years ago, you can have them back now. I think he was ill then. I never heard back from him. But that was my initiation into the industry.

Hochheiser:

Yes.

Harper:

The interesting thing about the electronics industry and Westinghouse was that it was constantly progressing to newer technologies. That had influence on magazines, technical societies and everything else which we'll get into a little bit more later because with my tendency to get involved in these things, I got involved in a number of industry associations, which was a lot of fun too. So working with all of these people in a wide variety of backgrounds and a wide variety of interests and characteristics, it was just tremendously interesting. And technology was progressing along the way, too, all the time.

Project Teams, Changing Programs

Hochheiser:

In your work on these components as a chemical engineer, how closely did you need to work with electrical and mechanical engineers at Westinghouse?

Harper:

Very closely. Very closely. I'll answer that in a minute. But the combination of when you get a new contract, whether it's Aero 13 or whether it's BOMARC, whether it's AWACS, a new system. You immediately put together teams. There will be an electrical engineering design group, mechanical engineering design group, a structures group, an environmental testing group, and that kind of thing. There always had to be a material and processes engineering operation because all of these systems, no matter what the system was, again, they were designed initially by electrical engineers and then the mechanical structures and the modular constructions were done by mechanical engineers and then all the testing by test engineers and environmental engineers and so forth. But eventually they would all need input on what materials shall we use, what type of modules shall we use, what process shall we use to manufacture these. It was an inter-technology team, if you will, of electrical engineers, mechanical, all these other guys. So we would have meetings and discussions. Initially when you got a new contract there was the design group. In designing this thing, you made decisions on what type modules, what type components, what type material would you use for the modules and for the antenna and for the structure and all of these things. So consequently, it was great when I looked around the National Electronics Museum this morning and refreshed myself on all of these different systems which I was involved in. Regarding the electrical engineering group, an electrical engineering group might be with their system for years, like the AWACS team. AWACS was forever and still going. And so the electrical engineers who started in designing that are probably still there if they haven't retired. Whereas in the materials and processes, that end of the engineering, we were in every contract, every program because they all had to have modules, antennas, structures, and we made those decisions as part of the team.

Hochheiser:

So then did you move from program to program to program? Rather than say the electrical engineers who got to AWACS who may have been with AWACS for decades.

Harper:

Well yes, we would, normally speaking. I would get a call requesting the need to have some guys sit with the system designers on deciding what type modules to build and what type metals, structures we will house these things in. How will we plate these metals? What - gold, nickel, aluminum - how shall we do that? So consequently our guys, the guys who worked for me, I would assign them to work with whatever project needed them at that time. And so the guys in my department were not working on any given program all the time - they might in fact be working on three or four programs at once.

Becoming Management, Contracts

Hochheiser:

About when did you become a supervisor?

Harper:

Well, when I started with Westinghouse, with the experience I'd had with Western Electric, I was hired as a senior engineer. And then I guess within five years after that I got in the supervisory ranks and then another five or seven or eight years, management ranks. I was a department manager, I guess, from around 1970 or early-70's, something like that. But then interestingly added onto that, within a three to four year period, the government started funding a lot of programs in materials and manufacturing technology development and research and development, and so I became a program manager of new technology programs in the fields of electronic packaging, materials, processing, manufacturing technologies. We would go out and I was the point man in working with the Air Force at Dayton, the Navy at San Diego, the Army at Fort Monmouth or wherever they were when we knew they had contracts coming up for these research programs. And so I played the role of a salesman I guess to the military for a good number of years -

Hochheiser:

[Interposing] Now is this something that you did alongside?

Harper:

Yes.

Hochheiser:

So basically there were two parts to your job from the mid 70's.

Harper:

[Interposing] Yes.

Hochheiser:

- one was managing a group of people who were going out -

Harper:

[Interposing] Materials and processing engineering for design through manufacturing, right.

Hochheiser:

And another part was going out seeking new business.

Harper:

Advanced technology, advanced technology business, yes. It was referred to simply as technologies development. All of these contracts which we went after were things which would be useful to Westinghouse in their programs. And more than that, hopefully, things which would give us a competitive edge against other companies in this electronic materials and assembly. The term electronic packaging came in perhaps the late-60's or mid-60's.

Hochheiser:

Right.

Term 'Electronic Packaging,' Publishing, Conferences

Harper:

I think I can claim co-inventorship of that term electronic packaging. This is interesting - it leads off into some extracurricular professional activities. One of the magazines was

Electronic Design and one of the editors in Electronic Design was a guy named Milton Kiver. His role as an editor for that magazine was in the area of electronic assemblies. At just about the same time that he moved, he left Electronic Design and started his own magazine, called Electronic Packaging and Production, well just about in the same time period I'd written my first book. I entitled it Electronic Packaging with Plastics. So he and I both about simultaneously came out with the phrase "electronic packaging." And so he and I of course then became close friends and I wrote a column for his magazine for a couple of years or so, a monthly column.

My first book was a McGraw-Hill book. It was the first book on this subject, plastics and electronics. So that made it very popular. In fact it was translated into a couple of other languages. That put me on my way to more books with McGraw-Hill. And it put me onto more work with magazines and conferences because Kiver was a very ambitious and forward looking guy. Within a year or so after he established this Electronic Packaging and Production magazine he said well, gee, we ought to have electronic packaging conferences. No one else had done anything like that. And he did. He started [the] first electronic packaging and production conference known as NEPCON, National Electronic Packaging Conference. NEPCON was the big name in the industry for the next 25 years. I was heavily involved in that and with him and then in other things, with McGraw-Hill. That's interesting how these things tie together with these technology programs that we were getting from contractors.

Military Programs and Miniaturization

There were a lot of these technology programs over the years, branching from plastics to structures to ceramics and so forth. We had programs in all those areas, a lot of technology programs - the area of molding, again it always comes back to a material and sensitive process because of the fine components, ever decreasing size components, ever decreasing size of electronics. You know how small cell phones are today and what they were when they first came out. And likewise TVs and everything else, computers and everything else. So with all this great miniaturization a lot of our technology programs for the military would deal with miniaturization and packaging of these fine components.

Hochheiser:

Can you give me any specific examples?

Harper:

Yes I'm going to give you a couple of examples.

Hochheiser:

Please.

Harper:

There are a lot of areas, of course, but a couple of them would stand out as being really important and making a mark on the industry and giving Westinghouse a leg up in some of these contracts in this area of transfer molding. When we got into it, we were among the first organizations getting into it. It was because of our close association with the Hull Corporation and their molding presses. The Army decided to let a contract on advanced technology for industry [set] guidelines so the whole industry would have a set of guidelines for molding fine electronic modules. This contract was actually from the Army Missile Command in Huntsville. It was a three or four year contract, maybe one contract after the other. But in that process we developed the industry guidelines for transfer molding these high performance electronic modules. And therefore in our contracts for future systems, like F-16, or whatever they were, Q-72, whatever they were, we could quote what we were doing as having set the industry standard for that.

Another area in the materials area, which is broad-based in every system just like modules, are circuit boards. The original circuit boards were big and bulky systems. They might be six or eight inches by four or six inches. They would have components soldered on them such as, again, tubes and resistors, capacitors, diodes, all those things, just those components soldered onto the boards. Well, this was a sort of a clumsy bump of stuff. And there was, immediately of course, technology development programs on reducing the size of those. We got into some of those programs. One in particular related to circuit boards, a couple in particular - one of them has to do with the fact that circuit boards in humid environments will lose their quality and their performance and the resistivity of circuit boards needs to be very high so there's no electrical leakage between components. Circuit boards when they're exposed to humid environments, their electrical properties will be degraded, the resistivity will be lowered and there becomes leakage between components. So what you have to do is coat these circuit boards. That became an industry standard.

Hochheiser:

About when?

Harper:

Well this also would have been in like the mid 60's or so - everything was really moving in the period of the 60's and early 70's.

Sponsoring Programs, Circuit Board Coatings

But we developed, Westinghouse developed, we sponsored programs at our research center, and that was one of the other jobs that I got involved in. We had to decide each year how much money we would allocate from our division to the central research laboratories for a variety of areas, one of which was materials development. So with this circuit board deterioration problem arose the need for a better coating and one which was easier to use, the conventional circuit board coatings required dipping or spraying or something like that and then a curing cycle again which takes time. So we sponsored a program at the research laboratories to develop a new, a greatly improved coating. And the research laboratories did in fact come up with a new coating which was a totally different chemistry than the conventional circuit board coatings. Conventional circuit board coatings were primarily epoxy or urethane coatings, which were relatively thick, a few mils. But this coating developed for us in our program with the central research laboratories was a fluorocarbon based coating. It was in a solvent dispersion rather than a coating which had to be sprayed and cured. This dispersion required only that the circuit board be dipped into this liquid or liquid sprayed on, probably it was a dip affair, but the solvent or the carrier in the dispersion would dry off immediately and here you had this nice essentially Teflon coating. And it was well known in the industry that of all the things that were affected by moisture, Teflon is the one thing that isn't.

Hochheiser:

Right.

Harper:

It never is affected by moisture. It doesn't absorb any moisture, none stays on the surface. So with this new coating we had developed, we could quote that in our new contracts we were proposing and use that in our systems and have a far better coating than anyone else had. There was some flak from some of the military agencies at first. This is new and this doesn't fit into the mil spec and so forth. We had to fight some of those battles. I can recall there was a group up at Rome Air Development Center, which was the reliability center for the Air Force but was also a major reliability center for the military industry. So I remember getting called up there a couple of times to explain why

this coating was so good and it didn't fit into a mil spec and why it should get into a mil spec and so forth. Eventually we did use it and it worked well. It was really easy dip, fast dry. You didn't even know the coating was there but it was there.

Hochheiser:

Is this still in the 60's? Or is this later?

Harper:

Into the 70's now.

Hochheiser:

Did things as far as these coatings get to more of a steady state, or do the changes keep going on throughout the course of your career?

Harper:

No, actually the circuit board coating industry did not change much. Circuit boards themselves did, and I'll talk about that in a minute, but circuit board coatings didn't. People in the industry would either use the epoxy or the urethane and since those fit into the mil spec a lot of companies, they're not going to fight the issue - they work and we're going to do it and they still do. Then some of the companies switched to the fluorocarbons. These fluorocarbons which were used for these coatings were developed by 3M which was big in advanced coatings for circuit boards. So 3M worked with us and worked with the military getting this stuff into the system. So probably not as many companies wound up using these fluorocarbons as we thought they would because of the military hassle and people were set into something that worked, the urethane, the epoxy coatings and they stuck with that. But both of them are there and they're still pretty much the same.

Circuit Boards, Military Applications

Now circuit boards themselves, you had a question?

Hochheiser:

No, go ahead. You seem to be going someplace useful

Harper:

The circuit boards themselves, that was also a can of worms as they say. Circuit boards in general are made with a fabric. You start off with a fabric. And the fabric can be cotton, linen, all kinds of fabrics. And then you wet this fabric. The fabric is in sheet form. As I said, large circuit boards are manufactured in large like four feet by eight feet pieces. And you wet the fabric through a chemical engineering process which goes through many steps. And you wet it and dry it and you have this circuit board. A lot of these fabrics will absorb moisture more quickly than is acceptable in the high performance electronics industry. So the circuit board industry then switched pretty quickly to glass as the fabric. And conventional glasses weren't that good either because nothing sticks to glass very well and a piece of plastic on a glass will come loose. So the fabric had to be coated with something known as a sizing, which effectively was a dipped coating. The object of the dipped coating was so that the fibers wouldn't absorb moisture so much. And the initial coatings weren't all that good either on the fiber, but eventually better coatings got developed for the fiber.

Hochheiser:

About when did these better coatings appear?

Harper:

Again this would have been in the 70's now, mid-70's. Improved fibers were developed because the original glasses had impurities in them which would result in electrical losses in electrical systems. Consequently the newer grade of glasses were developed by the glass companies. They were known as e-glasses or electrical grade glasses. These glasses were much better and with the higher performance coatings also developed and with the newer circuit boards like our fluorocarbon, you could get really high performance circuit boards which were mandatory because, say you have a typical kind of a problem. You have aircraft in Southeast Asia, some military action going on there.

Hochheiser:

Okay so, probably Vietnam in the period you're talking about.

Harper:

Vietnam would be a good example. These circuit boards in the radar systems which we made would start losing their electrical caliber, electrical quality. They resist everything,

the boards would go down and you have leakage and these kinds of problems. It was mandatory to make these improvements because, say in ECM systems, electronic countermeasure systems, but you want to in the radar systems, in whatever they were radar or ECMs, but you want to detect the enemy plane and missiles as early as you could so you could shoot them down. How fast you detected them depended partly on the caliber of the circuit boards. If the circuit board quality went down, then the whole electrical part of the system went down and you might get shot down instead of the other guy. So all these things were really not just interesting, innovative improvements but they were mandatory improvements to help with the battle.

A couple really major industry problems in the area of materials for electronics came up in the 70's. One of them was the coatings again. I mentioned that one of the conventional coatings was urethanes. Well it turned out that the humidity was so bad in Vietnam and Southeast Asia that the planes on the runways and so forth are being affected by the humidity. But these urethane coatings were starting to revert from a solid coating to a liquid, which is [where] you start out, as a liquid. So here you have no coating at all, plus you have a coating which has become a liquid and is running off the board. Well, this was a horrible experience. The whole military industry, electronics industry jumped onto that pretty quickly. But it meant a lot of systems out in the field had to come back and be refitted and that kind of thing. So that was one big industry problem related to materials and processes.

Hochheiser:

And you had to deal with it yourself at Westinghouse with components produced here?

Harper:

Yes we did.

Soldering, Indium, VHSIC

And there was another one. Everything, all the electrical joints and the connections have to be hooked together by something. And that something in many of the systems or most of the systems and circuit boards is solder. And here you think of something as commonplace as solder - what's the big deal, everyone uses solder. Well in the electronics industry, solder is a big deal, and for a number of reasons. First, you have to solder very fine interconnections. Secondly, soldering processes, whether it be a wave soldering process or a dip soldering process or whatever, solder gets very hot. I mean liquefied solder is very hot. And here, this heated solder can have very serious effects on

the components on the circuit board and on the circuit board itself. And so there was a move at one point, this would have been in the 70's or maybe in the early 80's, when some people in the industry started using indium solders instead of tin-lead solders. This was lower temperature solder and it looked fantastic except that when it got out in humid environments, it also reverted, and turned into a liquid again. And so this was a major industry refit problem. This just gives you a couple of examples of you how go from designing an electronic system with the materials and processes you use and then you get into new technologies to improve it and you still have problems out in the system or in some of the new systems. You would have to ask why the companies doing original research on indium wouldn't have found that out way before it got into equipment. But they didn't and it got into equipment.

Hochheiser:

It got into Westinghouse equipment?

Harper:

Yes.

Hochheiser:

Then you had to go scramble once it was out in the field

Harper:

Yes. In fact we had a major subcommittee that was known as the Commission for Indium Affairs. Sort of a reversion there, but it was a dead serious one of course. We worked on that thing for months. Of course, what you did is get rid of all the indium and don't use any more indium. That made the Indium Corporation look pretty bad for having sold it so broadly to the industry and it didn't work. Those are some of the problems in the industry and how you progress from the design phase to the manufacturing phase to the production phase and then to the phase where what you have isn't doing the job anymore. Alas, you need higher speed electronics. When you get into the semiconductors the name of the game always is higher speed, right? Higher speed, higher speed. You have to develop and everything has some plastics in it one place or the other, on a circuit board, a module, someplace where they are. So developing plastics with lower electrical losses was increasingly critical so that when the signal going from the chip to wherever else it went into the system, through the system,

signal speed wouldn't be slowed down. In fact there was one major Air Force program in which we were involved in the advanced technology aspects of high speed signals.

Hochheiser:

Which one?

Harper:

VHSIC. Very High Speed Integrated Circuits.

Hochheiser:

Right.

Harper:

VHSIC. It was sponsored by the Air Force at Dayton. I spent a lot of time at the Air Force in Dayton for a few years, good people to work with out there. And so we developed, the semiconductor guys, because Westinghouse had a semiconductor operation, ATL, Advanced Technology. Those guys were working on improved high speed semiconductors. Of course, a lot of other people in the industry were too, you're always in competition. And in my group we were working on lower loss plastics. Consider the AUG-10, or one of the systems in the 70's.Well, at the end of it, the antenna - there's a little plastic cover over the end of it, known as a radome. And I don't know if you have seen that out there but it's no bigger - my hands are like that but it's over the antenna, the end of the antenna. Well, the signal going out from the antenna has to get through this radome. The radomes were made from glass epoxy boards, not circuit boards but laminates, and the losses were too great. So we had to develop something better than epoxy and we would switch into like diallyl phthalate which was lower loss and go to lower loss materials and lower loss fibers and fabrics because whereas glass fabric was the industry standard for these glass reinforced glass structures it wasn't adequate for radomes. And so DuPont had come up with - and we worked a good bit with DuPont in this - with a new fabric called Nomex. That fabric is very strong, much stronger than glass. In fact, Nomex is what is used in bulletproof vests for policemen because a bullet won't go through it. But from the electronic viewpoint it has much lower electrical losses than glass. Quartz is another fabric which has much lower electrical losses. We worked with that to make some quartz radomes. The problem is that quartz is too brittle and you can't form it. If you have a flat piece you're okay but if you try to form it, the quartz fabric is too brittle and it breaks too easily so it's hard to work with that.

[End tape one, begin tape two]

Matrix Management, Harper's Management

Hochheiser:

About how many people did you have in your group in the 70's, 80's?

Harper:

Probably 25 or 30, something like that, and that would have included a few at the central research labs who worked on my programs.

Hochheiser:

At central research - that's here in Baltimore or back in Pittsburgh?

Harper:

In Pittsburgh.

Hochheiser:

So you had some people that were in Pittsburgh but they were part of your organization?

Harper:

No, actually, the people in our central research laboratories worked for the management at the research laboratory on the organization chart, but they worked for the responsible person at Baltimore on the programs that they were doing for us.

Hochheiser:

I got it.

Harper:

And so several of them were working on programs for me.

Hochheiser:

Yes. I know Westinghouse in general had a matrix management structure.

Harper:

Yes.

Hochheiser:

How did that work?

Harper:

It worked very well, particularly for the departments like mine where instead of having, for instance, all the electronic programs like AWG-10, F-16, APQ-72 or the ECMs or space programs - whatever - if every program had to have a materials and processes group that would have been extremely bulky. And so matrix management didn't cover everything. The electrical design engineers, they didn't work for a number of systems, they worked for whatever project they were on. If they were with AWACS, they were with AWACS. But most of the other ones didn't, whether it be materials and processes, whether it be environmental testing even mechanical engineers, they would work on a number of programs. So [the] theory of the matrix management is having groups which can work on a number of programs simultaneously and that's what it is. So the matrix management worked very well.

Hochheiser:

How did you manage your people for success?

Harper:

Well, first of all they're all specialists of course. We would have one or two people who were specialists in solders and you think, gee, all this, just solders? Yes, there were a couple of guys who specialized in that. I have a couple of circuit board guys. And you have ceramic guys. And you have ones in lubricants and that kind of thing because all these systems have lubricants. I have a specialist in cooling systems. So consequently what we did is each of the guys had his job for whatever systems he was working on [at] that time and he worked on those and he kept me informed. We did have regular

meetings to review what each guy was doing on his programs. We would have once a week staff meetings where we would all get together and review so any of the guys could pass on helpful comments to any of the other guys. So that's kind of the way it worked. And it was very effective, and I was fairly easy to get along with I think, and to work with, so I had a good group of guys. In fact all of them who are still alive are still good friends.

Hochheiser:

Good. And on the other hand where did you report to in the organization?

Harper:

I reported to the next higher level who was the manager of mechanical and materials engineering. That was P. J. Miller. Since we were a matrix management, we could report to a number of different ones. We reported to the reliability manager for the engineering operations which was Naomi McAfee. She was great.

Hochheiser:

Right. She's someone we've interviewed.

Harper:

Yes. She's great. And P. J. was great too. And they're still both good personal friends. So that's who I reported to and then they reported to the director of engineering for the entire division. That was the cycle.

Hochheiser:

So you were basically in this one management position for quite a long time is that correct?

Harper:

Yes. For I guess the last fifteen years or more. Actually, I had two positions, as I mentioned earlier - the technologies management and the materials and processes engineering management. And yes, maybe like 15 years.

Hochheiser:

In what ways did your job or your work evolve over that extended period?

Harper:

Well, I guess it evolved first in working for the guy who hired me, Al Hamill, and we did very well. We also had under him at that time - and eventually under me - was a chemical laboratory where we had a couple senior chemists and then a number of technicians. We had three laboratories actually, a general chemical laboratory where we had all of our experiments and tests done by these lab guys, and then a ceramics laboratory as we got into much more ceramics, and the third was a microelectronics laboratory. I would work with them and we had their operations.

Westinghouse Atmosphere, Publishing

Hochheiser:

We're going to circle. How would you describe Westinghouse as a place to work over the years you were there and what ways did it evolve over the years you worked there?

Harper:

Well, it was a great place to work. It was really truly for the most part like a family. This matrix management system helped make it that way because you were working with guys on every project. I mean we weren't insolated to one group. When we'd go to lunch, walking down the halls, you'd know everyone, more or less. Consequently, we evolved that way and I think that made Westinghouse a very good place to work. We'd eat lunch together and do all kinds of things together. And it was a more or less a family. And actually that was even the case in an operation like mine which was, if you want to call it that, a service operation. We served all of these groups.

Hochheiser:

Right.

Harper:

Well, what that meant was I always had to have enough work for all the guys so a lot of times when things were a little bit lean I'd have to go out to the programs and start selling my projects. Say, we ought to do some research on this. We ought to do some

testing on that. So I wound up being a salesman to the other departments in Westinghouse here as well as to departments in the military. And so it was very interesting, challenging, family-oriented, not like - none of the head to head knockouts like you see at some places. Very little of that.

Hochheiser:

You earlier mentioned your book on electric packaging. Can you revisit that? What led you to decide to write a book?

Harper:

Okay. That's a good question. Well, as I mentioned, I had a leaning towards writing and teaching my whole life, just a couple of my basic characteristics. And so I started since we were into advanced technology from day one - advanced for that particular time, whatever that time was - and I liked to write. Some of the magazine editors found out about that because they would see me at conferences and so forth and ask me to write an article on this or that or the other. So consequently I wrote a fair number of articles for different magazines. I was a repeat author for new articles for these magazines in my early career so I established a basis of writing and a reputation for writing. McGraw-Hill found out about this because one of the magazines was a McGraw-Hill magazine.

Hochheiser:

Which one?

Harper:

Electrical Manufacturing. And that was at one time a really good thick magazine. Things have changed a lot between then and now and some of these magazines have totally disappeared today

Hochheiser:

Yes.

Harper:

But McGraw-Hill asked me if I would consider writing a book on electronic packaging and my field was plastics and electronic packaging. Of course I was very excited to do

that. It was my first shot at doing a book. So I did that and it was published and was very well received. In fact, as I mentioned, it was translated shortly after it was published. The Germans wanted it and the war was over and they were friends by now. And so the German company, the Hanser Company, which is a large technical publisher in Germany, asked McGraw-Hill if they would agree to their doing a translation. And they did and in fact I went over and worked with the translators for a week one time which was very interesting too, over in Munich. Another interesting thing about that first book was that we were into the Cold War era now. And whereas most countries had copyright arrangements between countries and you would, if something was translated and sold, you would still get royalties from the copyright, due to the copyright laws. But with Russia there were no copyright laws.

Hochheiser:

Right.

Harper:

And it was the Cold War. And they stole anything they wanted to steal. And I didn't know about this, but some place along the way, maybe a couple of years after my book had been published in the United States, two or three years -

Hochheiser:

When was your book published in the United States?

Harper:

[Interposing] Oh, when was the book published? The book was published probably about 1960.

Hochheiser:

Okay.

Harper:

We were into the Cold War era as I say. So eventually a couple of years afterwards, probably two or three years, I got a letter from a guy in Poland, which was a country under the Soviet heel. He said there's an article you published in Electrical

Manufacturing and I can't get a copy of that. I'd really like to have a copy of that. Would you send me one? And of course it was public so I sent him one. But he said if you send me that I'll send you a copy of your book in Russian. I said, great. I'd like to see that. And he did. He sent me a copy and it had his notes in the pages where he had been using it and so forth. I still have that. And a lot of my later books were translated too but not so serendipitously as that one.

Hochheiser:

How did the higher ups in Westinghouse consider your publishing activities?

Harper:

Well they loved it because it was tremendous publicity for Westinghouse. I've just finished reading an interesting book about Wernher von Braun. When he came over, he worked for the Army. And he was into all kinds of activities, like Disneyland movies and writing books and featured in Time Magazine, all this stuff and the question came up why did the Army let him do all this extracurricular stuff. And the answer came back, it was good press for the Army. And it was. The same with Westinghouse. It was good press because anything, any book I did or any publicity always had Westinghouse also mentioned.

Hochheiser:

Right.

Harper:

I recall Westinghouse had an annual banquet and one year their theme was ‘we are the best’ or ‘we're the most’ or something like that. And they would highlight certain people who were most in this, most patents and most this and most that. And the most books was me of course. So they liked it. Along the way I guess I would have to say, here and there, there was a person or two who had a jealousy motive or something, wasn't all that happy about it, but in the main it was very well received and did a very good publicity job for Westinghouse.

Hochheiser:

Can you tell me a little bit about your publishing career after your first book?

Harper:

Yes. Now earlier in the discussion, we've gotten how electronic packaging got started and how it became a term, finally, which it wasn't earlier and my having had my first book with McGraw-Hill and it having been fairly well received. It was the only one in that field at that time so you would expect that to be pretty well received. The whole field of electronic packaging, that phrase, started mushrooming. And so they wanted to have a handbook. One of the McGraw-Hill divisions is the handbook division. They have a handbook for electrical engineers, a handbook for chemical engineers, all those. They wanted to have a handbook for electronic packaging engineers so they asked me if I would put together this book which I did. It was known as the Handbook of Electronic Packaging, of course.

Hochheiser:

Now is this the sort of book where you would have gotten a lot of other people to contribute as opposed to the first book which you wrote?

Harper:

Yes. The first book I wrote completely myself. And when I got into the handbook series I did some writing but they were all with contributor authors.

Hochheiser:

People who were experts in particular niches within the broader field.

Harper:

Yes. I would solicit these guys and pick the best ones. McGraw-Hill wanted me to produce a book on Handbook of Electronic Packaging, which as I said, I did. And that also was very successful. It went into five editions, and of course it's still out there. Several of my books are in the library here in the museum. So that's how that started. And then one thing led to another and they asked if I would be a series editor for us, McGraw-Hill. I said yes, I would because I enjoyed that - working with a lot of interesting people, a lot of really smart people, good people. So we went into a series of books in what was known as the electronic packaging and interconnection series. And then they asked me later if I would be editor-in-chief and series editor for another series, the materials science and technology series. And I agreed to that, too. I was in there pretty deep. And this was of course extracurricular and mostly in my own time, although of

course I'd have to have some phone calls on Westinghouse time but it was good press for Westinghouse and very enjoyable for me. And McGraw-Hill was a good company to deal with and as technology was progressing, here I am in the middle of it, not only at Westinghouse but in professional activities and writing articles and books. It just all worked together very nicely.

IEEE, IEPS and IMAPS

Hochheiser:

Maybe now we can focus a bit on professional activities. Since I'm from the IEEE, I'll start with that. I noticed that you've been an IEEE member for a long time.

Harper:

Yes.

Hochheiser:

And when and what led you, as [a] chemical engineer, to join IEEE? Or I guess it might have still been IRE back when you joined. In what ways were you active?

Harper:

They published. They also liked to publish book reviews. One of their journals was the EI Journal, and they needed someone who was into the book business, the book field, I guess. I knew the editor, John Tanaka, very well and so he asked me if I would do book reviews for them and publish them, which I did. I did that for many years and eventually turned it over to someone else, of course. That's how I was most active. But this EI, Electrical Insulation Group, of IEEE also held conferences. I participated in those conferences, put together technical sessions and chaired those sessions and that kind of thing. That's the kind of involvement I had with them over many, many years. They also had a reliability group which I became active in because a lot of the reliability is how reliable are your circuit boards and how reliable are your electronic modules. So these things kind of fit together. And that's how I got involved and remained involved with it and still am.

Hochheiser:

Can you tell me a bit about the founding of IEPS?

Harper:

Yes. Well, I'll get back to Milton Kiver who was the editor of Electronic Design who then started his own magazine, Electronic Packaging and Production who then started NEPCON, National Electronic Packaging Conference. It wound up there were a half dozen NEPCON conferences a year. One in New York, one in Anaheim, one in London. And I participated in all those things. But then afterwards he said there ought to be a professional society for electronic packaging which there wasn't. So he sponsored it and footed the bill for getting it underway and started.

Hochheiser:

About when was this?

Harper:

This was about in the early 70's I would say.

Hochheiser:

Okay, thanks.

Harper:

So consequently with my involvement with him in NEPCONs and with his magazine and so forth, I was obviously the first guy he would come to about putting together this professional society. A group of us put together this society known as IEPS, the International Electronics Packaging Society. I was the first president as you would expect and then it ran for a number of years and it held a number of conferences of its own. It did very well but it became increasingly apparent that IEPS and another society which was ISHM were overlapping - International Society for Hybrid Microelectronics, involved primarily chips on ceramic substrates, but it was electronic packaging. So it became apparent that these two societies were doing a lot of the same things. And they were competitive and so the question came. “isn't it a good idea to join these two?” Well, you expect a lot of flack because the guys who have their names strong in each society don't want to lose that. A lot of people objected to it, but I was one of the champions of joining them. I felt they should be joined, so consequently, eventually after a lot of discussions and debates, we did decide to join and create a new society, which was a

combination of these two and the new society was called IMAPS or the International Microelectronics and Packaging Society.

Hochheiser:

And about when was this merger?

Harper:

This was probably in the late 70's. ISHM had been in operation for some years before the IEPS came along. They were both in operation for several years. So it was in the late 70's I guess when they were joined.

Hochheiser:

Okay. So IEPS was not a standalone society for that long.

Harper:

The International Electronics Packaging Society, no. Five or six or seven years, but that's all. And the ISHM had been a society for that five or six or seven years plus maybe another five or six years before that. So it was the older society. We created this new society and even had a contest to decide on what would be the logo and what would be the phrase that described it and so forth. And those two combined, grew, and is now a very strong international society.

Hochheiser:

About how large is it?

Harper:

I don't know what the actual number of members [is] now. Probably 20,000 or 30,000. They have chapters in most of the major countries, and then local chapters too like there's a Baltimore-Washington chapter which has always been very active and it's been one of those pleasant experiences again of working with a lot of guys from different companies and the military.

Technology Seminars, Incorporated

Hochheiser:

When and what was Technology Seminars, Incorporated?

Harper:

Technology Seminars was incorporated in about 1985. And how that started, I guess, there was some seminar company in that time period which would have been in the early 80's, who had most of their seminars on electronics, wanted to have a seminar and advertise that on electronic packaging so they asked myself and my friend Bill Staley. He and I said yes, we'll present a seminar for you. We did a couple of them. And after we did one we said why should we do this? Why shouldn't we do it for ourselves? So we formed Technology Seminars, Incorporated. And Bill has long since retired, he's about 90 years old now actually. So we started doing seminars in major cities. We developed a flyer and we sent out these flyers. We would commonly for a fair number of years do a half dozen or more a year, say one in New York, one in Anaheim one in Washington, one in San Francisco, you know, Seattle, all over the place. These were very, very popular because there were an awful lot of people in material supplier industries like plastic companies, ceramic companies as well as people in the electronics industry who hadn't caught up with this term electronic packaging yet. It was new or relatively new. In fact there was a standing joke going around, what is electronic packaging, the box that you put the modules in? There were an awful lot of people who needed to know what really was electronic packaging and what were the parts of it and what were the important things. So Bill and I put together this three day seminar which we did very broadly and publicly. We did them in Marriott Hotels all over the country. It wasn't very long before people attending those seminars would say, hey, would you come and do it at our plant? So we did that too. We developed a series of seminars some by ourselves and some by other people, just like contributing authors in handbooks. We also did them onsite as we call them, go to people's plants. We did the public ones. We also did them jointly with some universities. For instance we and the University of Maryland put together a series which we did at College Park. And one time we did some with the University of Dayton. And of course in the end that got us into teaching the course at Johns Hopkins University as I mentioned. And so that's how these things grew.

Hochheiser:

Now did you start this while you were still an active employee here at Westinghouse?

Harper:

Yes, for the first couple of years. And initially that presented some questions in my mind but I made sure that my boss knew about it and what we were doing. Also everything we did was open material. We didn't include anything Westinghouse and nothing proprietary so we handled that very carefully. I only had the technology seminars for about two years then I retired and did it and the books full time. So there wasn't much of an overlap there but we were very careful about how we did it.

Teaching at Westinghouse, Retirement

Hochheiser:

Did you do any teaching internally at Westinghouse?

Harper:

Yes I did. Westinghouse had a college of science and engineering. These were courses in the evening, a wide variety of courses. It was well-accepted in Westinghouse. No outside people attended so we could use any Westinghouse material we wanted in these courses. And so yes - for a fair number of years, I would say maybe 10 years, I taught in this. I would teach various courses on materials, on electronic packaging, on thick film technology, on molding processes and plastics and electronics, a variety of courses in that college for Westinghouse.

Hochheiser:

What sort of people tended to take those courses within the company?

Harper:

Well, there would be people from departments other than our own because chemistry and chemicals are not things with which most people are familiar. And they're sort of a mystery to people who haven't studied chemistry and plastics. You don't speak the language. So all these mechanical engineers, electrical engineers who needed to use these things needed to know more about it. And environmental engineers, quality engineers, all of them. So those people attended our courses.

Hochheiser:

What led you to retire from Westinghouse in 1987?

Harper:

Well a couple of things. First of all I had 33 or so years [of] service. I was getting more and more interested in seminars, teaching. We taught internationally once I retired. We taught in Europe, in Asia. In fact I've been all over Japan - I did a lot of teaching there. And so wanting to get into those more, having as many years as I did. On one of my visits to Japan, I came home and right about the time I decided to retire, I found that my wife had breast cancer, which she recovered from. But I felt I really needed some time too. With all these time requirements, along with my interests, and the years I had, I decided to retire and go into the other things full time.

Hochheiser:

How would you characterize your career at Westinghouse as a whole? We talked about a lot of individual things.

Harper:

Well, I regard it as a very, very good career and a very fortunate career getting involved with Westinghouse. Not only in all of the roles that I participated with for all the different departments over the years, but in the friendships I made and people who eventually became teachers for me in my TSI technology seminars. The associations with Westinghouse over the years have spawned out into a variety of other interesting areas. It was, as I say, a family operation and it was a very good total experience. I loved it.

Teaching at Johns Hopkins and Maryland

Hochheiser:

Can you tell me a bit about the teaching you did back at Johns Hopkins?

Harper:

Yes. As I mentioned, I graduated from Hopkins. I had a very good advisor, a guy who I became very close with, very familiar with and very close to. He was an advisor there for many years after I left Hopkins. I kept in touch with him a little bit now and then. And once he found that I was getting pretty well versed in advanced technologies and material and plastics in the electronics industry, and he was a chemical plastics guy himself, he realized that the guys graduating from Hopkins had had no exposure at all

to this. In fact, I had the same experience with the University of Maryland. I did this for both of them.

Hochheiser:

Ah.

Harper:

What they did is they both invited me to do a senior seminar each year. It was one afternoon on chemistry and chemicals in electronics. Of course, it got into circuit boards and modules and plastics. I did this for a fair number of years at Hopkins. The engineering faculty there decided that they really wanted to get more deeply into electronic packaging and materials. Since I'd been doing these senior seminars all that time and they got to know me and I knew the field, they asked me if I would put together a course. It was not a daytime course. It wasn't an undergraduate course. It was an evening course and adult education and most of the people had their degree already. They were working in industry. We taught this course, myself and some of the guys who had worked with me in my seminars and in my books. In our series with Hopkins we'd have one night on thermal management or one or two nights. Well I'd have a thermal management specialist come in. Another night, other subjects. So we did this course for I guess three or four years in the late-80's and the early-90's. That did get them involved into some of this stuff and got them some research contracts in that field and that was an interesting experience.

The University of Maryland is interesting too, in that neither Hopkins nor Maryland had any courses in this subject and University of Maryland asked me if I would come down and do the same thing, do this senior seminar, which I did for a number of years. As it turned out the University of Maryland decided they wanted a whole curriculum in this, so they did establish a curriculum and they found a very good guy to be head of that department. And it has been very, very successful and still going very strong today. About a year ago or so this engineering department, and I guess other departments too, have what they call the invited lecturer so they give it some fancy name. They asked me if I would do a lecture in their distinguished lecturer series. They asked me if I would come and give a presentation to the engineering department, the whole department, which I did, and which was very, very pleasant. I explained to them a lot of the stuff like we've been through today. Of course a lot of these guys were taking courses in some of this subject, and I've gotten to know that whole staff and work with them very well.

As kind of an interesting side thing, I had [been] doing book reviews for IEEE. I had accumulated a ton of books, more than I could store in a house anymore plus my own books, [and] I wanted to give [them] to the University of Maryland because I was working very closely with these guys at that time. So I gave them a ton of books, a copy of each of my books, plus all of these books which I'd reviewed and no longer wanted to hang onto and then they put them all in a library in the conference room center which they named after me.

Hochheiser:

[Interposing] Lovely.

Harper:

Yes. That was a pleasant thing. Interestingly, a couple of years ago I took one of my grandsons who was getting college age on a tour of Hopkins. I hadn't been through the new Hopkins library, it's been there for a good while now, maybe ten years or something, this new large library. And I thought doggone, I'm going to go into this thing and see if they have any of my books on their shelf. I asked the guy at the information desk. I told him who I was and he looked up my name. And he said yes, we have one. Then, we have another one. Then he was really funny because he said we have 28 of them. They had 28 of my books in their library. And he called his boss and his boss's boss. I felt like the hero of the day or something. So I've had a good bit of involvement. And the reason I had involvement with the University of Dayton was because I did a lot of work with the Air Force at Dayton on these technology programs I mentioned. I did a number of seminars out in that area. At the University of Dayton, one of the professors there wanted to get some seminars on this and so I did a few. So there's been an interesting career professionally, teaching and books and so forth.

Hochheiser:

One minor point I'd like to circle back to. What was the name of your advisor at Hopkins that later got you involved?

Harper:

Ralph Witt. He is deceased now too, of course. He was fairly old at that time but I had a good advisor there and good people at Westinghouse, good people at McGraw-Hill.

Hochheiser:

Well it certainly sounds that you've kept very active in the years since your retirement from Westinghouse.

Harper:

I have and I still do to some degree, but needless to say, I'm tapering down a good bit now at this point.

Interesting Associations

They're still all friends and so you have some really interesting associations and if you have a little bit more room on your tape I'll tell you about a couple of these interesting things -

Hochheiser:

Yes, there's a bit more room on the tape.

Harper:

Okay. Well one of the guys I worked with in professional activities over the years - and he wasn't a Westinghouse guy, he was with Raytheon or some other company. I never knew this until long after I retired and he was retired, but it turned out that he was a forward observer for General [George S.] Patton. And here he was

Hochheiser:

What was his name?

Harper:

I'll give you his name in just a minute. But anyhow, he got old and his heart had problems. He moved in with his son who lives in Milwaukee someplace. He had kept notes over the years from being in the Army and his work as a forward observer for Patton. His daughter-in-law - can you imagine this, this is not his daughter but his daughter-in-law now - she was so attached to him that she decided she would take all those notes and write a book about his time as a forward observer for Patton. Which she did. And she asked me if I would serve as editor for her which I agreed to do. And I get

this big thick manuscript. It was way too big of a book. No one's going to buy a book that big. So we edited it down. Wayne Martin is his name.

Hochheiser:

Thanks.

Harper:

So out came this book of a forward observer for Patton which is now on Amazon and all these other places. So here's a guy like that who I worked with for years and didn't really realize he had done that. And another even more interesting thing, associated with this museum and with Westinghouse and Hopkins, is I worked and associated for a lot of years with a guy named Jake Beser - does that name ring a bell to you?

Hochheiser:

Yes. At least one other person I've interviewed has mentioned him.

Harper:

Well he of course, for those who don't know, was the only person who flew on both of the strike aircraft for Hiroshima and Nagasaki. About 30 years after the atomic bomb raids and the war was over and he worked at Westinghouse, one of the morning shows like Good Morning America or one of those shows had him go over back to Japan and meet with the mayors and the people of those towns and see how they took to him. And they had a little five minute segment on their program for each of about two weeks. He came back and wrote a book called Revisiting Hiroshima and Nagasaki. Of course I have an autographed copy of this book. I think there are none of them left, you can't get them anymore. It's a nice little book and a paperback but I understand it can be bought for like $600 or $700.So having been the only guy on those flights, I mean there's no one else like that, just him. So he started to write a second book on Nagasaki. Well, poor guy got ill and had cancer.

Towards the end of his life, and I didn't know it was towards the end of his life yet, I was program chairman for a conference on materials and electronics in Baltimore. This is probably about 20 year ago, like 1990 or 1991 or '92. So I was program chairman for this conference which was being held in Baltimore. I invited Jake to be the keynote speaker. And this was very funny, he titled his paper The Bombing of Hiroshima and Nagasaki. It

was a good title, except that 30 or 40 years after the war, Japanese people were going to these conferences. [Laughing]

Hochheiser:

[Chuckling] Of course.

Harper:

The conference people said no, we can't give it that title, we've got to change that. Well he was a pretty hardnosed guy and I thought no way is he going to change that. But he did change it. Well, we get up to within a couple of weeks of the conference and he's our keynote speaker, as I say, and he died. So he was never able to present that. So I had his last paper that he ever wrote. And his son read that a couple of weeks ago or a month ago here in the museum. He had a bumper crowd out there listening to it. And his son who read this paper a couple of weeks ago decided he would take over all the notes that his father had and write this second book about Nagasaki for his father using all his father's notes. Well, the son got very ill. And he still is. So another guy (Jack Spangler) took over and started working with him and they did finish that book.

Hochheiser:

Yes.

Harper:

So these are some of the interesting people you meet in your work and your professional activities and over the years. There were a lot more but those are a couple interesting ones.

Hochheiser:

Yes.

Harper:

Another interesting person was when we were making our trips into Japan. Fortunately my wife was able to go with me through a lot of these, so we got to see most of Japan. But anyhow, after the war the Japanese had to write a new constitution under the guard of [General Douglas] MacArthur - it gave women rights that they never had before, like

they could be elected to government offices now. Before no way could they do that. Well, it happens among the people that we met over there over the years was this one lady who became the first lady elected official. She and her family were very interesting. When we first met them, she and her husband - her husband has died now - she had two little children about four-years-old and six-years-old who are now 40 years old or something like that. We have over the years kept really close contact with her. This lady who was the first elected woman official came over to visit us about a month or so ago. We took the whole family - she had her two children who are now in their 40s as I say, and their grandchildren - to the Hopkins Club and had a very good day with them. But you know it's interesting how these things fan out over the years.

Hochheiser:

Well, unless you have anything further you'd like to add, I think I've asked you everything I knew to ask you.

Harper:

Well no, I think we've covered it pretty well. It's really been a pleasure presenting for you and the IEEE audience.

Hochheiser:

Likewise, it's been a pleasure listening to you talk about your career and activities.

Harper:

All the people I've worked with and my whole career have just been great. Thank you again and I hope it's useful to someone.

Hochheiser:

Absolutely. Okay, guess we're done.

Harper:

Thank you.