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AN INTERVIEW WITH ROBERT HOPKINS

FOR THE

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WORLD WAR II * KOREAN WAR * VIETNAM WAR * COLD WAR

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Shaun Illingworth: This begins an interview with Dr. Robert Hopkins in North Palm Beach, Florida, on June 10, 2009, with Shaun Illingworth. Dr. Hopkins, thank you very much for having me here today.

Robert Hopkins: You're welcome.

SI: This interview was made possible in part by a travel grant from the Rutgers College Classes of 1942 and 1949.

RH: 1942, the year I was born.

SI: Perfect. [laughter] That jumps to my first question; where and when were you born?

RH: I was born in 1942, in Southeastern Kentucky.

SI: Bevinsville?

RH: Bevinsville is just a little, bitty town. It's in Floyd County and south of Prestonsburg, which is the county seat of Floyd County, and to the west of Pikeville, which is the county seat of Pike County, and close to the border, actually, of Pike County and Floyd County. The nearest town of any size would be Wheelwright, which is where my mother went to high school.

SI: Okay. What were your parents' names?

RH: My father is Robert Hopkins, Robert Sherman Hopkins, and I was named Junior, so, I'm Robert Sherman Hopkins, Jr., but, for many, many years, I've just used the name Robert Hopkins. My mother was Virginia Belle Hall and they were married in 1938. I was the third of five children; the oldest, a girl, then, another girl that died when she was about six years old, and then, me, and then, two younger brothers.

SI: Okay. On your father's side of the family, do you know of any kind of immigration history or how they came to settle in that area?

RH: I don't know how they came to be in that area, but the family has a long background of being in Kentucky. My sister has done some searching back through time, I think it's five generations, and has filled in most of the names in those five generations, but not all. ... One of the links that's there is a family called May, M-A-Y, which is from Germany, and you can actually search back many generations of the May Family. So, that part is easier to find than some of the other parts.

SI: About how many generations back did they come to Kentucky?

RH: I believe that; if you'll put a hold on it for just a minute, let me get something.

[TAPE PAUSED]

SI: Sure. [Editor's Note: Dr. Hopkins retrieved his computer.]

RH: One of the things I have done to my house is set it up very nice for networking. In fact, if you wanted to get on the Internet, you could do it right now. I have a wired network that includes three rooms and wireless, ... with two different stations that cover the entire house, and so, ... I normally use the laptop with the wired network, but I can just pick it up, and come in here, like this, with wireless.

SI: Great.

RH: ... I wanted to check on how many generations back I have, and I believe that most are Kentuckians back to my great-great-great-grandparents, maybe some in North Carolina and Virginia, but mostly Kentucky. ... Okay, I have it on screen here. ... Let's see, what I have is back to great-great-great-great-grandparents. I have, just scanning down through here, about half of those filled in. The next generation, great-great-great-grandparents, there are some missing; great-great-grandparents, there's nothing missing. So, that's pretty much what I have filled in. Now, what was the question that prompted me to go get this?

SI: How far back the family has been in Kentucky.

RH: Most of those are Kentucky since about 1800.

SI: Wow.

RH: Yes, and the example of the ones in that great-great-great-great-grandparent generation, born in 1755, born in 1770, born in 1772, 1811; ... nope, that's not correct, not 1811. That's the next generation. In 1770, okay, ... here's one, 1759; looks like they're about 1750 to 1800 when they were born, that generation.

SI: Okay. Is that just your father's side or is it your mother's side as well?

RH: Yes, this is both my mother's and my father's side.

SI: Okay. Both sides go back that long in Kentucky.

RH: Yes, yes.

SI: That is one of the interesting things that we study, the migration of the American population. It begins in your parents' generation, and then, your generation went all over the place.

RH: Yes.

SI: Moving several times in their lifetime.

RH: Just thinking, ... my mother lived in Kentucky until she was married. My father's family moved around a bit more and they were in Indiana for some time, and then, back into Kentucky,

and that was the link to my growing up in Indiana, because my father went back to a place where he had lived before. It's interesting, in fact, that I graduated from Holton High School in Indiana in 1960, my father did in 1934, and three of his sisters, I think it was two or three of his sisters, I would have to check that, were also in the Class of 1934. They had been moving around and they ended up there and, apparently, my father was there only a few months. He had gone to some other schools in Southern Indiana, but the last few months of his schooling were at Holton High School, which is where I graduated and all four of his children graduated.

SI: Do you think that mobility, moving around, was a result of the Great Depression or for some other reason? Did he ever talk about why they moved?

RH: I do not know the reason. ... What I have is something that my father wrote; I've been doing some reading on this recently. There's something in here that indicates when it was, about 1990 would be my guess when he wrote this, and I know why he ultimately left Kentucky. ... I'm just checking to see if I can see what he says about why they moved the first time to Indiana. They moved several times, I can see this in what I'm reading here. Right here, somewhere, is where they first go to Indiana. "A trader, Dad;" this is my father's father, "Dad" would be my father's father here, "A trader, Dad traded for a farm at Lookout, Indiana, and moved the family there during late summer." Before that, they were in Kentucky. He doesn't say just when this was. "I had two sisters ready for high school," that sort of sets the time, "and another in the seventh grade." So, the two sisters that were ready for high school, if they graduated in 1934, this means that this must have been about 1930, which means he would have been about eighteen at that time. He was born in 1912. "It was nine miles to Batesville." Batesville's in Ripley County, Indiana, the northern part of Ripley County. So, that's when they first moved to Indiana, and then, they moved to Nebraska, Indiana. He went to Butlerville for three semesters, then, they moved to Dabney, Indiana, and that's when he finished at Holton. ...

SI: Did he ever share any stories about what it was like to be moving around all the time?

RH: No, not that I can recall. ... He may have said things, but nothing comes to mind. So, I can't really answer that.

SI: He was a coal miner, originally.

RH: He worked in the coal mines. He went to Coyne Electrical School in Chicago, and I looked that up on the Internet; it's still there. He went there in about, I guess it would have been in the mid-'30s. I'm not sure exactly when, and I don't know if he got some sort of a degree or certificate, but he then worked as an electrician for many years. He was an electrician in a mine owned by Inland Steel in Wheelwright, Kentucky. ... Some of the stories that he tells, even in what I was just reading from here, talking about a problem in the mine where it was going to cave in and they wanted to get some equipment out, and so, he and his helper were the last two in there [laughter] getting this machine out, getting it unwired, so that they could move it out before it got damaged. ... You could hear creaking and they were out just four or five hours before it actually caved in.

SI: Wow.

RH: And then, ... the ultimate move to Indiana happened in 1946. I was born in 1942, and, if you look at history, there was a big strike in the mines in 1946. [Editor's Note: The twenty-six-day strike involved over seven hundred thousand workers and caused production to drop to its lowest level in fifty years.] ... At that time, I guess Dad decided that he did not want to be involved in the strike, we went to Indiana and he got a job at a small company called Noblitt and Sparks, which later became Arvin. ... How it transitioned from Noblitt and Sparks to Arvin, I don't know if that was just a name change, but he then worked the rest of his working career for Arvin in North Vernon, Indiana. [Editor's Note: In 1950, Noblitt-Sparks Industries became Arvin Industries, Inc., primarily to capitalize on brand-recognition since many of their products bore the name Arvin.] He was an electrician, headed up the maintenance department; let's see, he started there in '46 and he retired then in '76, so, he would have worked thirty years for them.

SI: Was he a member of the union?

RH: I don't think he was. I don't know the reasons, but I know that he was very negative on the strike in the mines.

SI: What about your mother and her background?

RH: My mother never had a job, other than being a homemaker, no job outside the home. She apparently had enrolled to go to college. I don't know if she even started, but, if she did, she was only there a very short time. It may have been Eastern Kentucky where she had enrolled. ... Her high school graduation may have been '38, but that doesn't sound right, because she was born in 1918. She would have been twenty years old ... in '38 and I think she would have graduated from high school younger than that. I don't remember the year, may have been '36, that she graduated from Wheelwright. ... She and Dad were married then in '38, in Kentucky, and it was in '46 then that they moved to Indiana. ... Both of my grandfathers died either before I was born or shortly after I was born. I did not know either one of them. I did know both of my grandmothers, though.

SI: Had the previous generation been in farming or coal mining? Do you have any idea if there was a family profession on either side?

RH: No. I believe my mother's father taught school. I don't think he was college-educated. I think, in Kentucky, in the hills of Kentucky, in those days, you didn't have to be. ... You could check on this, but I don't think a college education was a requirement for teaching. ... I don't know what else he did; my father's father did many different things. I believe he may also have made moonshine, but I'm not totally clear on that. [laughter]

SI: Do you know how your parents met? What circumstances brought them together?

RH: I don't. I don't remember. If I did know, I don't remember.

SI: Were they roughly in the same geographical area?

RH: Oh, yes, yes. ... Let me just call up a map, so that you get a feeling here. ... I'll bring up Google Maps and show you the part of Kentucky that I'm talking about. ... Here's Kentucky, you see the border here of Kentucky, and I'm talking about this area right here, in the southeastern corner of Kentucky. ... Here's Wheelwright, where my mother went to school. Okay, here we go, Pikeville, and I mentioned Prestonsburg; this is Prestonsburg up here and Wheelwright here.

SI: Wheelwright and Pikeville are about ten, fifteen miles away.

RH: Pikeville.

SI: Pikeville, I am sorry.

RH: No "S;" just a few miles apart, mostly a mountain that's between them. Now, here's Pikeville. Pikeville is in Pike County, named after the same Pike of Pike's Peak in Colorado, Captain Zebulon Pike. I think he was a captain, but here's Wheelwright, where my mother went to school, and do you see Jacks Creek? Jacks Creek is also where I'm from. Bevinsville, Jacks Creek are basically the same and, ... rolling in on this Google Map, there's a school here right now. ... I've been working on a lot of pictures, something that we'll talk about at some point, scanning slides. My father took about nine thousand slides and I have scanned all of them. They're on the [Internet](#), and I'm now working on [my own slides](#), and one of the things I'll show you here, in around, ... I think it was 1966, when I visited my parents in Indiana, see, here's Holton School. This building doesn't exist any longer. ... This was all twelve years of grade school and high school, until I was a freshman, and, in my freshman year, they opened up this new building, a large gymnasium, and then, rooms over here, so that high school then was in this building and grade school was in this building. ... You can see, just back here is the high school building. So, the gym was sort of beside here, and then, went around behind it, and what I was really heading for was to show you the place in Kentucky that I'm talking about. ... See, this is the school that's there and I remember, as a little kid, this little electrical transformer thing here and there was a house right here. I don't think it was that little greenhouse. There was a house right in front of it. ... I was actually born in the house, not in a hospital, and then, where the school sits, my mother's mother had a home that was right here. So, this, literally, right here is where I was born, but it's changed a little bit over the years now.

SI: Was that your house or was it a midwife's house?

RH: I'm sorry.

SI: Was that site where your family lived?

RH: In a house that was right here. ... Yes, my mother and father lived in a house here, my grandmother lived in a house that was right here. If I go to some old photographs, my father's pictures, ... this is my mother. This would have been done, picture would have been taken, about 1952 or 1953 and that's my mother with her mother and this is in the yard of my mother's house. ... They're standing right now where that school is that's in the picture I showed you a moment ago. That's my grandmother on the porch of her house and my youngest brother with

my mother and that's my grandmother's house. That's no longer standing, and you see this house up on the hill here? That house was still there in 1966 when I took this other picture. Let me just go back to that. ... This picture here, do you see this house up on the hill right here?

SI: I see.

RH: And that is the same house. This picture was taken in 1966 and this picture, which was around '52, '53, that's that same house, right there. ... That's the house, and none of these pictures show the house that I was born in. I don't know if it was still there at this time, I can't remember, but ... we're finished with those pictures now. ... I was showing you ... where in Kentucky all this is. ... Did we finish that topic?

SI: Yes, we were just trying to get an idea of, geographically, how close your mother and father were.

RH: Yes. ... That's right. My father was born in a little town right here, near Martin, or Langley, right here. A part of this little town, Langley, is called Maytown, and so, that's where my father was born, in Maytown. ... So, that's just a little south of Martin, and my mother was born in a little town called Kite. ... So, if my father was born right about here somewhere, my mother, and I haven't found it, it's right about where that "A" [a Google Maps pointer] is. So, you see how close together they were born, approximately twenty miles, but I don't know when they first met each other, though. That, I don't know.

SI: All right. You were about four when your family left Kentucky.

RH: Yes. This was in the Spring of '46, so, I was about three-and-a-half, maybe.

SI: Do you have any memories of growing up in Kentucky?

RH: Very, very few, almost nothing, couple things that I can remember, just like a scene or two. ... One of the things I have realized about myself, over time, is, I don't remember very much back in time, very few things that I remember. ... I have a vague memory ... of the move we made to Indiana, and I don't know if that's just a dream I had some time or if it was real. The early days of being in Indiana, not very much I can remember, but one thing does stand out particularly and that is, I remember when our house was first wired for electricity. I remember some things from before it was wired and I remember some things during that time. I can remember trucks coming with the poles and digging the holes and dropping the poles into the holes, but I can't specifically remember the wires being hung. I can remember the poles being put in, and the date on this, probably about 1948, but I don't know exactly.

SI: Before that, did they have the gas piping?

RH: No, we just had kerosene lamps in the house

SI: Okay.

RH: And I can remember, my father made a washing machine that would work without electricity. He took some little gasoline motor, like a lawn mower motor, and rigged that up to drive a washing machine, so that it was a mechanized washing machine.

SI: It sounds like your father was pretty handy.

RH: Yes, he was, yes, he was. We had an ice chest. I can remember the ice chest, buy a big block of ice and put it in there to keep things cold in the ice chest. ... I can remember, we had a well outside and I can remember having a manual pump with water carried into the house, but there was a pump in the basement after we had electricity, and a water reservoir, it would pump water into a pressurized tank. ... The air would then force water upstairs into the kitchen sink. Only an outdoor toilet; my father, at some point later in time, actually, I was in college, at Purdue, when he put a bathroom in the house.

SI: How far away was that homestead from a town, or was it part of a town?

RH: We were about eight, ten miles out in the country.

SI: How far did your father have to travel for work?

RH: Half an hour, fifteen miles to twenty miles, something like that. I rode a school bus all the time. ... Again, what I'll do is, I'll go back to ... a map of Southern Indiana. ... Here's Cincinnati, here is Southern Indiana. ... Okay, here's Madison, Indiana. It's on the Ohio River. Here's Cincinnati over here, a little town called Versailles, which is the county seat of Ripley County, and this little place, Holton, is where I went to school, where my father went to school. He went to Butlerville for a little bit in his high school career, and Batesville.

SI: Nebraska, Holton and Butlerville are all right next to each other.

RH: ... Here's Nebraska and here's Dabney, which was mentioned. These were all in the same area, and this little town, Zenas, is getting pretty close now to where we had the farm, and it still exists. That farm still exists. My mother and father are both deceased now. Okay, you see how the road zigzags right here? Right here is where my family's home is, and I'm going to switch to satellite. ... Okay, right here is the place I was looking for; okay, now, when I switch to satellite, right there, that's their house.

SI: It is still there.

RH: Oh, yes, it's still there.

SI: Wow.

RH: Okay, and, to give you a feeling now, see, ... I said that Dad added on to the house. This area back here, he added on to the house and that's where that bathroom is, and this was a garage that got added on in even later years. I'm going to try and zoom it back the other way now. You can see the house is standing right there in the middle. You can see how this is really wooded or

farmland and, if I then go this direction, the little town of Holton is nearby and the school is still there, too. The high school building is still there, but not that grade school schoolhouse. Okay, ... that's the railroad track and the school is right here; that's the high school building, that's the gym and the classrooms and that other building sat right here. The one that's no longer there sat right here and, if you look just to the south of this school building, you'll notice that there's an area here on the Google Map that looks quite different. ... Do you see this whole area that looks quite different?

SI: Yes.

RH: ... It's a large area. ... You see how large that area is right there, that's totally different looking? This is what was called the Jefferson Proving Grounds and, during World War II, especially, a lot of munitions testing was done in here. I can remember the explosions. We did not move to Indiana until '46. The war was over, but, for years after that, you'd still hear testing going on here in this place. I believe it doesn't even show on a regular map now. On older maps, you probably will find Jefferson Proving Ground, that big, large area right here, but, ... when a bomb would go off, the windows in the house would shake, and I remember all that. So, you could see that we were way out in the country, gravel roads, dirt road, gravel road, and I rode a school bus to school. All twelve years were at Holton. I did not have a kindergarten. None of the four of us kids did; all twelve years at Holton. ... We're sort of talking about how many things I can remember that far back in time. I can remember a few things at school in those very early years. As I get to high school, I can remember just a little bit more, but it's really vague; I don't remember very much of it. I remember far more from my Purdue days than I do my high school days, and even though they're virtually the same in time now, you know how many years back that was, ... being at Purdue was just so totally, radically different from my years before that, just so different. ... That's probably why I remember it so much better. ...

[TAPE PAUSED]

SI: Let me just turn the recorder back on.

RH: Okay.

SI: We were just talking about when the new addition was built and the high school moved.

RH: And I pulled out a copy of a book that was put together many years after the school closed that has graduating classes from many years, and we looked at my father and his two sisters that were in the Class of '34 and another sister was in the Class of '35. We looked at his sister in the Class of ...

SI: 1936?

RH: I'm sorry?

SI: Was it in the Class of 1936?

RH: Oh, I have trouble remembering now. ...

SI: None of the classes are very large.

RH: Let's see, it was '36, yes, '36; very small, yes. Then, my class was 1960, we looked at my picture, my sister's in '56, then, I had a brother in '63, Larry, and a brother in '64, Johnny, should be here somewhere; here, right here. ... Then, I believe that '69 was the last year of Holton High School, yes, Class of '69 was the last year, and then, school consolidation had closed down the high school. Apparently, they still had a grade school there for a few years. I'm not sure just how long, but ... I guess, from the cover of the book, 1852 must be the first year of the school. ... Here's sort of a picture that shows that new building that went all the way along the back. This is US 50 and US 50 is interesting, because, see, that's a coast-to-coast highway and it went right through that little town of Holton. The first year that they seem to have pictures of the graduates was; what year is this? '27. So, they just barely had my father's pictures in there. They have a reunion of sorts every year. I have gone to one only and that was ... in the year 2000, I guess. So, that was my fortieth anniversary. Fiftieth will be next year. I may go back next year, I'm not sure.

SI: What did you think of the quality of the teachers in this school?

RH: What I think is interesting is how well I did versus how small the school was. There were twenty-two kids in my class and, ... when I was ... a senior, there were eighty-two kids in high school. So, that suggests my class was about an average size, if you divide eighty-two by four. Very few kids would have gone on to college. In my class, there were maybe three or four, I don't know exactly, but, for being a small, country school, it must have been okay, because I did well at Purdue. ... I can remember, my parents worked very hard to make sure there was a chemistry class available for me. I did not have any physics in high school. It was not offered. They never had a physics teacher, but my senior year, they did get a chemistry teacher, so, I had chemistry. ...

SI: When you say your parents worked hard, did they help bring the teacher in?

RH: Working with the school board or the board of trustees, I don't think there was a school board, it was the board of trustees, to push them to hire a teacher. That new building had a chemistry lab in it. The old building had nothing like that, and I believe my parents played a role in making sure that it had that kind of facilities in that new school. ... I had algebra and a second year of algebra, trigonometry and plane geometry and solid geometry. I think that's pretty much it. At Purdue, I was almost eligible to be in an accelerated program. This is coming from this little, teeny school, and there was one course I was lacking, and I guess this was from some tests I had taken. ... I needed analytic geometry to be able to enroll in this advanced program, and so I studied analytic geometry ... during the summer after my senior year. I went to visit my high school math teacher a few times to have him help me understand some things, but some of this was beyond him also, and so, one of the things that I was doing was self-study. I took an exam and I passed it, and I started in that accelerated program. My first semester at Purdue, I was actually categorized as a second-semester freshman, which I think is significant considering the school that I came from. When I took, ... it was either trigonometry or solid geometry, and

maybe both, I can't remember, I was the only student taking it, and so, my teacher did not have a class hour. Basically, again, I would do self-study and consult with the teacher whenever necessary, took tests, and so on. I remember something else; I wanted to learn to type. I'm a touch typist. We had typing in high school, and ... so, I took two years of typing, and my anticipation was that that would be very handy for me to be able to type, going to college, and it's kind of funny, ... the awards given out in my senior year, I was valedictorian, I got a math award and I got the typing award. [laughter] The school had one electric typewriter, you can imagine that the kids in the regular class would have to share that with each other. Once every week or so, you might have half a class on the electric typewriter; the second year of typing was the last period of the school day. That was also gym, and the basketball team, I was on the basketball team, ... basketball practice started during that last period of the day. So, I ... could not be in the regular second-year typing class, because it conflicted with basketball, so I did second-year typing by myself, again, consulting with the teacher, and that meant that I had the electric typewriter to myself a hundred percent of the time. [laughter] So, I just ... lucked out on that.

SI: Did you have access to other educational outlets, like a library? Did you read a lot?

RH: No library. This school had a very little library, a small library, but I don't remember ever checking a book out of the library. I did not read a lot of other stuff, didn't have it available to me. ... I read a lot of novels now, but that was more an adult-type thing, not childhood.

SI: What would a typical day be like for you when you were an adolescent? Would you have a lot of chores? Were you just focusing on schoolwork?

RH: Yes, we usually had at least one cow. I milked the cow. I would do that every morning, every evening, and I can't remember when I first started doing that, somewhere in grade school. Then, all through high school, I would have done that. So, every morning, I would go out and you saw, Googled from air, that place was seventy acres, well over half of it was fenced in and was, you'd call it pasture, or woods, I'd have to find the cow, or try calling the cow. ... She may or may not come, I may have to go find her, bring her in, give her some feed, milk her, and then, in the evening, do the same thing. Regular chores, that was primarily it. That doesn't mean that's the only thing I did, but it's something I would do day after day after day. Milking the cow was the thing.

SI: You said you were on the basketball team. Relatively speaking, were there a lot of other things to do, like clubs or sports?

RH: No, nothing like that. There was a home ec. something or another, the Sunshine Society, or something like that, that girls participated in, in high school, and about the only thing I can think of that some of the boys would have done was the FFA, Future Farmers of America. I was never a member of that, but some were, and, otherwise, there were no clubs or anything. ... Also, I did not have a car. We lived well out in the country, I had to stay after school for basketball practice, it would be that last period of the day and continue on. ... So, what would happen is that my father, on his way home from work, would come by and pick me up and, usually, he was a lot later than when I was finished. ... So, I can remember, I would always go across Highway 50 from the school to a little place, Holton's Gas Station. ... They had a little dining room of

some sort in there, with a breakfast bar-type thing, and just wait in there, a couple pinball machines, which I generally did not play, and just wait there for Dad to come by and pick me up and go home and milk the cow. I would ride the school bus in the morning, but, then, if there was basketball practice, I would not ride it going back home that evening. You asked me a question there, that I was going to say more than that, but I can't remember now what it was. What did you ask me that prompted that?

SI: About clubs, that sort of thing.

RH: Okay; no.

SI: It is interesting that your mother had considered college herself and your father had an education beyond high school. How important was education as something that was impressed on you, their children?

RH: That was a very important thing. As long as I could remember, I was going to go to college. I had decided very young that I was going to be an engineer. ... I had an Erector Set, which many boys my age would have had, and I think as early as maybe the fourth grade, I was going to be a civil engineer, and I think it was the Erector Set that did that, build bridges or buildings or this or that. Somewhere in my high school time, may have been about the time I was a junior, for some reason, and I can't remember the background on this, my parents enrolled me in a course at UEL, United Electronic Laboratories. This was something out of Louisville, Kentucky, I believe. It was a correspondence course. I should look this up on the Internet, see if there's something like this that still exists. I still have my books from that. They're in storage, not here in the house, and it was a correspondence course, with many, many, many chapters, and, when you finished one chapter, they would mail you a future chapter, take some sort of test. ... It was like a correspondence course to become an electronics technician. I built little things like a radio transmitter, stuff like that, during my high school period, and somewhere in there is when I decided I wanted to be an electrical engineer, and that is indeed what did happen. When I went to Purdue, I was in electrical engineering and I found that the work that I had done helped me very much in my electrical engineering studies, because I had an understanding that many other students did not have. This was also a period of GI Bill use. A lot of guys had been, especially, in the Navy, I'm not sure why, but having been in the Navy, and then, coming to school at Purdue, and these guys were really advanced. So, they were tough competition during, say, the first couple years, but, by the time you get beyond the first year or two, those differences had begun to fade quite a bit.

SI: Going back to Holton for a moment, were you unique in living eight miles out from the school or did most of the kids live in the town?

RH: No, Holton was a very small town, basically in the middle of a farming area. Most kids lived out in the country somewhere.

SI: Okay. Did your parents ever talk about the Second World War and how it affected the family?

RH: No, not very much, and you just ... reminded me of what it was I was going to say. You were asking me, "How important was school?" and that's what I was going to respond to and I had forgotten what the question was. It was very clear that my parents wanted all of us kids to excel in school. It would be very embarrassing to come home with not a good grade. You needed "As" all the time and that's pretty much what I had, "As" virtually all the time, and I credit them, you see, with whatever it was, of instilling in all of us, this desire to go on to school. The question you just asked me that triggered this thought, what was it?

SI: Of World War II?

RH: World War II; no, I don't remember much about World War II. My father was considered in a critical industry, so, he was never drafted. He was working in the mines during that time. ... Let me segue into me, on the military; I was in Air Force ROTC at Purdue. Purdue's one of the land-grant schools. At that time, I don't know if it's still true today, but, at that time, ROTC was required of all male students and two years were required. Then, you could go on two more years and become an officer or you didn't have to participate. ... I would have liked to have been a pilot, an Air Force pilot, but my eyes weren't good enough. I wear contacts now. ... So, I only did the required part, and then, went on to graduate school. I was married, I had children, so, what was happening was that ... my draft board, which was always in Southeastern Indiana, I was always deferred, because of either my being in school, when the Vietnam War was beginning to be very significant, or I was married, and then, I had children and they weren't drafting people like me. Later on, I think they were, but, by that time, I was older, and so, ... if I had been a couple years younger than I was, I probably would have ended up in Vietnam. So, you see, I'm sort of in that period between Korea and Vietnam. That's where I fit in in time.

SI: Growing up in Indiana, how aware were you of what was going on in the world? Were you able to follow current events?

RH: Not very aware. ... We got a newspaper daily, but I just can't remember things like that being significant to me. I just can't remember anything where any kind of world news was a significant thing to me during all that time. Even then at Purdue, that was still somewhat true. See, the Bay of Pigs happened while I was at Purdue; what year was that?

SI: 1960.

RH: In '60; that was fall, right? [Editor's Note: The Bay of Pigs Invasion took place on April 17, 1961.]

SI: I believe so. I am not certain.

RH: I started Purdue in September, August/September 1960, and, see, I don't even remember when that happened. I was that unaware of it. I can't remember anything else during that time, except the Kennedy assassination. That was very shocking; that's memorable even today.

SI: Where were you when it happened?

RH: I can't remember exactly where I was, but I do know that classes were suspended and I sat in front of a TV at the Purdue Memorial Union, watching a lot of stuff, and that's where a lot of the students were.

SI: Just as a general sense ...

RH: I guess that was probably the week of Thanksgiving, because it was the 22nd, I think, right?

SI: Either the 22nd or 23rd. [Editor's Note: President John F. Kennedy was assassinated on Friday, November 22, 1963.]

RH: And it seems like it was like a Monday, maybe, maybe a Monday or a Tuesday, and so, later that week, I'm sure, was the Thanksgiving period. ... So, when I say classes were suspended, it may be what they did is, they just closed down early for the Thanksgiving holiday. That may have been what happened. I'd have to check dates to make sure on that; go ahead.

SI: Just as a general sense, growing up in the 1950s, with the ongoing Soviet-US tension and the Cold War threat, do you remember any of that impacting your life?

RH: Not really. I do find it interesting, now, to look back at history books that I had in high school, of how anti-Communist the school books were.

SI: Was that something in the consciousness of your community, the idea that, "There are Communists everywhere," that they are a threat?

RH: I don't know how much that feeling existed. I wasn't really aware of that. The only thing I can point out is what I see when I go back and look at my history books.

SI: Did you ever have a job outside of your home, like a part-time job after school or during summer?

RH: ... Okay, during high school, I occasionally did work on farms for people, putting up hay, doing some plowing, things like that. Then, ... I think between my junior and senior year in high school, I think I may have worked at Arvin, my dad's place, and then, between my senior year and freshman year at Purdue, I worked there, I may be wrong on when I started doing that, and then, during maybe one summer while I was at Purdue. I had a scholarship from Arvin. They paid something like five hundred dollars a year, and just to give you a feeling, ... I can remember, when I was at Purdue, the tuition was 130 dollars a semester. ... I had a scholarship from Purdue, so, I only had to pay sixty-five dollars a semester. Room and board was about a thousand dollars a year, and so, the Arvin scholarship helped that quite a bit, at five hundred dollars a year, but I still needed more money and my parents really didn't have money to help an awful lot. So, I worked while I was a student and I did some work for the Electrical Engineering Department. One time, I had a job where I would be checking out equipment in the lab to other students. ... The company, Arvin, built a little research facility at Purdue, not on the campus, but off campus somewhere, and I worked for them, ... certainly during my junior and senior year and full-time the summer between my junior and senior year, and I can't remember how much

more. ... That helped quite a bit, too, having that job, so that my parents did not have to contribute. ... Between the scholarships that I had and the work I did, most of my expenses were covered that way, not totally. I got some, took some loans while I was a student, not big numbers, today, thinking of what kids go through today, but, ... within, oh, five to ten years, I had paid those off, after graduating.

SI: Was it the connection between Arvin and Purdue that led you to choose Purdue?

RH: No, no, going to engineering school in Indiana, Purdue would be the place to go. ... I believe I applied only to two schools, to Cincinnati, which had engineering, and to Purdue. I don't remember what the cost of Cincinnati would have been, but Purdue, and being an in-state student, Purdue was probably cheaper. Purdue was four years, Cincinnati was five years. Cincinnati pretty much operated on a co-op program, and I wanted to finish in four, not five years, and so, it was almost automatic ... that I went to school at Purdue.

SI: Was going to Purdue the first time you had really traveled outside of your home area?

RH: No, my parents had done some traveling through the country. ... One of the things I did, a year ago, I ride a Harley Davidson and I signed up for an American Motorcyclist Association, AMA, for a tour that they did on Route 66. ... I rode the bike to Chicago, met up with a group, and then, we rode old Route 66 all the way to Los Angeles and broke up there, and then, I came back home from California on the Harley. All together, I was gone five weeks and ... a lot of what I was doing there was retracing something my parents did in 1952. We did a vacation that was very similar to that. ... It basically started in St. Louis. We went west on US 50 to St. Louis, and then, down Route 66, there are a number of things I can remember on that trip, but I also remember a lot of the pictures. Sometimes, I don't know if I remember something for real or if I remember the picture. [laughter] That's also part of what prompted me to really start scanning my father's slides, looking at some of this old stuff. So, part of what I was doing on this motorcycle ride was trying to find some of the places I had been in 1952, and I did find quite a few of them and even ... did a daily travelogue with lots of pictures, so that Hanna, my wife, could keep up with what I was doing. ... Over time, different people learned about that, a lot of the riders. I guess all the riders on the Route 66 ride knew I was doing that and they were having people back home follow what I was putting on the Internet, because they were doing the same stuff. ... So, we did trips like that, down through the Southeast, two big trips, and we would often go down to Kentucky to visit family. I had family up in the Detroit area, all Kentuckians, they had moved up to Michigan to work in the motor industry, and so, that's pretty much the kind of traveling that I did as a child. ... On the Western trip, we did get into Mexico, in Juarez, just walking across the border, and, some time in Michigan, we had gone across into Canada. So, even as a child, I had been in Mexico and in Canada, just barely across the border, but that's more than most kids, certainly that lived around me, would have done.

SI: Does anything stand out from your travels as being so different from your own life, something that opened your eyes to what else was out there?

RH: I'm sitting here thinking; the quietness on the tape is the thinking. ... I don't see it at all the way you're talking, the way you asked the question. It's more like I just experienced it. This was

happening to me. I don't see it as an "opening of eyes" or anything like that. It was just happening, taking it in.

SI: Indiana is above where the South starts, but it is close; growing up, was there any segregation that you were aware of?

RH: Not that I was aware of; I'm sure it existed. ... Kentucky is called "the Bloody Battleground," because, in the Civil War, families were split. ... In my school, there were no black kids. At Purdue is probably the first time that I encountered different kinds of people. Just thinking, I can't think of anything. Nothing pops into mind before Purdue; not very many black kids at Purdue. ... There were many black kids in Indianapolis, and perhaps other cities in Indiana, and, see, one that stands out particularly is the high school Crispus Attucks in Indianapolis, which no longer exists. It's a kind of sad story, but it no longer exists. Oscar Robertson came out of Crispus Attucks in Indianapolis, went to school in Cincinnati and, of course, a great basketball player. [Editor's Note: Oscar Robertson played basketball for the Cincinnati Royals and the Milwaukee Bucks.] ... One thing I should mention, the movie *Hoosiers*, have you seen the movie?

SI: Parts of it, yes.

RH: Parts of it? You know the story is about this little school that won the state championship in Indiana, and that school was Milan. That name is not used in the movie, but the town was Milan, which is in Ripley County, which was my county, and we would play Milan two, three times each year ... in regular games, in the county tourney. ... I specifically remember the real event when it happened. It was ... '54, Spring of 1954, when Milan won the state championship.

SI: Were you at the game?

RH: I was not; I was at the games in the county. My school played Milan. We lost to them, obviously, or Milan wouldn't have gone on, but, if you ever see the real game, and I have a tape of the real game, ... Milan was a very slow-playing, stalling team. ... Indeed, one of the things that happened was, during the second half of the final game, one of the Milan players just stood there for minutes, holding the ball, just standing there, which is not allowed today, there's a shot clock, and the game with my school was played very much the same way, very low score at the end, close score, but very low, and that was the kind of basketball that they played. How did we get onto that? You were asking me ...

SI: I was asking about; I forget. [laughter]

RH: Oh, meeting other kinds of people.

SI: Yes.

RH: Yes, there were black kids at Purdue, not very many, or it doesn't seem that there were very many. ... I think, today, in fact, the head of engineering at Purdue is a black man. He was the head of electrical engineering, and then, there was an opening for the full College of

Engineering, he moved from head of electrical engineering into the dean of the engineering school. [Editor's Note: Dr. Mark J. T. Smith was the head of Purdue's School of Electrical and Computer Engineering before becoming dean of Purdue's Graduate School.] ... I met him when I lived in California, because I did a number of things where I would participate with Purdue; what do they call it? It's the council, the something council, [President's Council]. ... He came out of Georgia Tech, I believe, and he was going around, meeting different alumni groups, and I met him then in California, and it's interesting. You see how that the school which was pretty white has had now a black head of electrical engineering. I could go pull my schoolbooks out. They called it *Debris* [Purdue University's official yearbook], D-E-B-R-I-S. I had all four years. You could just flip through that and look at the seniors and get a quick feeling, if you're interested, of what people looked like.

SI: That is okay.

RH: Most were white. [laughter]

SI: I just noticed, as I was going through the high school yearbooks ...

RH: Oh, everybody there, everybody; in fact, I doubt there was ever one black student at Holton. ... No black people lived there. No Oriental people lived there.

SI: I was going to ask about basketball and how important it was to you and the community.

RH: Very important. ... You can get that from the movie *Hoosiers*, it's called the "Hoosier Hysteria," very strong in that part of the country.

SI: Did your school have a rival, or do any particular games stand out in your memory?

RH: Pretty much, ... it was the county. You played outside of the county, also, but the big thing was to be the county champs. There was a trophy, a little lion, called Vic, "Old Vic." I'll bet there's a picture of Old Vic in here, and ... the way that Old Vic worked is, whoever had him, if they lost a game and it's a county game, or against one of the other schools in the county, the winner of that game would take Vic. ... So, he didn't necessarily pass to the best team; it's whoever won the game when he was there. So, that's kind of an interesting way of doing it, because all the; here's Vic, here, there. [Editor's Note: Dr. Hopkins points to a picture in a book.]

SI: Wow.

RH: ... This "New Vic," I don't know the New Vic. That must have been after I left. This is the Old Vic that I remember, and I guess "Vic" is probably for "victory," [laughter] and we would have him at times, even though we, generally, weren't the best school. See, Milan was a larger school than we were; they had about one hundred sixty kids in high school, whereas we had eighty, so, two times as big.

SI: Were you the first person in your family to go to college?

RH: My sister. She was four years ahead of me in school. She went to Indiana University, but did not finish and got married some time later, and then, some time after that, did continue school, but, ... by the time I got through my first four years at Purdue, she had not wrapped up yet. So, I may have been the first one to get a bachelor's degree. ... Then, my sister later completed her bachelor's degree, and, in fact, ultimately, got a PhD, also. My youngest brother went to Purdue, got a bachelor's degree, went to work for Motorola, moved to Phoenix, Arizona, continued school at Arizona or Arizona State, I'm not sure, whatever's in Tempe [Arizona State University], and got a master's degree. Then, some time later, he moved back to Indiana and took a job with RCA and, at some point, got a JD, and I think he did that in Indianapolis, but I believe that it was part of Indiana University, but I'm not sure of that. Anyway, he has a JD. The other brother went to school at Purdue, but did not finish, and then, stayed more in the community. Whereas the rest of us had gone out somewhere, he tended to stay more in the community, and then, my brother from Arizona went back to Indiana. So, both of them now live in Indianapolis. Marion County is sort of a center square county in Indiana and Indianapolis is pretty much it; the city limits are pretty much the entire area of Marion County. So, they don't live in downtown, they live in Marion County, but that's a part of Indianapolis. My sister lives in Louisville and ... my sister has always lived in Louisville. Then, after leaving ... Indiana University, she went to Louisville and that's where she's always lived, a couple or three different houses. ... The brother that stayed in Indiana has lived a couple different places, but has basically been in Indiana all that time, and my other brother was four years, five years in Arizona, then, back to Indiana. ... I'm the only one that has moved away and stayed away. [laughter] I have lived in New Jersey, in Florida, in Washington, DC, not DC, but the suburbs, in Jersey Island in Europe, and in California. So, I've moved around a lot. They have tended to stay closer to home.

SI: To get into Purdue, what were your first few days and weeks like at Purdue? What was it like to go to college in 1960?

RH: Well, it was just that everything was so different. First time I had been away from home; that's not exactly true. I went to Boys State, and so, that's a week, less than a week, you're away. I had gone to a Baptist camp, where you'd be away for a few days. So, it's not like I'd never been away from home, but this was the first real time away from home, and I liked it very much. I studied very hard. I think I may have overcompensated, coming from a small school. So, I studied very hard and I did very well at Purdue. ... Future years, I never studied as hard as I did in my freshman year. [laughter]

SI: From focusing on Rutgers people, I know there were a lot of traditions in terms of freshman hazing and that sort of thing. Did they have that sort of thing at Purdue?

RH: Yes, yes. The seniors had cords, yellow corduroy pants, and they'd paint things on them and, the first football game of the year, seniors would march, ... around the field in their cords. Most of the men had a beard and a cane and cords, and the girls wore, generally, a skirt, a yellow skirt, corduroy skirt, with things painted on it; all kinds of clubs, just innumerable things. ... So, there were all kinds of activities you could participate in, just totally, totally unlike what my schooling at Holton had been, where there was nothing like that.

SI: You went immediately into electrical engineering as a major.

RH: Yes, except, at Purdue, the first year would be general engineering, so that mechanical engineers, electrical engineers were basically taking the same courses and, in sophomore year, you start doing things that are different from the others. The different schools of engineering would do different things beginning in the sophomore year.

SI: Do any of your professors or classes stand out in your memory?

RH: Probably the one that always comes to mind more than anybody else was the professor for statistical thermodynamics. I think his name was Belafonte, Professor Belafonte, and he would come into class, into the classroom before class started, and this was a large lecture hall. There may have been five hundred seats in there, but the class had maybe ten students, and so, there was this large blackboard, and it was black, all across the front. He would come in and have that board totally filled by the time class started. Then, he would lecture, going across the board. He carried a pail of water and a towel and sort of a wooden thing like a trowel, and so, about halfway through, he would wash the board. [laughter] Then, I can remember him fanning it with that towel, to get it dry, and he would proceed to fill the board up again [laughter] during the second half of class, and so, taking notes, ... part of what I remember, too, is, it was almost like you could either listen to him and understand it, but ... you didn't have anything on paper, or you could write down what he had on the board, paying more attention to writing it down than what he was saying [laughter] and have a record of it. It was very tough, because of the enormous amount of stuff that he would do during each class. So, that's why that stands out, because of a different approach, more than anything else. Nothing else stands out in my mind when I think about it. I can think of a different professor here and there, but the one standout of something that was different was Professor Belafonte and his statistical thermodynamics. [laughter]

SI: In general, what did you think of the courses that were offered at Purdue and your options?

RH: I had signed up for something called the R&D option and this was courses that were much more physics-oriented, rather than, "Here's how a vacuum tube works." ... I did okay, but, at about my junior year, I was beginning to feel that that was a mistake, that I thought it was too theoretical, that I was going to be graduating as an electrical engineer and I could derive the equations for Brownian motion, but I have no idea how anything electronic works. ... I did not like that feeling, and so, I dropped; dropped is the wrong word. I changed my curriculum to be more like the traditional electrical engineering curriculum, and I think I then took a course, or two or three, during the summer between my junior and senior year, I think is when I did that, to pick up some of the courses that I really wanted to have, and then, I think my senior year, I was in pretty much the traditional program. So, I had a combination of the two ... and my grades were pretty good all the time. So, it wasn't an issue of not being able to make the grades. It was just that I'd decided I didn't like what was happening with me, and that had some effect, actually, at Rutgers, the thing I was finding, which actually bothered me a bit, some of the courses I was taking as graduate level courses were things I had done as a sophomore and junior at Purdue, because of the accelerated kind of course I was in. ... I really protested, but I didn't seem to have any choice, those were required courses at Rutgers. I had to take them and, as you can imagine, they were very easy for me, because, basically, I had already done them, and I even remember

one of the courses. I can't remember which specific one it was, but I didn't even take the final exam. The professor told me I already had an "A." Even if I had a zero on the final exam, I had an "A" for the course, so, it was sort of, like, optional whether I even took the exam, and I didn't take the exam. ... You know, I just didn't need to, and so, that was a negative thing, that I felt that, "I can understand that there's a curriculum, that you've got to follow the curriculum, but the thing is, I'd already done it," but that didn't seem to count.

SI: What was state of the art when you were at Purdue? What was the state of electrical engineering and electronics at that point? I know that is a big question.

RH: Yes, yes. Motors were already not a significant part of the curriculum. If you go further back in time, motors would have been a big part of any electrical engineering curriculum; by that time, they weren't. Transistors were very, very new. Integrated circuits, ... it may be that integrated circuits did not even exist yet in my freshman year. That may have been very early '60s, late '50s, early '60s. So, the courses would have focused much more on vacuum tubes than transistors, and that was something, though, that I did want and, actually, I think my first course where I really got into transistors, I think, was at Rutgers, not even at Purdue. I maybe remember that wrong, but I think that was the case, because it was all fairly new at that time, getting worked into the curriculum. Software was not a big thing. I did learn FORTRAN programming as a student, but ... a little project here or there might be done on a computer, but, understand, everything was done on a mainframe computer. You would go punch up a tape. You write your program, go to some machine where you would type it out and put it on a tape; do you know what I'm talking about, a tape? This is like a paper tape that's maybe an inch wide and it would punch holes in the little tape, and then, you could put that in a machine and it could read what you had punched in the tape, sort of like IBM cards. ... So, you would submit a program, either on IBM cards or on a paper tape, they would run the program, sometime, and then, give you papers back showing the results of running your program; quite different now. See, I have a computer sitting here; I have four computers running in my home right now. [laughter]

SI: When I was at library school, some of the professors would talk about the systems they would use for running searches and they would do it basically the same way. It is kind of interesting for people of my generation to learn that something that would take us five seconds would actually take a couple of days for you to get the information.

RH: Yes, yes, but, generally, when they would run the program, run your tape or your cards ...

[TAPE PAUSED]

RH: You can turn it back on now. One of the things that I have done over the years is keep books. Many of my freshman books, I don't have any more, but about that time is when I decided, "I'm going to keep books," and so, I have a very nice library. ... This book is *Pulse, Digital and Switching Waveforms*. This was a class that I did at Rutgers, and I know that because I have my Princeton address in it. [Editor's Note: Dr. Hopkins flips through the pages.] See, these were tubes, but transistors, okay, see, this had transistors in it also, but I'll bet you the word "integrated circuit" doesn't even appear in the index, but we'll find out here in one second.

No, the word "integrated circuit" is not in the glossary. It's not in the index; let me just look in the table of contents. No, nothing in here that would indicate such a thing as an integrated circuit. So, that's one thing I brought from my library. I just did a quick thing. ... This would have been a Rutgers book and this was more the kind of stuff I was studying, much more theoretical type stuff. This one is *Solid-State Physics*. This book, *Electronic Engineering*, I don't have a date on it; this was probably one of my Purdue books and it does talk about P-N junctions, diodes, and so, transistors are in here. Integrated circuit? "Linear integrated circuits, Page 472;" so, there was something in here, but, see, that was very new kind of stuff. Just looking to see what they have written; yes, see, just imagine this now, these are transistors here. Today, there are millions and millions of transistors on a circuit. [laughter] It's amazing, the difference. So, this was a very early integrated circuit and, see, this, this would have been what was in the integrated circuit, just a very simple little circuit, a dozen, what's that, eight, transistors? three, six, nine transistors, and let me just see when this book was copyrighted. Copyright, first copyright, was 1966, but, then, it also has a '73 copyright. Now, I don't understand this, because, see, ... I got the PhD in 1970, so, I don't understand why there would be a '73 copyright in this book. That doesn't make sense to me; ... I can't understand that. I noticed that, when I was in there, I had two copies of this book and maybe, somehow, I picked up a second copy. I should look at the other one and see what the date on it is. I picked up my senior Purdue book and when you just flip through here, seniors start, well, just about where I am. Okay, this is one of the first pages; we're in the "Cs." African-American, one on that page, fifty people here, one black male. This page has more than fifty and I see no black, no Oriental people; this page, the same thing.

SI: Is this the entire school or just the engineering college?

RH: No, this would have been the entire Purdue graduating class. So, I'm not going to flip through every page here, because there's a few thousand seniors.

SI: It is quite large.

RH: But, you can see that it was pretty much Caucasian. I haven't even seen an Oriental yet.

SI: How many women were in your courses?

RH: I cannot remember any; here's another black and here's an Oriental face. ... I can't remember any women. There may have been, but it would have been a very small number. I do distinctly remember a couple women in engineering at Rutgers.

SI: No professors?

RH: No, no professors, and this is a high school history book and I see here, in fact, they're talking about, "Friction grows between Soviet Russia and the West." [laughter] ... Here's a picture of an atomic bomb blowing up in Bikini. [Editor's Note: The United States tested nuclear weapons at Bikini Atoll in the postwar period.]

SI: As a general thought, in the late 1950s, with *Sputnik* going up, there was a nationwide idea that the US had to become more advanced in the sciences and engineering.

RH: Yes.

SI: You would have been getting the benefit of that a few years later. Did you notice improved facilities or an increased emphasis when you were at Purdue?

RH: No, no. Something may have been going on, but I'm not aware of anything; no, nothing specific. Purdue is one of the better engineering schools. ... They have a nuclear reactor at Purdue. They did when I was there, they still do, and, in fact, I was back on campus in 2000 and one of the things I asked was to see the reactor, and it's still there, kids still doing work with it. So, in a sense, you see, that was pretty far ahead. This was in 1960 that they had a nuclear reactor at Purdue. ... Purdue also has made more astronauts than any other school. Neil Armstrong was Purdue, ... and that was before I was there, so Purdue was an advanced university. I don't know what he would have been called, [laughter] I have to check on this, when he was there. I mean, did the word "astronaut" even exist in our vocabulary at that point in time? but several of these guys came out of Purdue. [Editor's Note: As of 2009, twenty-two NASA astronauts called Purdue University their *alma mater*, most notably Neil Armstrong, Class of 1955, the first man to walk on the Moon.] So, Purdue was out in front on a lot of that.

SI: That early 1960s period was a particularly interesting time in the Space Race; were you following that?

RH: No, I don't remember specifically much about it. ... A couple things that stand out in my mind; ... my high school class did what was called a senior trip, that a lot of schools did. We went to Washington, DC, and to New York City. We took the train. We caught the train right there in town. You know, when we were looking at Holton, you could see the train tracks running through town. Normally, a train didn't stop there, but that train would stop and pick us up and we rode it all the way to Washington, and then, rode the train on up into New York City. ... I can remember Times Square, when I was there, that the thing running around the building [the news ticker at 1 Times Square] was about Francis Gary Powers being shot down; you know what I'm talking about?

SI: Yes, the U-2 incident. [Editor's Note: On May 1, 1960, the USSR shot down a US Air Force U-2 aircraft piloted by Francis Gary Powers over Soviet territory, creating an international incident.]

RH: Yes. So, that happened, I certainly was aware of it. I remember it. My son, whose birthday is Saturday, was born in '69 and '69 was when Armstrong landed on the Moon, in late July, [July 20, 1969], if I remember correctly. ... I can remember watching on television at home and, indeed, took a picture of my son, holding him up, one month old, in front of the TV, so that you could see Neil Armstrong, you could see this baby, in one picture, [laughter] just so he would know that he was there. He may not remember it, but he was there when Neil Armstrong landed on the Moon. At RCA, I can remember that a guy I worked with, sort of like a mentor, was very into all the Moon shots, the Ranger shots. [Editor's Note: NASA's Ranger

series of missions, running from 1961 to 1965, aimed to take and transmit back to Earth images of the Moon's surface.] ... During the working day at RCA Laboratories, we'd have a TV on, watching those things, watching, and I can remember the Ranger coming in on the Moon, and then, all of a sudden, it goes black, because it has impacted the surface. So, I was aware of it. Did I answer that question?

SI: Yes. I was also curious if, being an engineering student at the time, you would be following the technical aspects of what was being developed by the space program, if they were sharing that information with engineering schools.

RH: No, not that much. I do know that stuff like ... our technique of going into orbit around the Earth, and then, leaving Earth orbit to go into Moon orbit, and then, leaving Moon orbit to go to the surface of the Moon, that was something that had been debated, about the best way of doing this. There were some people who wanted to go directly, and I guess that the people who won out were ones who could show that it was easier to do it that way. To go from Earth orbit to Moon orbit would be much easier than going straight from Earth to Moon orbit. The cameras that were used, I can remember a bit about that, because the early cameras were field-sequential color system cameras. I'm going to get into television standards, and the FCC [Federal Communications Commission]. Around 1948 or '49, I'd have to check, the FCC adopted a color standard as proposed by CBS. That was not well-received by the technical community and that was fought and, ultimately, that standard was retracted and there was a new standard, which was the color TV standard that we have even today, the one that's going to get shut down on Friday. [Editor's Note: The CBS field-sequential system was adopted as the standard for color television from October 1950 to December 1953 when it was replaced by the National Television System Committee (NTSC) standard. The NTSC system was later supplanted by the Advanced Television Systems Committee (ATSC) system, a process which began with the adoption of the ATSC standard by the FCC in December 1996 and which was completed on June 12, 2009, in the United States when broadcasters ceased analog NTSC transmissions.] ... The way that the CBS color system worked, you'd send a red picture, a green picture, a blue picture, a red picture, a green picture, and, if you do that fast enough, ... the retention of phosphors in your eye, that would blend into a color picture, instead of seeing this as three separate colors. The RCA system was integrated from the beginning, where it's pixels that were red, green and blue, instead of a full picture at a time that was red, and then, a full green, but those early space cameras, all, [laughter] even those made by RCA, all used the sequential-field color system, which I found as kind of an ironic twist, that RCA had won the color standard, but that's the way the cameras were that they were putting on the Moon shots.

SI: Was that because of some government standards?

RH: I'm not sure why it was that way, probably for bandwidth savings. I just don't know. I can't remember. I may have known at the time, but I don't remember now.

SI: At Purdue, did you have any opportunity to take any other kinds of courses besides engineering, any electives?

RH: A small number. I had some German and I had some psychology courses. English was a required thing, literature, throughout all four years, but the electives, I had to have two electives. My two electives were psychology and German. At the time, I saw little value in them. Today, I think I was wrong, that, actually, probably should have had more, and I have these mixed feelings about things like that, whether the students know what's best for them or not. ... So, thinking back to my student days, I would have liked less of, let's call it liberal arts courses. That's what I would have preferred, but, today, I say I was wrong. Also, I've already told you I thought that the courses I was in, the track I was on, was too theoretical. I wanted some more practical stuff and, on that, as a student, I think I was right. [laughter] So, how much do we leave up to students? I don't know. I was right on some, I was wrong on some, the way I look at it now.

SI: Some other engineers, who graduated from Rutgers, who I was speaking with recently talked about this need for some more liberal arts for engineers, particularly the need to learn how to communicate, to write effectively.

RH: Yes.

SI: Which, up until recently, engineers ...

RH: Engineers are notoriously bad writers.

SI: You have done a lot of public speaking. I was wondering if there was anything from your Purdue days that led you to that.

RH: No, not really, nope, not from Purdue or Rutgers that set that up. I will tell you that I've done a fair amount of writing and I struggle with it. What I mean by that is that it doesn't come easy to me. I have to work to do the writing I have done. It doesn't just flow.

SI: We can go back to Purdue, but I wanted to ask, towards the end of your days there, what were you looking at doing in your career?

RH: Okay. I was ahead of most other seniors in ... going on the recruiting part in the first semester of my senior year. Purdue would bring in all kinds of representatives of different companies and they had interview rooms and, you'd set up appointments to go talk to these people. ... If they were interested in you and you were interested in them, they might take you to their place, wherever it was, and most of that was done, though, ... early in the second semester, but I started doing it early in the first semester. I was doing it at the same time that kids that would be graduating in January were. That's when they were doing all that, that's when I did it, and I don't know exactly why I did that, but I just wanted to get ahead on that. I can remember, I did an interview with RCA; it was for RCA Laboratories, for the David Sarnoff Research Center. I did an interview with Lawrence Radiation Laboratory; I think it's called a different name now. It's the Lawrence Livermore Laboratory [Lawrence Livermore National Laboratory], but, in those days, it was Lawrence Radiation Laboratory, and I can remember, it may have been Hughes or an aircraft company; I can't remember which one. Take a break again?

SI: Sure.

[TAPE PAUSED]

RH: You can turn it on. I brought in my other [Charles L.] Alley-[Kenneth W.] Atwood book, [*Electronic Engineering*]. You know, I've, a couple times, noticed that there is a difference in these two. See, it's the same authors, the same title and they're different, and that, I may have picked up at a library closing or something like that. This one's copyright '62, okay. ... I have just the name "R. S. Hopkins" in here, so, I can't tell you immediately if this was from Purdue or if this was from Rutgers, but was this the one where it had ...

SI: Yes. That one had integrated circuits in it.

RH: It did. ... Where did I find that? right here, chapter fifteen. ... Are we running?

SI: Yes.

RH: Okay, and let me just see what chapter fifteen was in this book. Fifteen is, "Frequency Modulation;" well, let's see, in the other edition, "Amplifier Noise;" no, the titles are just quite different, "Oscillator Circuits," so, actually, a big revision in the book, big revision in the book between these two. There's no chapter on integrated circuits. So, when this was updated, in the '73 version, it had a lot of things that the '62 version did not. So, see, ... I just picked that one up as I was going through and I couldn't tell you why I have this. Another one I picked up, when I was in there just now, *Engineering Electronics*, this, I know, is a Purdue book. ... See, that's how I signed books at Purdue, "R. S. Hopkins." That was exactly the same way. Nine dollars and ninety-five cents this cost as a new book, [laughter] and these were both, [George E.] Happell and [Wilfred M.] Hesselberth are both, Purdue professors. ... What's the date on this? copyright '53, and so, obviously, this won't have anything about integrated circuits, and probably won't even have anything about transistors in it. ... There's a chapter, "Solid State Electronics;" let me just flip to that page, 461. I'm just curious, because, see, the transistor, invention of the transistor, was late '40s. ... Okay, here, they're talking about a Germanium transistor. This is a very early transistor, but, see, that, by definition, would have had to have been very early, because of the timing of this, and, if it was, what did I say, '52 or '53? whatever it was, understand that the book would have been finished writing at least a year, probably, before that. So, anyway, what were we talking about when we broke?

SI: I forget. Were there student chapters of the IEEE [Institute of Electrical and Electronics Engineers] and other clubs for engineers there?

RH: Yes, yes, there were at Purdue and, see, ... let me make a big distinction between my Purdue years and my Rutgers years, and then, I'll come back; remember IEEE. ... As a Purdue student, I lived on campus. That was my life. I may have had a job to help get me through school, but my life was school. Rutgers was quite different. I had a job at RCA, I went to work and part of my job was to get a master's degree, and then, PhD, so that the whole focus was different. ... I lived near where my job was, not where my school was. I was like a commuting student. So, I would drive up for a class and, if I had just that one class, I would immediately

leave again. If I had a couple classes and had some time to kill, I would stay in the area, but, ... see, I never participated in any student activities of that nature; so, a radical difference then between my Purdue years and my Rutgers years. As a result, the way I look back on things now, I see the two quite different also. The "rah-rah" school spirit exists for Purdue; it doesn't really exist for Rutgers. I like to see Rutgers win basketball, men's or women's basketball, and I will root for them, but not against Purdue, [laughter] but, generally, ... the way I see sports, college sports, Purdue is number one, there's just no question whatsoever about that, and, typically, my number two choice will be Big Ten. If Purdue can't win the NCAA tourney, I'd like a Big Ten school to win it. ... How does Rutgers fit into that? Then, there would be sort of a conflict. I would sort of root for both. I'm not sure I would root for Rutgers over Indiana University; probably would. I'd almost have to be in the event to know it. I probably would root for Rutgers over a Big Ten school, but not by a lot, but, certainly, if it's not playing Purdue or Big Ten, there's no question that I would be a strong Rutgers supporter, but, see, that comes about because of the total difference in the educational experience. I never went to any Rutgers sports game. Basketball, football, I never went to a single thing, whereas Purdue, I went to many of the basketball games, I went to many of the football games; so, just a total difference in the way I view the two. So, just keep that in mind, as we go along here, that the Rutgers kind of feeling will be totally different from the Purdue. ... Rutgers is much more, in that sense, a professional thing. I was doing that for professional reasons, whereas at Purdue, yes, I was doing it for professional reasons, but it's a lot more than that.

SI: More of a life experience

RH: Yes.

SI: We were talking about the IEEE.

RH: Oh, yes. I remember, back in those days, though, it was IRE [Institute of Radio Engineers]. The IRE and the AIEE [American Institute of Electrical Engineers] combined in the '60s, I believe, to make the IEEE. So, during my college days, it was IRE, and then, sometime later, it was IEEE. ... I may have been a student member of the IRE; I can't remember for sure, may have been, but I did not continue that after I left school. So, if I did, that was only while I was in school. I did become a member of IEEE, later, though, because, in probably the early '90s, maybe late '80s, but definitely early '90s, I decided to become an IEEE member. ... I wanted to participate in one of the IEEE committees in Washington, DC, having to do with policy issues, and the reason that became so strong is because I saw a lot of conflicts going on between what I will call the television engineering side and the computer engineering side. ... I did not like some of the things that were happening, and so, I wanted to be a voice for the television engineering side. I have been a member of the Society of Motion Picture and Television Engineers, SMPTE, for a lot longer and, basically, the standards volunteer work that I did was all SMPTE. I really haven't participated in any IEEE standards activities.

SI: As a student in the IRE, what would the student chapter do?

RH: Too long ago, too long ago; can't remember it.

SI: All right. You said you had the three job interviews and you went with Sarnoff.

RH: Yes, I took two trips; that's where we were. I took two trips, RCA and Livermore. I did not do the Hughes, or, I don't think it was Hughes. What are the aircraft companies?

SI: Boeing?

RH: It wasn't Boeing. St. Louis, it was in St. Louis.

SI: McDonnell Douglas?

RH: I think it was McDonnell. I did not do a trip with them. I did with Lawrence, I did with RCA, I got an offer from both, and, actually, the offer from RCA was 655 dollars a month. ... I believe the offer from Lawrence Radiation Labs was 660. It was like five dollars more, but I saw a big difference in graduate school, where the RCA offer, part of that was that I would be ... getting my master's degree. ... I mean, that was part of the hiring, because, at RCA, they only hired people with advanced degrees, they did not hire bachelor's degrees, and so, if you came in with a bachelor's degree, it was automatic that you were on this program to get at least a master's degree. ... I would be given time off to take the classes, to go to class, tuition would be paid, books would be taken care of. At Lawrence, I could go to graduate school, it would be the University of California, probably, but I'm pretty much on my own. It would have a tuition refund kind of thing, and I can't remember, specifically, would it pay a hundred percent or half? or this or that, but it was sort of like, "You pass the courses, and then, you'll get a refund, and you do it at night," and stuff like that. So, there was just no comparison whatsoever between these two jobs on the future education. So, no question which one I was going to do. ... I went to RCA in the fall semester at some point and, actually, I then went to Lawrence. It was approximately over New Year's. I don't know if it was exactly over New Year's, and it might have been, but it was that time of the year. It was during the ... Christmas/New Year's break, and I already had an offer from RCA, before I even made the trip to Lawrence, and so, I wanted Lawrence to get on with it and, if they were going to make me an offer, do it, because I didn't want to keep stringing RCA out, but there was no question which one I was going to take. ... I did do the RCA one, obviously, and going to school was part of that, and so, that was part of my job. ... During my first couple years, I went to Rutgers, I worked three days a week and I went to school two days a week, and that's pretty much the way it would break down, full day of work or a full day of going to Rutgers. Later on, things didn't work out quite so conveniently that way and I would go up and take a class, and then, come back and maybe go back to the office. So, it's sort of like, if I wasn't in school, I would be at the office, nominally, work three days, go to school two days. Then, for the PhD, I competed in an RCA Laboratories contest, I'll call it, to get a scholarship, and I did get something. They had two different kinds of awards they would do. One was clear, out and out, called a scholarship and the other one was called a doctoral study award and, here, you could go to school full-time for one year. ... The reason for setting it up that way is, most schools had a residency requirement and, typically, it was two semesters residency, and so, I satisfied that and, during the time I'm in school, I get half pay, which is not bad. I would go in and work during school vacations, I would work in the summer, but, when classes were going on, I would be a full-time student, and that was for two semesters that I did that. Now, I may have had some other classes that I took here and there and I would just go as

needed to do those courses. ... So, that's how I got the degrees, the master's under that first program of go to school two days, work three days, and then, the master of philosophy; the master of philosophy, is that a degree that Rutgers still awards? Do you know?

SI: I am not sure.

RH: Basically, the way I define it, actually, I used to put it on my resume; do I do that now?

SI: You did write down that you earned it in 1968.

RH: Let me have that sheet just a second.

SI: Sure.

RH: I want to look at one thing. I used to put an asterisk and define what M.Phil. was; I don't do that anymore. I did that once upon a time and that footnote would say something to the effect that it's a degree conferred by Rutgers for students ... with exceptional performance who have not yet fulfilled the requirements of the doctor of philosophy, or something like that, and, basically, master of philosophy, the way to look at it was a PhD without a dissertation. So, some schools have a degree called doctor of engineering, and that's typically what a doctor of engineering will be. There was no dissertation, you did all the coursework, and that's sort of what a master of philosophy is from Rutgers, with one exception, and that is there's a high grade requirement. I can't remember what it was, but it was like you had to have a 3.5 or higher, or something like that, I can't remember. ... I wanted the PhD from the beginning, but my attitude was pretty much, "If I can get a degree along the way, take it, because I may never end up with what I want, so, take what you can get when you can get it." So, I had all three; I got the master of science from Rutgers, I got the master of philosophy in Rutgers, and then, the PhD from Rutgers, and all that was paid for by RCA. I didn't pay any of the tuition or books, and that's something that I don't think many people were able to do, and I don't think anybody does anything like that now. RCA ended up with some difficulty on that, though, because, too often, what would happen is that, see, by the time I got my PhD, I would have been on a certain salary track and somebody being hired with a PhD would invariably be hired at a higher salary than what I was making, because the increases that you would get yearly would not be as great as the jump of somebody coming in fresh with a PhD. So, one of the things that happened was, they had people leave. They'd get the degree out of working for RCA, and then, leave, because they'd get paid something more somewhere else. ... I thought that RCA was making a mistake by not paying them more and recognizing that they had the degree, but RCA took a different approach, because they did tighten up on that and you had to sign agreements that you wouldn't leave and this and that, but that didn't affect me. That was some time after me, but it was the kind of program that you didn't see very much, but I was very lucky to have been able to do all that.

SI: Did you have a choice in where you could take your degree?

RH: Yes. Some people went to Penn, Princeton, Columbia, I think maybe Drexel, but I wouldn't swear to it. I think Drexel might have been one of the schools, and I can't remember if there was a formal relationship that existed with all those schools, but I know that Rutgers was

very oriented toward the professional student, I mean, somebody who was already working. ... So, they would have classes at night and they were very flexible, because so many of the students, enough of the students, were in a kind of environment where they had to be flexible if they wanted them to be a student.

SI: You moved to New Jersey in 1964.

RH: Yes.

SI: You started right in at Rutgers.

RH: Yes, that fall. I started working for ... RCA in the summer, June or July. I graduated June 1st, I got married on June 6th, and then, immediately left Indiana, driving, rented an apartment in New Brunswick on Easton Avenue for about five weeks. ... That was a weekly rental, and then, got an apartment in Princeton and lived there ... from say July-ish, late July, early August, until December '65, so, that was a year-and-a-half, when I bought a house in Hightstown, New Jersey, and then, lived in that house until my wife and I split. ... Then, I've lived in different places after that, but my kids stayed in that house in New Jersey and went to Hightstown High School and that's where they graduated.

SI: I actually live in Hightstown. Where was the house?

RH: Oh, in East Windsor Township. If you're on US 130 and you go south, you cross the Princeton-Hightstown Road, then, a little bit farther down, you could turn right and go in and there's a school back in there.

SI: Kreps [Melvin H. Kreps Middle School].

RH: Kreps, yes. Okay, there's a community right there, the older community at Kreps, Brooktree. ...

SI: That is interesting. My aunt actually taught at that school.

RH: At Kreps?

SI: Yes.

RH: ... My kids both went to Kreps, and then, to Hightstown High School.

SI: When you started at Rutgers, you mentioned that you had to take these classes that were kind of a repetition of what you had already done.

RH: Yes.

SI: What was your focus in graduate school?

RH: Solid-state physics. This was going back to what I had done earlier at Purdue on the R&D option. ... I had both theoretical courses and practical courses, and that was true at Rutgers, also. I had a combination of both. ... Some of my courses at Rutgers were through the Department of Ceramics. You know, ceramics, you think of vases, but this was physics, crystals, ceramics. ... Everything was through the Department of Electrical Engineering, but I had many of these other kinds of courses in solid-state physics. In fact, ... it may be that all the solid-state was taught by other departments, not electrical engineering, and I can't remember for sure. I had a Professor, Ed Della Torre, who had some of the physics-type courses in electrical engineering, and he left. He was my PhD advisor and he left, went to a school in Canada. Normally, I can think of it; right now, it doesn't come to the tip of my tongue. He's no longer there. He's at George Washington University now, because I've seen some IEEE papers with his name and I did a search on that and, sure enough, he was the guy that was my professor at Rutgers. ... So, I had already done a lot of my work on the dissertation and had to get a new professor. ... I wanted somebody who would let me continue the work I was doing, rather than having to start all over again, and, if I remember correctly, it was Professor Donald Molony that agreed to that, in Electrical Engineering. James L. Potter was the head of the department. Professor Sylvan Fich was, the one who sort of seemed to be. Although he wasn't the head, he sort of ran things, it seemed; do you know what I mean? [laughter] He was always the one you'd go to talk to about what you've got to do.

SI: What about the facilities at that point at Rutgers? Did you have access to what you needed to work on?

RH: Yes, but I didn't do much work there; I can't remember any laboratory-type courses I had at Rutgers. I did at Purdue, I even made transistors at Purdue, but that was one of my accelerated courses. I can't remember any kind of laboratory stuff at Rutgers. I think it was all bookwork, lectures, studies, ... but, see, it was recognized I was doing work at RCA. ... The dissertation, all the experimental work I did, was at RCA. It was not at Rutgers, it was at RCA. In fact, let me grab something; I'll be right back.

SI: Sure.

[TAPE PAUSED]

RH: ... This is [my thesis](#) for the degree of master of philosophy, and it was under Professor John Sauer, who was in the Department of Mechanics, even though I was in Electrical Engineering.

SI: Did they have second readers then?

RH: I don't know what that is.

SI: Another professor who examines your thesis, in addition to your primary advisor.

RH: I don't remember anything like that, this was related to some work I had done at RCA, one of the projects I was on about negative resistance in semiconductors. ... Basically, well, not

basically, this work was all done at RCA and this is on thesis paper. That was for the degree of master of philosophy. ...

SI: What was the upshot of the thesis?

RH: [Editor's Note: Dr. Hopkins mouths that he does not recall.] [laughter] I whispered that because I'm not sure I want it known that I don't remember. ... I was working with indium antimonide and how it would behave. Under certain conditions, it would have a negative resistance. Normally, the way materials work, if you put a voltage across some object, current will flow. If you make the voltage higher, more current will flow. If you make the voltage higher than that, even more current will flow. Well, now, with negative resistance, what happens is, you increase the voltage and the current gets less, and that's an unstable situation. ... This curve that I have here [[Figure 1-5 on page 26 of the thesis](#)] is an example of it. You see how, ... normally, it would be a curve that moves in this direction only, but, here, you see, it's gone backwards.

SI: Yes.

RH: ... That's the negative resistance portion. Now, generally, what'll happen is, it'll try to snap either to this state up here or this state down here, rather than stay in this middle state, but, if you do certain things, you can constrain it to stay in here. ... If you can keep it in that regime, it will have a negative resistance and there are certain things that you can do then because of that. ... Anyway, I don't think anything ever came of using this material as a negative resistance, but it was a theoretical thing I was observing in the material. ... I'd have to read it; I can't remember. Now, I believe that I have this on the Internet; I don't know if you've looked at [my website](#).

SI: Yes, I have.

RH: ... I believe that this is one of the things that I actually have online. I think all of my theses are there. Let me just check and see what I have done, because I believe that, a number of years later, I scanned them and I have them there, scanned; [papers, interviews, dissertations](#), I have two. I think there was some sort of a master's paper; I don't have that on there. I'll have to check and see if I still have a copy of it, because I think I wrote some sort of a paper for the master's degree, but I can't remember for sure. This is the master of philosophy thesis, here's the PhD dissertation, this is the original and, see, this is even a signed copy, ... under Professor Don Molony, ... and here's Fich, Potter, Darrell R. Morrow, and I can't make that out at all, Walter Wellington or something like that, these were the guys who signed it. ... I put the signed page online and, actually, I'm on the Internet here. This is not just on the computer; I'm literally looking on the Internet at the moment.

SI: For the record, for people who will read this on the Internet ...

RH: Yes, see, it's got the photocopy of this page on there, yes.

SI: Your website is [RHopkins.us](#).

RH: Yes. I'd usually give the one that's DrBob.tv. I like that address, but DrBob.tv or RHopkins.us both take you to the same page.

SI: All right. There will be many things that we will not cover in this interview that people can look up on your website.

RH: Yes, yes. I have put up many, but not all, of the various papers I have written, speeches I have given. Wherever I have an electronic copy, I have put it up, and I've even spent some time, like this, [the dissertation](#), scanning it. I can scan a paper copy to have an electronic copy and put it on my website. I can remember, I had finished up my work on this pretty quickly with Professor Molony, after I had transitioned over to him, and I came in one time and gave him my paper. ... I can't remember how long it was, but it wasn't that many pages, and I can remember him holding it in his hand, like he's seeing how heavy it is, and it just wasn't heavy enough. "Not enough pages; you've got to do more than this. [laughter] You know, give me some more stuff, give me some background, give me this, give me that, but you've got to have more than this," and so, I think it ended up being, how many? Not counting the appendix, it's how many pages? and this is double spaced, fifty-four pages. If you take out the references, it's fifty-two pages, and, if you take out the title page, it's a little bit less than that. Is there a table of contents here? Yes, there is; there's an introduction and basic theory of the MOS transistor, and that's probably stuff that I added to satisfy Professor Molony, and then, the real meat of it is chapters four, five and six. I did make measurements. That was done at RCA. ... Notice that part of the equations are hand-drawn. Some of this is typed, this would have been a typewriter doing this, but some of it, like the square root, I think that's all drawn by hand. The figures that are in here were drawn by the drafting department of RCA Labs. I did the sketching of it, but, then, they would have made the formal copy that was used and, indeed, ... this is an RCA Labs technical paper, 1970. It was the sixty-fifth technical report in 1970 and it's got a different title page, the abstract of the title page says, "This paper was submitted as a doctoral thesis at Rutgers University on May 1, 1970." So, ... this was the formal RCA paper. The thing that I have scanned is not a copy of the RCA version, but the actual Crane thesis paper copy that was done through Rutgers. [Editor's Note: The RCA version is noted on Dr. Hopkins website, in the "Publications" area under the "Company Private Reports" heading, as "'High Frequency Y-Parameters of the MOS Transistor,' RCA Laboratories Technical Report, PTR-065 (also Ph. D. Dissertation for Rutgers University), June 18, 1970."] My recollection is that there were two copies of the paper. You had to have two; one would be signed for your own personal copy, ... a second would be signed and would be the copy that the school kept. So, presumably, somewhere at Rutgers, on some shelf somewhere, is a copy of that, but it's much easier if you just go on the Internet.

SI: Yes. Tell me a little bit about the dissertation. First, what was it like to work with Dr. Molony? What are your memories of him and how he worked?

RH: Well, understand something I've told you already, that I have trouble remembering things long ago, and even a lot of this falls into that category. ... I really have difficulty remembering any specific things, but what I can, absolutely will, say was that I was very happy that Professor Molony accepted the work I had already done and would let me continue it, because I was really afraid that with Professor Della Torre leaving that I was going to lose everything, have to start all over again. That could have been a serious problem. Would RCA have supported me for a

restart of doing something else? So, I was extremely grateful to him and that's the thing that will be more significant than anything else to me, my gratitude for his letting me continue the work I was already doing.

SI: You mentioned that the master of philosophy work, the thesis work, dovetailed with your work at RCA.

RH: Yes.

SI: How did that come about? Does RCA give you this assignment, and then, you go to your advisor and say this is what you are working on?

RH: Okay, the way I was hired at RCA, ... it was assumed that I would get a master's degree and, during the first year, I would be on, I think it was three different assignments, each of four months, where I would go to different parts of the laboratories to do different kinds of work. ... The paper for the master of philosophy was actually one of those four projects. Now, I would've done the project long before I needed it for the master of philosophy degree. So, it was already done and I then incorporated that and wrote it up in terms of treating it as a thesis. The PhD one was quite different. This is a project that I made up and did specifically for that purpose, but it was a project that would satisfy Rutgers, or Professor Della Torre, and a project that would satisfy the people at RCA, that was something worthwhile for me to be doing. ... I had a friend, Joe Burns, that had done some work. He was at Princeton. ... I'm sorry, he was an undergraduate at Princeton, and then, did graduate work at Rutgers, ... you notice that the title of mine is "High-Frequency Y-Parameters of the MOS Transistor." There are four different Y-parameters. Joe concentrated on two of them to explain the physics behind it, a model for the transistor, and I wanted to take the other two of the four parameters, which are generally less important. The two he's doing are the ones that ... really make a transistor action. The two that I'm doing are ones that are really more like parasitic or negative effects, instead of the positive effects that you get from a transistor, so I'm taking those other two parameters and trying to substantiate what they are, doing measurements. ... See, ... in some of the curves that I had here, where there were four on a page [[Figure 7-5 on page 78 of the dissertation](#)], Joe worried more about these two guys right here, Y_{11} and Y_{21} . I worried more [laughter] about these two over here, Y_{12} and Y_{22} . Y_{11} and Y_{21} are the ones that you really take into account most when you're designing a circuit, but these two, Y_{12} and Y_{22} , you can't forget about them, because they limit the positive effects that you can get from the other two. ... So, that's what I was concentrating on, and it came about partly because of Joe's work. In fact, do I mention Joe's work in this? Let me go to the actual thesis, I gave an acknowledgment, "Dr. J. R. Burns to be thanked for stimulating discussions." ... Well, I haven't found where I mentioned Joe's work, ... but there's no question that's what I was doing, I want to go to the references I have at the end and see if I referenced Joe's thesis. Oh, here, in the conclusions, "Burns suggested in his PhD thesis that the output admittance of the MOS be studied because of," blah, blah, blah, and so, that's what I was doing, the stuff that he had said should be further studied in his thesis, and that's the first of my references. It's "Transit Time Effects in the MOS Transistor," his thesis from Rutgers in 1968. Did I answer your question? The master of philosophy thesis was based on work I had already done at RCA; the PhD thesis, dissertation, was based on work that I would do at RCA.

SI: When you started at RCA, you mentioned that you would go to these four different areas, one of them being the work you would do in your graduate studies.

RH: Yes, I sort of dropped off on that, yes. One of those four was working with the guy that I have mentioned was sort of like my mentor in many ways, and the Moon shots. That was one of the areas they were working on, high-resolution storage. ... Some of the kind of stuff I was doing was using a laser, focusing it down to a small spot and recording stuff on a disc for high-density storage, and work in that area became the RCA videodisc many years later. Second year ...

SI: Was that SelectaVision or something else?

RH: They called it SelectaVision. SelectaVision, actually, was two or three different things. One of them was this thing, [laughter] ... but there was a videodisc that RCA sold in the early '80s for a few years, and that disc absolutely came from some of the work that we were doing. Second area was working with Paul K. Wiemer on thin-film transistors. I was using indium antimonide to make transistors. A third area was the microwave group, and that's where I was doing some of the negative resistance work with indium antimonide. So, it's interesting, two of my projects were associated with indium antimonide, but doing totally different things with the material. Then, after finishing those cycling things, I went back to the first area, which was working with the high-density storage people, that was the systems research lab. Even though ... all my studies had been oriented towards solid-state physics, with RCA, I kept moving back into systems areas and stayed in systems, and specifically TV systems, for all of my career, one way or another, even though I had all of this physics type of background; go ahead.

SI: Who was the man who you said was your mentor?

RH: Bob Flory. He worked for RCA Labs for many years, went to school at Cornell. ... I think he had at least a master's degree. I don't think he had a PhD. ... I've run across him many, many times over the years, even after I left RCA.

SI: Tell me about going into systems, television in particular.

RH: Okay. ... After I finished the PhD work, I had moved off of this high-density storage to do the dissertation, and then, after that was done, ... some other guys were doing some work that was a silicon storage tube. ... This was a device that, originally, was to be a silicon vidicon. A vidicon is a device that you focus an image on the faceplate and it affects the charge of the material that's inside the vacuum of the tube on the back side of the faceplate, and then, if you ... do an electron beam scanning of the back side of the faceplate, you can read out the image that was on the faceplate. Light, bright light and dark light, hitting the faceplate causes different charge characteristics to occur in the material on the back side of the faceplate. With an electron beam, you can read out those different charge characteristics, which then gives you an electronic image. One of the things they found, though, was that the tube ... had too much lag. ... When you scan out an image, you want there to be no remnant charge pattern left, so that in the next, say, sixtieth of a second, you can have a whole new picture and you totally discharge that in the

scanning. Now, if the tube has a lot of lag, instead of having zero percent of the previous image left, you might have five or ten percent of the previous image left, so that you get smearing from one frame to another. If something's moving across the scene, you don't see sharp images of the object moving across. It's smeared, because of the lag in the device, and, indeed, they found that they could do things to make the lag even greater, great enough that it would actually hold an image, even as you scanned it, the image would stay there, these guys were using the tube then as a storage tube. ... You could also read the image in as an electronic image using the electronic beam. So, you could have a light image that you would read out or you could store an electronic image on it. ... I got interested in that because of slow scanning. I had this idea that what you could do is take the picture that was stored on this tube from a live camera, read it out in a slow manner and actually send the data through a telephone line. ... Then, using one of these tubes at the other end, you would build the image up, and then, once you have the entire image there, you could read it out like a camera tube, to put it on a monitor. Did that make sense, what I was saying?

SI: Yes.

RH: Basically, ... store an image, transmit it slowly across a phone line until you have the full image here, then, you could see the full image at the other end. Now, it sounds a lot like facsimile, because that's basically what facsimile is. You have a piece of paper, you scan that, send it across the phone line, then, reconstruct it at the other end, but this was doing it using television cameras and television monitors instead of using facsimile-type scanners. ... This became of interest to a different division of RCA and they made a product, didn't sell a lot of them, but they made a product. ... One of the clients they had was the People's Republic of China and one of the significant things I did, this was in 1972, you may remember from your history book, you're not old enough to have been there, but President Nixon went to China in 1972. ... This was the beginning of a thawing of the relationship between the United States and the People's Republic of China. I was there. I was there before Nixon, I was there while he was there, and then, I was there after he left. One other guy and I had gone with this equipment that the Chinese had bought. We were installing it during the same time that all this was going on with regard to Nixon. ... RCA had a contract to put a satellite earth station in Shanghai, Western Union put an earth station in Peking. ... Then, while Nixon was there, there were TV images coming back to the US, before those two earth stations went in, that was not possible, but there were images coming back during Nixon's trip that people in the United States could see. ... I was part of that overall communications team that went to China to do these installations. That was certainly a systems-type project. It may have come about because of some unique physics of this silicon storage tube, but that wasn't really my involvement. My involvement was taking the data off of one storage tube and getting it onto another one and doing it in the very limited bandwidth of a phone line. ...

SI: What was that experience like, going to China and setting this up, being one of the first Americans there?

RH: Oh, that was a totally different kind of thing, and, if you go to my website, which I'll bring up here, again, one of the things that I've done in more recent times is, I've added a line across the bottom. See, here's [my Route 66 motorcycle trip](#). That's that daily log that I was keeping,

and [my father's slides](#) that I said I have been scanning, and I have many of [my own slides](#) up there now. I've scanned many more slides than I have up, but here I have all [my China pictures](#). [March 1972, Roll 1 through Roll 18] ... This was the trip by train getting into China, and then, the train ride into Canton. We flew into Shanghai, and then, this is the Huangpu River. ... This is one of my favorite pictures [Roll 7, Slide 7203g-16], actually, because you see the ancient ...

SI: Sampan?

RH: Sampans [a wooden, flat-bottomed Asian boat] and junks [an ancient Chinese sailing vessel] and modern boats here, side by side, in this river. It's amazing. The equipment that we took [Roll 7, Slide 7203g-25], see the TV camera right here? it has its case off, a TV monitor, this is all the power supplies and the circuitry to run the storage tube and the slow scanning stuff. The Chinese were interested in this because ... they could take something that they had Chinese characters written on, stick it in front of the camera, send it to somebody else real quick and, in one minute, you'd have that picture at the other end, like a facsimile, but more versatile because you can point the camera at a blackboard, but you can't do that with a fax machine. With facsimile, you have to have a piece of paper. That's the equipment that we were doing this with. This is the earth station that was put in [Roll 17, Slide 7203q-01]. This was a temporary earth station and it was done at the airport, and here is *Air Force One*, sitting at Shanghai [Roll 17, Slide 7203q-02]. [laughter] ... One other picture I have here was my passport [Roll 17, Slide DSC_1970], because, see, China and the United States did not have any kind of relationship. They did not recognize our passport. You had to have a visa, but they can't put a visa in a non-existing passport and my passport, to the Chinese, was non-existent, and so, this is actually my visa. It was on a separate piece of paper. [laughter] ... A paper clip would hold that to my passport.

SI: Were you briefed beforehand by the State Department?

RH: No, no, we had very little prior knowledge; very little outside knowledge existed of China at that time. We were pretty much on our own. ... It was an exciting thing, but a little bit frightening also, because we really didn't know what we were going to be facing. It was unknown; so, very exciting, but very unknown. There were very, very few Caucasians, virtually none, in China, and I can remember, any time we would go walking, there would be throngs of people following us, because we were strange. We were different, we looked different, a very, very different kind of situation.

SI: Did you always have Chinese security with you or somebody following you?

RH: In Canton, we did not. We could walk around and we were there just in transition, spent a night there going in and a night there going out, and, in Canton, we were not restricted at all. In Shanghai, they did not want us going out. We were always chaperoned. One day, Dennis and I, though, we decided we were going out on our own and we did go looking around, but, then, we went into this store. ... All of a sudden, all of a sudden, who showed up beside us but our chaperone. [laughter] So, somehow, he found out we had left the hotel and he found out where

we were and, suddenly, showed up with us, and he scolded us a bit, ... "It's not safe to be out." I don't know why it's not safe, but [laughter] I don't think they wanted us out on our own. ...

SI: Does anything else stand out about that trip? Did you have any interaction with the Presidential entourage?

RH: No, but one of the things that we did was, we went to a place called ... some of the touristy things that we did were the same that the Presidential party was doing. ... One of the specific things I can remember; let's see, where do I have it in here? ... Right here, okay; we were in this place called the Industrial Exhibition [Roll 8, Slide 7203h-34] and, a camera crew was doing something here and you can see this person right here is on camera. ... On the next picture, we're looking at him close up, and you're a little young to know him, but that's John Chancellor, who is deceased now. He was the anchor for *NBC Nightly News*, or something like that, and, apparently, a group had just come through here and he was still doing some taping for the news that night. ... We came across him and met him and talked to him a little bit. So, that was the only real interaction that I had with that other part of the group, but, see, we were basically all doing different things now. One other thing I have, that I did, I brought home and still have a Chinese newspaper, ... and this is a large paper. It's probably about this tall, and this was Nixon meeting Chairman Mao and Zhou Enlai and that was in the Chinese daily newspaper [Roll 16, Slide 7203p-28], just like we had stuff in our newspapers here. ... I had the Chinese newspaper while I was there, so, obviously, I knew what was going on, but we were on different tracks, let's say.

SI: This is going to sound like a very dumb question to you, but the device that you were working on, that you installed in China, was that kind of the beginning of digital television?

RH: Not really, ... but you've given me a good segue, because this was an analog device and I was using analog techniques to read out and send through the phone line and reconstruct at the other end. It was all analog. One of the problems, though, of the storage tube was that the image did decay. What I said earlier was that it ... had too much lag to be a good camera tube. But, it didn't have enough lag to be a long-term storage device. You could only count on a picture lasting for maybe fifteen minutes, half an hour at most, and it would just gradually decay until there was nothing left. ... It's like the contrast, you might have a good difference between black and white initially, but that difference between black and white would gradually erode until there was nothing left. ... I decided that it would really be good to have a digital storage device instead of an analog storage device, and so, I, on my own, started a project of replacing the silicon storage tube with a digital memory. ... I can remember, I used 1K shift registers, takes a lot of them, 1K means one thousand, one thousand bits. Compared with today, in a computer, what would you have, four gigabytes, or maybe more? That's a million times [laughter] more storage in this laptop computer than what I was talking about, a million times more storage. I used only three bits per pixel, so, it was eight levels, not very much. You could see the difference in the levels. It's not fine enough, between different levels, but I designed my own analog to digital converter, to take the analog video signal and make it into a digital signal, stored it in this digital memory made up of 1K shift registers, and, as long as you kept the power on, the picture would stay there. ... Then, because of this work that I was doing, another division of RCA ... became very interested in what I was doing. That was the broadcast

division, and they were wanting to do something similar, and so, they invited me down to help them design this device. They called it a synchronizer. Today, what many people would call it is a buffer, a frame buffer. ... Back in the old days, when a TV station would switch from, say, local news to network news, the picture would always roll. You may never even have seen what I'm talking about, but the reason the picture would roll is because everything has to be synchronized very tightly in time. ... When you're doing your own local news, then, you switch to network, which is coming in remotely, that's a different timing clock. Now, what you could do for your studio is lock it to that network, but there were a number of disadvantages of doing that, and where you really saw the disadvantage was in the early days of electronic news gathering, because somebody could be out with a camera somewhere and doing live reporting, sending that back to the station. Well, the station could not simultaneously lock to the network and lock to this remote camera, and they may have different remote cameras in different places. So, they couldn't do this. Any time you would switch from one of these things to another, the pictures would roll until it resynchronized with the new image. What you would do with this frame synchronizer is run the studio, the local TV station, on a clock, and then, anything coming in, like the network feed coming in, you would put it into this one-frame buffer. ... Suppose that the network was half a frame out of synch with you; then, the synchronizer would read the images into this frame store and read them out according to a different clock, so that you're delaying the network feed coming in somewhere between zero and one-frame. You could do that with any of your remote cameras that were out in the field somewhere, ENG [electronic news gathering] cameras, put them through this box to run a zero to one-frame delay to make it come out synchronized according to the studio. ... So, this was a very desirable device for TV stations, to be able to get away from this synchronizing problem that they all had, and so, I was invited to join ... with the broadcast group in designing this new product, which I did do. ... Then, after about a year, I was on loan from Princeton Labs, they made an offer for me to actually come down and be the head of the group that was doing that work, which I did do. I should point out that I had already done something like that before with RCA, because I was here in Florida for a while, and that was associated with the Video-Voice equipment, which was the silicon storage tube slow-scan project. The division of RCA that wanted to build that, they were going to build them here at the RCA Palm Beach facility, and so, I was here for a year-and-a-half, bringing technology from Princeton down here for them to build that equipment. Then, I went back to Princeton and that's when I started working on the digital version, and then, after a year in Princeton, that's when I ended up being a year on loan [laughter] to the broadcast division, and then, a year later is when I transferred into the broadcast division.

SI: That was 1976.

RH: Yes, yes. Let's see, no; ... boy, I have trouble remembering now. I'd have to look at my resume. [laughter]

SI: I think you said 1964 to 1976 with Sarnoff Labs.

RH: Okay, so, I guess the year that I was on loan would have been much of '75 and early '76, then, in early '76, like March, is when I was ... offered the position in Camden, which I took, yes. So, it was in '75 that I first went to Camden and '76 is when I actually made the transfer.

SI: At Sarnoff Labs, you had been doing a lot of hands-on work, direct applications.

RH: Yes.

SI: Was becoming a unit manager a big change?

RH: Well, with the unit manager position, I still did some work like that, but much less, ... but was still involved in some of that. The actual design work, though, I didn't do much design work. In fact, I may not have done any design work, but I still was heavily involved with the technical aspects with the people that worked for me.

SI: Before we move off of Sarnoff Labs, can you give me an idea of, when you were working on a project, what a typical work day would be like?

RH: It can vary quite a bit, because it depends on how intense things are at that moment, maybe something where you stay late a lot of the time, maybe not. ... It was, in many regards, a more casual atmosphere than exists in, say, a product division. ... It would be easier, let's say, to take some time off during the afternoon to go get something done than it often would be in the product division, because the project is more individual, what you're doing. ... You're probably, in many ways, less involved with other people, maybe totally on your own. A lot of the work I was doing, I was often on my own in what I was doing. So, it didn't matter if I did it in the middle of the night or the middle of the day; it didn't matter. When you're working with a group of people, that's not quite as easy to do.

SI: When you switched over to the broadcast systems, you were just focusing on the one-frame buffer system.

RH: Yes, that's what my group was doing, ... and I was in that position for a year or two, hard to remember exactly how long, and then, became a manager of several of those groups. ... That was more of a broadening, because I now became responsible for things like telecine cameras and some advanced research that was going on, product research; ... so, spreading my time, much less technical involvement on my part, maybe still some, but not very much, but more technical management at that time, making sure that the groups ... had what they needed, that they kept their focus proper, and so on.

SI: Was it a matter of forming it into a product that could be sold or were you still doing the research on how to make it accurate?

RH: Generally, in a product division, there's not much research going on. There can be some, but, generally, not much; you're working more directly with a product. You have some specifications of a product ... that you've decided that you're going to build, your marketing department or product management department will have decided that there's a product need here and that you had the expertise to be able to make that product. ... You're designing a specific product, that you know exactly what it is you're doing, and then, part of that will also be maintenance of that product, because there could be a problem or you've got to keep things rolling in the factory over that product life; quite a different focus between the initial design, and

then, sustaining, to keep it going in the factory. All of a sudden, you can't buy a certain integrated circuit anymore; so, somebody's got to do a redesign, because you've got to have a different device in there now than you had before, or something like that. So, it's all of that. We did have a small advanced research department, that they would look at things like, with cameras, using solid-state imagers instead of vacuum tube pickup tubes. So, we would be doing early work on things like that, no specific product yet, but making sure that we knew how to use these things, how to get the best out of them, and so on, so that when it did become time to do a product, we would know how to do it. ...

[TAPE PAUSED]

SI: We have gotten into your move into unit management. You are now in charge of several work groups. As a general question, what were the major challenges that you saw in that period of your career?

RH: Actually, the biggest challenge was getting the resources I needed. We'd have lots of ideas of products to do, that would be desirable things to do, but there's only so much money. ...

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RH: The biggest challenge seemed to be in getting the money to be able to do the project that we wanted to do. ... At that time, RCA was really being challenged by, especially, Japanese manufacturers, who could have multiple new cameras at the same time, it seemed, and we just didn't have the money to do that. ... Fighting, then, to get your project the limited funds to support your project, that was probably the biggest challenge. More so than actually designing the product was getting the resources to be able to do what we wanted to do.

SI: What was the corporate culture like at RCA?

RH: RCA Broadcast was maybe a little different than many others. RCA felt that, and I'm giving a personal look into the company, RCA felt that television belonged to them, that it was their thing and, other people participated in it, but it was really RCA. RCA was the only company that operated across the spectrum in television. RCA made TV sets that people would have at home. RCA made studio facilities that the TV station or the networks, or whoever, would have to make a TV program. RCA did antennas for a TV station to broadcast. RCA did the transmitter for them to do the broadcasting. RCA even had a television network and television stations, NBC. RCA did everything, and, in fact, much of the way that color TV came about was because of what David Sarnoff was doing, promoting color television everywhere, so that people would buy color TVs for their home, because that's where the money would be. ... So, they had the whole thing and they could cause something like this to happen. ... It was company policy to promote color television, and they could do it because they had broadcasting and the network and made TVs and could do all that. So, that was that part of the culture that existed, and that was true in the broadcast equipment division. The TV stations would buy RCA equipment unconditionally. It was the best equipment and that's what people would buy, and that was the climate. ... That started being threatened, because people liked the cameras that Sony made, for example, and that just ... made it very difficult for RCA, because, in the past, it

was almost like, "Build it and they will come." That was beginning to not be the case and that was a big problem that RCA was facing. We saw that very much. We wanted to design new products to be competitive with the others, but we didn't have the money to be able to make all these new products that we wanted to do.

SI: Was there any stubbornness, sticking with old systems or old products?

RH: Yes, but that was more out of necessity than out of desire. Many people, you see, would want to have a new product, but they didn't have it yet. They had to stick with the old because they didn't have the new one yet.

SI: It just seems similar to what happened in the automotive industry, where they were top of the heap for so long, and then, they did not want to admit that the Japanese could even cut in on their business until it was too late.

RH: ... It's hard to understand all of the issues, I have a great deal of sympathy for Detroit. I don't count myself among those people that say, "They've done stupid things and, now, they're paying for it." I think it's a lot more; there's a lot more involved than just that. ... I'm not sure I want to go off on that track.

SI: Okay.

RH: With broadcast equipment, one of the things that we saw happening, too, was that, whereas in the earlier days, everything was very expensive, high-level equipment, you saw more and more of what I would call consumer or industrial-grade products being used instead of professional equipment. ... That was a serious problem for us, because of the kind of manufacturing we did, we were high-end manufacturing, we could not make far greater numbers of cheaper things. That was a serious problem. To be able to compete in that kind of environment, the entire structure would have to change. We couldn't be what we were any longer, and that continues even today, the equipment that you'll find being used by TV stations, for example, is getting closer and closer all the time to what you have as a consumer.

SI: During this period, the mid-1970s, there had obviously been the Civil Rights Movement and the Women's Rights Movement. More minorities and women were moving into new areas. Was RCA receptive to that? Were they trying to bring more women in, bring more minorities in?

RH: Yes, yes. I don't know what else to say except yes, ... always a focus to try and do that. In engineering, there were very few women engineers, though. That was part of the problem, very few women engineers.

SI: In the situations you had an eye on or access to, were the men receptive to bringing in these new populations?

RH: ... Yes. I don't recall ever having any kind of a problem. ... See, also, at RCA, ... there was very little hiring that went on anyway and, any time we were trying to hire somebody, we certainly would be looking for a female engineer. We did not do a lot of hiring, but would be

looking for a female engineer, but very hard to find, actually, very hard to find. I don't know, today, how the ratios are, but I think that software has made a big difference. There are a lot more women involved in software than in hardware back in earlier days. I think that, for some reason, software seemed to be a more attractive entry area.

SI: When did you first join the Society for Motion Picture and Television Engineers?

RH: ... Not long after the work we were just talking about. I was asked if I would lead an SMPTE group to standardize digital video, and I was not an SMPTE member, and I don't even know if I had to be an SMPTE member. To be a chairman of the group, I probably did have to be a member. To be a member of the group, of a standards group, you didn't have to be a member of SMPTE. So, that's when I joined SMPTE. That would be some time in the late '70s.

SI: I was reading an article, through the IEEE, [(Baron, Stanley. "The Foundation of Digital Television." 11 December 2008. [IEEE Global History Network website](#). Last accessed 25 August 2010)] on the basis for digital television and your name came up several times in it, your work with these working groups. Could you talk a little bit about that period that led to the 4:2:2 standard?

RH: Okay. ... I chaired the group for SMPTE that was the Working Group on Digital Video Standards and, basically, different companies were now making digital equipment and there was no digital interface. ... So, what you would have to do in your digital equipment is, you'd bring in analog video, then, in your box, you'd convert it to digital, do your digital processing, then, convert it back to analog at the output of your box, because it was analog connections that you had. ... What we all agreed on was that it would be very beneficial to have digital connections, so that we ... didn't have to keep going between analog and digital. ... The problem was that different companies did these things in different ways, and so, there would have to be agreement on how you're going to do it for you to be able to have a standardized interface. ... In sampling, in converting video to digital, some people in the United States, and NTSC [National Television System Committee] countries, everybody ... would lock up to the color subcarrier and sample coherent with the color subcarrier either at a three times subcarrier frequency or four times subcarrier frequency. So, part of the discussion was, "What should the standard be? Is the standard three times or is the standard four times?" Four times generally implies higher cost. Three times would be lower cost, but, then, there could be a question of quality, because you're sampling closer to the Nyquist limit. ... Also, sampling it four times gave you a certain advantage to decode from the composite color signal into red, green and blue. So, there were reasons for doing each of these. The bulk of the people wanted four times subcarrier, but we worked by consensus, and so, we had to get to that point one way or another. While we were doing this, ... interest was growing worldwide in digital video and there was interest in having a worldwide standard that would satisfy SECAM [Séquentiel Couleur à Mémoire] people, satisfy PAL [Phase Alternation Line] people, and satisfy NTSC people. ... I became interested in that area, as chairman of the group, and one of the things I did, because what we were doing was zeroing in on something that was inherently NTSC, ... I wanted ... the group to take some time and study some of the component approaches, to see if we might be better off doing a component approach instead of an NTSC-only approach. So, we put our NTSC work, the four times subcarrier work, on hold while we did this other investigation. ... What came out of the work

that we were doing, and others were doing, there was actually agreement on what became CCIR 601. Now, it's ITU-R 601 [alternatively Rec. 601 or BT. 601], same thing; it's just that the organization changed name in the meantime. [Editor's Note: The Consultative Committee on International Radio or *Comité consultatif international pour la radio* became the International Telecommunication Union-Radiocommunication Sector (ITU-R) in 1992.] ... That was some of the early work that was done then on the digital standard. What we agreed to is that, in fifty Hertz countries, they would still use fifty Hertz frame rates, field rates. In sixty Hertz countries, you'd still use sixty Hertz rates. You'd have ... a different number of scanning lines, but what we could agree on is how many samples across the line, I'll call it the picture format, ... not in terms of pixels up and down, but definitely in terms of pixels left and right. ... So, this became the number that was used then in DVDs. ... That standard was adopted in the CCIR in 1982, I believe. ...

[TAPE PAUSED]

RH: ... In the meantime, though, before we reached that point, I had moved higher up in the committee structure in SMPTE and had turned over my committee to somebody else and was the chairman of the parent committee, and then, even moved up to Standards Committee chairman, but that work continued and ended up in CCIR 601. ... Some time after that, they picked up again this four times subcarrier issue and did go ahead and do a standard at four times subcarrier because there was enough equipment that operated only on the NTSC standard that it made sense for them to have that kind of a standard also. Both of those standards ended up going ahead; we temporarily halted the NTSC-only work, then, the worldwide standard happened, and then, some time after that, the NTSC-only work was concluded. Then, the high-definition standard was built on top of CCIR 601, because the concept of high-definition was twice the resolution and it was very easy then to take twice CCIR 601 resolution, which was 720 pixels, and double that to be 1440 pixels, and then, to go from the picture aspect ratio of 4:3 to the widescreen ratio of 16:9 takes 1440 pixels exactly to 1920 pixels. So, the horizontal resolution of 1920 for HDTV is precisely related to CCIR 601 because it's two times it, and then, four-thirds times that for the four-thirds wider aspect ratio; still there was disagreement, though, on the number of pixels up and down. ... What happened, over time, was that there was worldwide agreement on having the same number of pixels up and down, 1080, which was based on square pixels [1080 is 1920 divided by 16 and multiplied by 9]. So, we ended up with a worldwide standard for the full picture format for HD. CCIR 601 had 720 across and different numbers up and down and different frame rates. HD is 1920 across, 1080 up and down, but different frame rates; it can be a still picture, it can be twenty-five frames per second, it can be fifty, it can be thirty, it can be sixty frames per second.

SI: That came after much debate between the different countries, different companies, different groups of professionals.

RH: Yes, yes. The ultimate final wrap up of the ... HD standard was late '90s. I can't remember exactly what year, '97, '98, '99, something like that. In fact, let me just do a segue here for a second, to try and remember something. This may be on my website. No, I don't have it on the website. It's a press release from ITU. ... I know it's there, but it's under a different address. I know I have an electronic copy, but I can't remember where it is. ... Actually, it was a 1999

press release, so, that must be when it was approved, finally, in ITU, in 1999. That's when the full agreement was there on 1920 by 1080. ... Because I'm mentioned in the press release, ... that's why I was looking for it, I have a copy of that somewhere, but, I'll tell you, I don't know where it is right now. [laughter]

SI: To go over this whole thirty-five-year period since this really began, for example, when you were the chair of this original work group, would you be working directly with the Europeans?

RH: Yes, yes. Much of my work has been worldwide work.

SI: How did those negotiations go? How would a meeting like that go, typically?

RH: ... Let's talk about how the ITU works. ... The members of the ITU are countries. ... It's a United Nations organization, and so, it's countries that are the basic members. You develop a country position, typically. ... You go to the meetings and you are presumably taking your country's position and you'd like for everybody else to agree to that. It may be that they're quite happy to do that, it may be that they won't and you have to work out some agreement. Working out an agreement is not an easy thing, because you don't walk in there with full authority to do anything you want to agree to. You've got to get people back home to agree that that's the right thing to do, and so, things like this don't happen in one meeting. They take time to get there. When you go to a meeting, you may have a brief, "Here's what you want. You're willing to accept this. You can't go beyond this." Maybe you'll have discussions with people back home during the meeting. People in the State Department, who are the head of all this, may give more flexibility some times than other times because of bilateral agreements they have with other countries to do this or that, maybe having nothing whatsoever to do with that technical issue. So, typically, it just takes time. ... The work on a high-definition standard in ITU began in 1974, I believe, even before CCIR 601, that's when the first papers were introduced into the ITU on high-definition television. ... Serious work on a high-definition standard began, I guess, immediately after CCIR 601. Once that agreement was reached, they immediately turned to high-definition. The US had a strong position, in '86, that they wanted the world to adopt, but it did not happen, and then, things sort of started going in different directions; instead of going together, going apart. In the early '90s, a great deal of interest in digital television started. I don't think that was there at all in the '80s. It started in the early '90s; we were still drifting apart, and then, by the mid-'90s, things started coming back together a bit more and, like I say, '99 was when the ultimate agreement happened on that format for high-definition. So, the first attempt to pass a recommendation on high-definition was in '86. That was the first time anything had gotten to a recommendation stage. It didn't pass, and by the time there was full agreement, it was '99. So, for thirteen years, that was going on.

SI: I was reading one of [your papers online](#) where you pointed to 1982 as being a particular pivotal year because of the CCIR making a decision and the FCC deciding not to make a decision, which I guess led to the committee that you were the executive director of.

RH: Yes, probably, that probably played a big role in that, yes.

SI: Considering things like the overall tenor of, say, the Reagan Administration, what impact did that have on this policy making? The Reagan Administration's idea that "big government" was bad and the government should not interfere in the markets, how did that ultimately trickle down and impact your work?

RH: Well, for television standards, I think it's been fairly consistent, over decades, that the policy has been that what TV stations broadcast is well-defined by FCC standards. What happens on video disc, like DVDs, is totally non-involvement on the part of the FCC or government regulations, you saw it play out with VHS and Beta, you saw it play out with HD DVD versus Blue Ray DVD. The government has not taken a role in that kind of standardization over all these years. So, there's no difference in the Reagan Administration, Clinton Administration, in regard to that. Now, there can be with regard to broadcast TV stations, because that has been regulated by the FCC, and the concept is that the airwaves belong to the public, and so, anybody that's using those airwaves must do it under certain conditions, whereas, if you just stick this disc in a machine, ... it's not affecting anybody else. ... That continues to this day now. ... I don't know that there was that much difference during the different administrations, but you do see a change of administration having little effects, some effects, in this. For example, we were getting close to a high-definition broadcasting standard in the US at the end of the Bush Administration, ... in '92, '93, I guess, January '93 became the Clinton Administration, but that got stopped by the incoming administration, because the FCC changes. It goes from Republican control to Democratic control. So, you can see how that causes things to have to start over again. You saw that pan out this year also, originally, the transition from analog to digital television broadcasting was to be in February, February 19th, maybe, but the incoming Obama Administration wanted to slow that down, make sure that everything was right, and that led to the delay into June. [Editor's Note: The DTV Delay Act of 2009 moved the switchover date from February 17, 2009, to June 12, 2009.] So, I've seen those kind of things happen, but not what I would call major changes. That may add a year or two to something, but that's not what I call a major change. ... During the early Clinton years, there was an involvement by computer companies that had the ear of the Administration, through Al Gore, presumably, ... almost taking on, like, an industrial policy, that computers are far more important. "We make more computers in the US, we make a lot of software," the computer industry representatives argued, I'm stressing this point, now, I'm over exaggerating, "that the computer industry should really be determining television standards, not the television industry." [laughter] ... So, that was something that was happening during that period, and I told you I became involved in an IEEE committee; it was during that time, as I said earlier, but because of the fact that I felt that some wrong things were happening in the television industry, or happening to the television industry, and you'll see that in some of the [speeches](#) I have made over time. I talk about "convergence," because that was a hot word back in those days. All these technologies are converging, the computer and the TV and telephone and everything, but my philosophy then, and I still believe it today, is that ... there's a convergence of the technology, but not ... a convergence of the applications. Now, in a sense, you'll see the iPhone, maybe that's a convergence of the applications, but only in a minor degree. Most people do not do Internet searches on an iPhone and most people do not make telephone calls on an iPhone. I'm not picking on iPhone, it represents a device that seems to do many different things. Often, my view has been, and this was true with stereo equipment, I would buy a tuner and an amplifier separate. I did not buy, tend to buy, receivers, because I might like the way this company did the

tuner, I might like the way this company did the amplifier and, invariably, when they put it all together, well, there's something I don't like about it anymore. I have never bought a TV that had a DVD player built into it, sort of a continuation of that philosophy. I remember a line I would use in speeches is that, "My motorcycle uses tires, my SUV uses tires, but they sure don't use the same tires, totally different kinds of tires." So, the technology for making the tires may be the same, but the tires are not the same.

SI: Another issue that kept coming up was the relationship of Hollywood to setting these standards. There, you are not working through an international body to try to set these standards. How do you work that out with the whole industry?

RH: Elaborate a bit more on what it is you're really asking me here.

SI: That the cinematographers, the professionals within that industry, had their concerns; how did they approach the body making the standards?

RH: Okay. ... If you look at motion pictures, there are many different aspect ratios and there may be a relatively small number that are in high use, but there have been many different standards. ... It's almost like when you're making a movie, you're going to pick a particular kind of image you want for your movie. The screens in theaters, I'm exaggerating a bit when I say this, but it's sort of like the whole front wall will just make a big screen, and then, whatever kind of image you want to put up there, go ahead and do it. You can have it as wide as the room is, you can have it as high as the room is, and you can do whatever you want with the screen that's up there, and that's sort of the attitude that's used in making the movie. Also, the attitude is pretty much one of, "We made the movie the way we did for certain reasons and, when you watch that movie, you should watch it the way we made it, because we made it that way because that's part of the story, that's part of the image. ... It's all the same thing. We didn't make it for you to watch just a part of it; we made it for you to watch the whole thing." If you are showing a movie on a 4:3 TV screen and you're chopping off the sides of it, like a CinemaScope, widescreen image and you're chopping off the sides, you're only seeing part of the picture. ... In presentations I gave, I took clips of the movie with Catherine Zeta-Jones and Antonio Banderas ...

SI: *The Legend of Zorro* [(2005)]?

RH: *Zorro*, the first *Zorro* movie, [*The Mask of Zorro* (1998)], and one of the scenes that I liked doing this with, there's a sword scene, ... when the two of them are fighting with swords and they're far apart, and, if you have the widescreen image, you see both of them, but, if you have the narrow screen, you can't get both of them in, because, if you take the center part of the picture, neither one of them is in the center part of the picture. So, you've got to go over and pick up one or you've got to go over and pick up the other, and so, there's a whole bunch going on ... in that whole picture that you don't have if you just look at one of them or you just look at the other one on a 4:3 screen. ... This is a case where this wide screen is used to the filmmaker's advantage, because there are certain things you can do with that wide screen. ... So, that's the movie industry, sort of, you know, a summary, of, "It's all part of the art of making the movie and the format that's used is a part of that art, it's all a part of the story." TV, on the other hand,

is very physical. This screen is what the screen is. ... I can treat this like the front of a movie house, and, if it's real wide, just have this real wide picture on here, but, see, ... that's not a good way of using this screen, because much of the screen's going to be just blank now. ... Generally, as you make the screen bigger and bigger, it gets much more expensive, and so, all of a sudden, the physicalness starts becoming an issue. Also, when you have a standard and people are going to be broadcasting this standard and you're going to make millions and millions of receivers, and so on, you really need standards to make it cheap, because, see, you can't have all different aspect ratios of screens. ... It would be a nightmare to be able to manage that, or at least I tend to think that's the case, and so, when you start getting to the physical presentation, you start having some constraints. The "free spirit" movie people don't like that, but, at the same time, the hard, conservative makers of the screen don't like it the other way. ... So, a lot of the discussion then was, "How can we satisfy both of these requirements?" and so, that's partly how the number 16:9 came into effect. ... I don't know if you realize it, but the geometric mean of 2.35 [2.35:1 ratio], which is CinemaScope, and 4:3, which is standard TV, the geometric mean is 16:9, and what that really says is that if you have a screen that's 16:9 and you put on it a 4:3 picture, you're wasting a certain part of the screen, you might say, by putting that 4:3 picture on it. If you put a CinemaScope picture on there, you're wasting part of the screen at the top and bottom, but it turns out that, if you have a 16:9 screen, the loss that you have with a 4:3 image is the same as the loss that you have with a CinemaScope image, and, if the aspect ratio is bigger than 4:3, but smaller than 2.35, you're actually using more of the screen than you do with either 4:3 or you do with CinemaScope. So, that was sort of the concept of 16:9. It's sort of the optimum physical screen and it's the optimum screen front of the movie house wall. If you have 4:3 and if you have CinemaScope, and you have things in-between, it's sort of the optimum of that. Some people thought that it should be 1.85:1, because that's what most movies are, and, actually, that would be better for CinemaScope, because it would use a greater percentage of the screen, others thought it should be wider, like 2.00:1, ... there's a lot of archival material at 4:3, in movies as well as television, you would be using even a smaller percentage of the screen, and so, that's pretty much how 16:9 came about. Now, part of what cinematographers did not like is, "Hey, we're going to be forced to shoot in 16:9 and we may not want to do that," ... but those kind of arguments can go on for ever and ever. So, 16:9 was a compromise, was a technical compromise, ... between two things that were considered extreme, extreme of 4:3 and extreme of CinemaScope.

SI: Do you want to take a break now?

RH: Okay, sure.

[TAPE PAUSED]

SI: In talking about your career at RCA, we left off where you had moved. You were now managing several projects in the late 1970s. At that point, also, you decided to go to Harvard.

RH: What happened was, I was engineering manager and ... my boss, who was the head of the division, wanted me to attend a Harvard Executive Education program, which he had done, once upon a time, and so, I did that. When I came back, not long after that, I was asked to take a job in charge of a new group that had been carved out, as the business manager of that group. When

I was an engineering manager, earlier, I reported to a business manager. The business manager would have all of engineering and all of product management for some number of products, and so, I was asked to take a group like that. They carved out a new group, because, by that time, field cameras, or ENG cameras, had become big enough that they decided to have field cameras be a group of its own. I was ... asked to be the business manager of field cameras. I was in that position less than a year when the Jersey Island office had a vacancy at the top spot, and so, I was asked if I would take that job, which I did, I was responsible for the manufacturing and product marketing, and finance of the office. In my job as a business manager, I had not been responsible for finance; here, I was responsible for the financial department, and I was there for two-and-a-half years. ... At the end of that time, RCA had decided to close down the foreign operations. RCA Broadcast, was starting to really have some difficulties. ... Indeed, after closing that down, that's when I left RCA and went to Washington, DC, to run the committee for the high-definition standard [Advanced Television Systems Committee], and RCA Broadcast didn't even last a year after that. They ran into severe troubles, and so, I think that, in retrospect, I probably did the right thing by leaving when I did, instead of staying there, and having the whole thing close down. So, that's how it is that I ended up leaving RCA, and taking the job in Washington. This was not a government job; it's a private sector organization. Because of the extensive experience I had in television standards, the worldwide contacts that I had from the jobs that I had had, plus the standards work I had done with SMPTE, which had international aspects to it, ... I was a good fit in that position, and so, that's what I did for several years. ... The way I have said it often is, "What I had been doing as a volunteer, I was now getting paid for it," [laughter] you know, running a standards organization. So, that's how I ended up with that, and then, ... the situation when I left ATSC, we had finished the work that I went there to do. The organization was going to continue, but I had decided that I had been on a mission, let's say, and my mission had been accomplished and anything that would be done in the future would be a letdown from what I had done, if you follow what I'm getting at, because, see, they've done all kinds of things since that time that are related to the standard, of beefing this up, taking care of that, little problems here, little problems there, but the "big picture" thing had been done. ... So, I was offered a position at Sony Pictures, where the work was to be using high-definition technology related to movies, converting film to high-definition, shooting movies in high-definition, shooting movies in high-definition and converting it to film for showing in a theater, that was something that was interesting to me. So, I took that job and left Washington at that time. My job at ATSC effectively had ended about the end of November, because that's when the standard was handed over to the FCC, and we were done with it. You know, it was time to do something new.

SI: How large of an organization was ATSC?

RH: About fifty members. Companies were members and a company would send representatives to the meetings. Different parts of the organization would have a specific responsibility to draft a portion of the standard, ... actually, it's on my website. ... I'm going to go to the section called "Editor," okay, ... "[ATSC Digital Television Standard](#)." This is the document that we handed over to the FCC at that time. ... Different people did different parts of this, but I'm the one who put it all together. In terms of what this looks like, that was my formatting, to make it look like this. Whatever the fonts are, that was all my decision. People would write different parts, but I edited everything because I wanted it to sound like one person

wrote it all. ... Different individuals all have a different style of writing; well, this has my style of writing, because anything that anybody gave me, I put it into my style, so that it would look like one person had done it. ... One of the things we decided is that the actual standard would be the annexes to the document. So, Annex A is the video standard, Annex B is the audio standard, ... Annex C is the way stuff's put together in the packets, Annex D is how the RF is handled, and then, Annex E, which was not a required part of the standard, was simply guidelines on what receivers should be able to do. Typically, in FCC standards for broadcasting, the FCC doesn't specify the TV set that goes in the home; they do not get involved in that aspect. If the TV set is creating interference, if it's radiating something and creating interference, they can get involved, but how manufacturers decide to build a TV set, the FCC doesn't get involved in that. ... What the FCC will do is specify what the signal is, and then, receivers can decode that signal any way they want to, that's why there's no required part of the standard with regard to receivers, it's only guidelines of what you might want to do, and it has stayed that way. We don't standardize receivers; we standardize the signal that is broadcast. ... Now, why did I want to mention this? Why did I pull this up? There's something I was getting at; you asked me a question.

SI: I asked you about ATSC.

RH: Okay, and so, this paperwork was handed over to the FCC on the 30th of November in 1995 and that basically wrapped up what I was doing.

SI: Did the FCC make any changes?

RH: The FCC only did one thing. The FCC said this table is not required. [laughter] Okay, that's all, table three in Annex A. Table three is not a requirement. This was to satisfy, for the most part, computer interests. Table 3 was specifying some specific numbers and there was a lot of debate on that. ... The FCC decided, "Okay, we won't require that table," but you know what? That's exactly what's being broadcast. It's exactly what's being broadcast, even though it's not required. So, out of that whole document, it's just that one table that was not a requirement.

SI: When you went to Sony, were you joining a unit that was already established?

RH: Yes. Sony had, several years earlier, when Sony first bought Columbia Pictures, ... set up a little lab to introduce people in Hollywood to high-definition, and it had gotten bigger over time. ... The lab pretty much had operated not as part of Columbia Pictures, but as part of Sony Electronics using facilities provided by Columbia Pictures. ... Sony Pictures had made a conscious decision that they were going to start mastering all films, I'll explain that in a moment, in high-definition. For years and years, you've been able to get videos of movies. They call that mastering, when somebody takes the film and uses a camera of some sort to scan it and make video from it. That's called mastering, and all that mastering had been done with standard-definition video. Sony Pictures made the conscious decision, in '95, that they were going to start mastering all their movies in high-definition, not in standard-definition, the first of the studios to make that decision. ... Also, what they decided, or part of what they were deciding, was, "Shall we take this unit that existed sort of like a lab and make that become a commercial facility to do the work that we want? Because they have the capability of doing the work, but they're going to have to develop that capability to do it on a larger scale and to do it as a business, as opposed to

as a demonstration." ... That was why they were talking to me, ... if they did hire me, I would be responsible for taking this lab and making it into a business, and that is, ultimately, what they decided to do. The reason they did it in-house is because none of the postproduction houses had the capability that was needed, to do what was required, and so, they set it up themselves, with this in-house company, converting the company from a lab into a business. ... What that Emmy is about is that we did a very good job of it and, indeed, we were recognized for our capability in terms of the equipment and in terms of converting movies, ... part of what has to happen to get a Technical Emmy is that you have to show that it has been a worthwhile thing to do. [Editor's Note: The National Academy of Television Arts and Sciences awarded an Emmy to the Sony Pictures HD Center in 1998 for its achievements in developing a high-resolution digital film scanner.] Some new invention that's not used will not qualify for an Emmy, and so, part of the justification was that we had already converted three hundred movies to high-definition.

SI: I was reading one of [your documents online](#). It seems like, aside from the technical issues, there was the idea that you have to convince people that this is a worthwhile medium. How much of that is just simply creating the mass of films, in this instance, so that people see them and see it is worthwhile, or do you have to actually go out and convince ...

RH: Are you talking about the mastering or are you talking about shooting a movie with digital, because they are two totally different things?

SI: Okay, I guess to get more people to adopt HD.

RH: Okay, well, in adopting HD for mastering, it was not a big issue for Sony Pictures whether other companies did or did not do that. For my little company, it was important for other studios to do it, because that gave me more business. As far as Sony Pictures was concerned, whether other people did it or not didn't matter to them, because they had the strong belief that, at some point in the future, they would want high-definition masters because they're high-definition. In the meantime, if you take a high-definition master and make a regular, standard-definition DVD, it will be a higher picture quality DVD than one that's made from standard video. So, they could justify it on two grounds; one, we're making better quality DVD, and, secondly, we have these masters, high-definition masters, on the shelf for when we have high-definition DVD or high-definition distribution to the home or high-definition broadcasting. So, they didn't need others to go along with it, but what happened was, others did start following us. The production houses in town, postproduction houses, started buying high-definition equipment. When we first started doing what we were doing, nobody else could match what we were doing. Over time, they could match what we were doing.

SI: You were taking in business from not just Sony.

RH: We were doing it for other people, too, yes.

SI: Okay, all right.

RH: The bulk of our business was Sony, but we worked for other studios also. That also made it a little bit difficult at times, because ... a different studio is competition, and so, they're a little

reluctant to have their competitor do work for them, if you know what I mean. So, it's easier for them to justify a neutral postproduction house doing the work than it is for a postproduction house that's owned by a competitor.

SI: In your role in the business as the boss, how much were you able to get your hands into the technical issues?

RH: I didn't get involved in much of it. However, we were constantly working to get better scanning equipment and I would get involved in discussions on that, but certainly not inventions or, "How do you do this?" but, what we were doing, what our focus was. We were having a company make a special scanner for us and I would hold weekly meetings with them where we'd go over a lot of technical issues, presiding over the meeting, let's say, taking charge of it.

SI: Would you spend most of your day in meetings?

RH: Yes, in meetings, not doing technical work. We're running a production house, where many different people are interfacing with different clients, ... making videos of the work that they're doing, putting it on tape, doing this, doing that. I'm just being the boss of all that. ... Also, you know, ... in the pictures I'm scanning here, ... what I can do with Photoshop, I credit a lot of that to what I learned from the colorists that worked at Sony Pictures, how I know what needs to be done. It's not an easy thing to do. I don't know if you've done color correction; how do you know which color you need to emphasize? You have to learn to do that, and I'm not trying to say that I am an expert at it, but I understand it and I can usually figure out what I have to do without too much difficulty, and that's because of what I learned from the people who do it to movies. You know in a movie, all these different scenes are different negatives, and then, at some point, they take these different negatives and put them together into the story. ... The different negatives are shot at different points in time, developed in different chemicals, and, if you have any experience with developing film, you'll know that things aren't going to match perfectly. You know, from one to the next, ... it just won't match, and so, one of the last things that's done is to make it look like a single movie, just like I'm talking about editing the high-definition standard to make it ... sound like one person wrote it, to make it look like it's all one movie. ... They call that color timing. What will happen is that the exposure that's done on each piece of negative to make a positive print can be different, and the cinematographer is generally responsible for overseeing that, to make it look consistent throughout. ... When they finally made it look consistent throughout, they take these different negatives with the different exposures and they make a print of the negatives, called the interpositive, the IP. From that interpositive, ... they make an internegative. The internegative is then used to make the release prints, so that that color timing that went into the interpositive is in all the release prints. So, when we electronically color correct a movie, then, we improve even on that IP, because, with electronic color correction, you can do even more critical matching of color timing. This has become very popular. All the directors want their film done that way. They want it to have a good, consistent look throughout. Movies like *Pleasantville* (1998); do you remember *Pleasantville*?

SI: Yes.

RH: And, you know, it was mostly black and white, but some color. It was shot all color, of course, but it was processed digitally to take out the color in some scenes, and then, allow color only in certain places. That was sort of the beginning of a trend, where, now, virtually all the movies are color timed digitally, the film that goes into the theater has come after electronic processing, rather than from all film processing.

SI: What were the biggest challenges that you faced during your time with Sony?

RH: I think it's probably introducing a new technical way of doing things to people who are very committed to what they're doing, what they have been doing and how they have been doing it. See, one of the interesting things you find is that they're in the business of making movies, not in the business of using film. ... You would think that they're in the business of using film, but that's not the case. It's just that they know film so well and they know how to use it, and to do something different is very difficult to bring about. Still today, I suppose that film can capture a greater dynamic range than digital can, but one of the things that people have found is that shooting digital is a very handy thing to do. It simplifies certain things. ... They call it digital intermediates, where you shoot in film, make a digital master, and then, make film from that digital master. That's called a digital intermediate, and the reason for doing that is because it's so powerful what you can do, that even if you're shooting film, doing this digital intermediate helps you get either faster or cheaper or better, or some combination of that, to your end product, and introducing something new like that is very difficult.

SI: I guess that was what I was asking earlier; in introducing something new, does it just sort of happen or do you have to actually try to convince people to use this?

RH: Oh, you have to convince people. ... Once people start using it, then, it can be judged by the other people on whether it's good or not good, and so on, but, initially, somebody has to do something. It's almost like, how do you invent something that never existed before? ... How do you get people to use something which has never existed before? Those first steps are difficult ones, and either people see it being used and like what it does, and then, they adopt it, or they don't.

SI: It is kind of like Edison lighting up Menlo Park. In this instance, transferring all these films to HD, creating these HD masters, and then, doing all the things with it, is that the equivalent?

RH: Yes. People have to see it, see what it can do. One of the kind of things that was done to show how good DVD is, compared with VHS, was to put on a DVD, as a split screen, a movie where the right half of the movie is VHS quality, the left half of the movie is DVD quality. ... It's striking, the difference, and just watching a VHS in one room, and then, go in another room and watch a DVD, you may not be as aware of it as seeing it on that split screen. You can do the same thing with high-definition, see what the difference is between high-definition and standard-definition. One of the things that I did many times, I had a theater; I could run high-definition projection, I could run film. ... I liked to use the movie *Lawrence of Arabia* (1962), it was sort of like an icon, iconic film, of Columbia Pictures, ... run a few minutes of *Lawrence of Arabia* in film, and then, run the same thing in the high-definition conversion, and it was shocking to people how good that was, because, keep in mind, at that time, when you go back just ten years

even, people think of television and they think of analog television sets and high-definition is not like a television set, if you know what I mean. [laughter] It's just much higher quality, and to show people that it's on the same quality level as projecting a movie with film, it's something startling for people to actually finally see that and understand it. It may not be that significant today, because there's many high-definition televisions around, but, in the earlier days, it was not that easy.

SI: There is some idea of salesmanship there, trying to sell it.

RH: You can call it salesmanship, but I don't really see it as that; it's not like you're having to sell something. It's like, "If they can see it, they'll come." [laughter]

SI: You worked primarily with film, but did that include working with the television industry in different aspects? Maybe I am not thinking of it correctly, but did you have to convince sports people, convince film people, convince TV news people?

RH: Okay, if we go back to the overall high-definition, yes, I'm sure that some of that had to happen. ... See, sporting events are something that's really nice in high-definition, and so, different people were involved in that, not me, but other people were. ... See, video is so much easier to use than film, and that's a selling point itself. Do you remember the movie *Blair Witch Project* (1999)? That was all done with a video camera, and it changed the industry. Video cameras, ... not necessarily high-definition, but video cameras in general, changed a lot of what you do, can do, compared with film. Somebody who's shooting thirty-five-millimeter film, it's a big camera, you only have a few minutes of film in a load and to have this little camera, it's just so radically different and what you can do with it. ... Big movies are still made the same way, even if they're using digital cameras, pretty much done the same way, but ... part of what was allowed with video was for individual people to do things that individual people would have great difficulty doing with film.

SI: You spoke about the Emmy and what you received it for. The same year you received the Emmy, your first Emmy, you also received the National Association of Broadcasters Television Engineering Achievement Award. Was that award for the same thing or was it a different accomplishment?

RH: The Emmy was for work I had done at Sony Pictures, or the work that the company did at Sony Pictures. The NAB Award was for the things I had done in Washington, DC, with ATSC in developing the high-definition standard. So, those two awards were in the same year, but they were for totally different things, two different jobs.

SI: Okay, yes. Could you talk a little bit about this most recent Emmy? [Editor's Note: The National Academy of Television Arts and Sciences awarded an Emmy to the Advanced Television Systems Committee in 2008.]

RH: Okay, ... took a long time, but, finally, the Emmy organization, the National Academy of Television Arts and Sciences, decided to give an Emmy to the organizations that developed that high-definition or ATSC standard. There had been a lot of political issues and, because of the

political issues of different people with different philosophies, it took a long time for the Academy to recognize it. To my way of thinking, it was long overdue that there should have been an award for that, but that finally happened. Then, the award, the Emmys, were given out in January of this year [2009] and, basically, it's for developing that digital standard, digital broadcasting standard.

SI: Those two awards were ten years apart, but for the same thing.

RH: Yes, yes. My NAB Achievement Award and the Emmys this year were for the same thing, but ten years apart, yes, ... and the NAB Award is literally to me personally. The Emmys earlier this year were to the organizations that did all that work, not to me personally, but to the organizations.

SI: You listed on your resume that you also were an adjunct at NJIT [New Jersey Institute of Technology].

RH: Yes. ... That was back in my earlier years, and I can't remember now exactly when I was doing that, if I had the PhD yet or not; I can't remember now. It may have been at the same time I was going to school at Rutgers, I can't remember, but ... I taught a communications course and something else. It's been so long now, communications and I don't remember what the other thing was, but the communications course is the one that sticks in my mind. ... I would go up once or twice a week and teach a class or two.

SI: Do you remember roughly how many years you did that for?

RH: A couple or three years.

SI: What motivated you to do that?

RH: Just interested in doing it. I think I got paid a little bit, but it paid so little that I did not do that for pay, [laughter] I did that because I was interested in doing it. Even when I retired, I've considered doing teaching now, but, ... for various reasons, did not do it, didn't happen, but, someday, I still might. I don't know. I'm enjoying doing nothing. [laughter] ...

SI: It seems like you have a lot of projects.

RH: My own projects, yes. [laughter]

SI: Would you like to say anything about your patents, the patents you hold?

RH: Actually, there's ...

SI: You have them on [your website](#).

RH: Yes, I do. I have, like, the cover pages. ... There were seven of them, but one of them was pulled back. I did not know that until recently, actually, that ... one was challenged by some

other company and, apparently, RCA pulled back on it, and I didn't even know it. ... Okay, of those six, ... four of them were related to the, what was called Video-Voice, taking a slow scan off the silicon storage tube, putting it through the phone line onto another silicon storage tube. ... I'm still not correct. The first one listed was related to the synchronizer ... that we did in Camden, the frame synchronizer. The second one is something that was totally different. During my earlier assignment from the labs to Florida, to the Palm Beach division, something that one of the other guys was doing was something he called electronic book, which is something even now, and he was using a regular TV display, putting, basically, bit scanned black and white onto a TV display. ... A regular TV display didn't handle that very well, and so, I came up with a little scheme that did special kinds of processing, so that these alphanumeric characters were more readable on a regular TV screen than they normally would be. That's what that one was. The next one was for the synchronizer in Camden, and then, the other two were related to the work that was done; no, even this one, this was while I was in Florida, related to the ... slow-scan off the silicon storage tube and the last one was slow-scan. So, all of those were in those early years, in the '70s. In fact, I wonder if the dates were all in the '70s. 1980, 1980, '78, '78, '74, '74, yes, and that's also the end of the time that I was doing regular engineering. By 1980, I was not. I was a manager; I wasn't working as an engineer at all.

SI: Did you miss doing more practical engineering?

RH: In some ways, yes, in some ways, no. You know, ... I've put ... a lot of effort into everything I have done, whether it's the engineering role or managing engineers or managing the company. That's the way I do things. ... It's not that doing the engineering things becomes tiring, I don't mean that. It's almost like, "Well, I've done that. What can I do now?"

SI: How much of a learning curve is there when you go from a job like practical engineering to management, and then, say, when you took the job in Jersey, all of a sudden, you were in charge of finance? How quickly do you have to come up to speed on those and how do you do it?

RH: I believe that a lot of what you need to do is just common sense. ... You need to listen to people. You need to have a feeling so that you know when somebody's trying to pull something over on you. You have to see through the crap that can be thrown up in front of you at times, and just common sense. I think that's more than anything else. To be responsible for the financial area doesn't mean that you have to be a financial expert. I certainly think you need to have a basic understanding of what they're doing and why they're doing it, but you don't have to be good enough that you could do that job, but you certainly have to know, you have to be able to determine, if somebody's trying to pull something over on you, if they're not doing something right. Am I making myself clear in what I'm trying to say?

SI: Yes.

RH: And so, I think, I really believe that common sense is a very significant part of it, being able to work with people, being able to get people to open up in the areas that are relevant to the business that you're running. ... In an organization where the boss is responsible for everything, I think you have a very limited organization, because you may have a whole bunch of people out there and they can do much more than they're allowed to do, ... if the boss has to do everything,

and so, ... to be able to do a lot of great things, you have to let the people do great things and, to let them do that, you have to let them do it. You must make sure you understand what they're doing, why they're doing it. They need to justify what they're doing, but, if you believe ... that they're good people and doing good things, you can give them more latitude to do that. ... Indeed, I think that's how good organizations come about, where the managers of the organization at the different levels are able to let the people do the good things; find the good people and let them do the good things.

SI: What was the most enjoyable part of your career?

RH: A lot of things I enjoyed very much in the Sony Pictures period, because it was just a different kind of thing than I had done before, a different kind of life. I enjoyed that very much. ... I'll say the same thing about Jersey Island. When I was in Jersey Island, my boss was thirty-five hundred miles away. I was pretty much on my own. ... I enjoyed a lot of aspects of that also. I enjoyed my days in Princeton, the freedom. So, it's almost like I'm picking things about the different jobs, and I liked each of them for different reasons, and it's hard for me to pick any one. It's like all of those made me what I am. I enjoyed all of them. I wouldn't have stuck with them if I didn't enjoy them. I don't think any one of them stands out stronger than any other. Perhaps the one that was the most personal was the work in Washington, and that's because I made it personal; didn't have to be that way, but I made it that way.

SI: Sticking with that, how do you feel about this Friday, the end of analog broadcasting? Is that a personal victory, perhaps?

RH: Yes, absolutely, but, see, it's a funny kind of victory in a way. When we started all this, I really didn't have any idea how it was going to end up. ... When we went, in the '50s, from black and white to color, the decision that had been made was that the new color signal would be, we'll use the word compatible, with the black and white, so that people with black and white TVs could still receive the color picture. It wouldn't be in color, but it would work. They could keep using those TV sets. The same channels were used, the broadcast stations used the same channels, just a change of the signal, but the way the signal was changed was in such a way that the black and white TVs would keep working, but, in the meantime, new color TVs would give you color. With high-definition, many people thought that was the right way to go, to do something similar to that, in which case this transition that's happening tomorrow, Friday, would not have to happen, because they would just start broadcasting the different signal. All the TVs that are out there would continue working the way they had before, but a new TV would have this new and glorious picture, but it was decided that, the basic signal dates back to 1940, that's a long time when you think of what's happened with integrated circuits and with computers, and so on. It's a long time to still be locked into a standard from 1940 and that baggage was just too great. It was too hard to get a significant improvement and maintain that compatibility with the old. ... So, over time, what developed was the attitude that there's another way of being compatible, that we have each TV station have two channels, one channel to do the old style color signal the way they've been doing for many, many years, and the new channel would be that new service that is high-definition, digital, and then, over time, when people have bought new sets, we can then turn off the old style and only have the new style. ... That's the way the decisions were made. The standard was adopted by the FCC in late '96, and so, what is this

now? This is twelve, thirteen years later, twelve-and-a-half years later, that we are finally doing the turn off of that NTSC channel. Most people don't receive pictures over the air. They get them from cable, they get it from satellite, Direct TV. ... Now, I guess, even people are getting it on what I'll call phone lines, Verizon FIOS, and so on. So, the only people that are affected now are ones that still use rabbit ears, an antenna, and tune directly to the TV station. So, that's a small percentage, except it turns out that a lot of people have more than one TV in their house and one of those TVs might be tuned to the regular TV station, so that even though the house has cable, there's a TV back here that is not on the cable. So, the impact is greater than just those people whose main TV is on broadcast. So, there is some impact from it and, indeed, that's why the transition was delayed a few months, because the new administration wanted to make sure they were satisfied that enough had been taken care of for the people who will be affected by what happens. Now, I won't be. I don't have any TVs in this house that use a regular antenna. I use Direct TV and I do have the capability of doing off air, but I only have a UHF antenna. I don't even have a VHF antenna. So, some of the digital stations here I pick up, occasionally, directly, as opposed to through Direct TV. Here in Florida, there's a different issue. We, every now and then, have a hurricane come through, and so, there typically are a lot of power failures. People want to have a battery-powered TV, to be able to see what's going on. That's still an issue and will be an issue for a while. There are battery-powered digital televisions that you can get now, but they're still relatively expensive, but I think that's going to change pretty quickly now that the transition is finally happening. I think you'll see additional things like that happen. So, yes, I'm happy to see it happen. It's been a long time coming. That was one whole, actually, if you count retirement, two whole jobs back. [laughter]

SI: Would you like to say anything about your family?

RH: All right; let me say one other thing, before I forget it. It just occurred to me. I think that I had a stronger feeling of accomplishment when stations first started broadcasting high-definition, a stronger feeling than I have for what's happening Friday, because ... Friday is sort of, in many ways, the completion of it all. ... I guess the beginning of it really happening felt more significant to me than the wrap up of it on Friday. Now, come Saturday, I may feel different, but I don't think so, because it doesn't impact me very much. My family, ... I have two children that considered going to school at Rutgers, because we lived in, they lived in, New Jersey. That did not happen, but they considered doing it, and both of them got a bachelor's degree, and then, went on and did various things that I'm happy for. It's the thought that comes to me immediately.

SI: Okay. Just for the record, I would like to mention a few of your affiliations and honors. I will just read these and, if you want to say anything about them, just stop me. You are a fellow of the Society of Motion Picture and Television Engineers.

RH: That happened at a fairly young age. It was after doing all the digital stuff early on that SMPTE voted me as a fellow, and I was still very young. In fact, let me just check and see what that date was; 1981, that was fairly quick. So, that was, to me, a very high honor, to be considered a fellow at that young age, and I wasn't even forty yet.

SI: You are a senior member of the IEEE, a member of the Royal Television Society and you served as a Vice-Chair of the Board of Directors in the Advanced Television Technology Center

in Arlington, Virginia. You served on the board of directors at the Model HDTV Station Project in Washington, DC.

RH: Yes, the Advanced Television Test Center was the organization that did all the testing for the digital standard. ... My role on the board, though, was after that. ... When I was already at Sony Pictures, I was asked if I would serve as a board member, representing Sony, which I agreed to do, but that was after they had done all the testing for the standard, but still involved in testing things relating to digital television. ... The Model HDTV station was, again, representing Sony; Sony asked me to do that. The station, in Washington, DC, it was based at the NBC affiliate in Washington, where they sort of set up a small area with high-definition equipment and were doing high-definition broadcasting, they had a permit to do that, channel allocation, and so on, to sort of ... be the first to do it and see what kind of problems they encountered, and so on, sort of like a test, not testing the standard, but a test to see what you need to know to be able to broadcast in high-definition.

SI: That reminds me of something else I was reading, about the first test of, I think it was digital TV, either HDTV or digital TV, in San Francisco in 1981. [Editor's Note: The SMPTE presented a demonstration of digital television in February 1981 at KPIX Television, Studio N, in San Francisco.] Were you involved in that?

RH: Yes, but in a funny way. ... My committee did the work. I threw a little reception for it and I wasn't even there, because ... that was when I was at Harvard and I could not get away to go to my own thing, [laughter] and so, yes, I was quite aware of that work going on. I just couldn't be there.

SI: That must have been disappointing. You received the 2000 Outstanding Electrical Engineer Award from Purdue University.

RH: Yes, and that I'm very happy for. That's one of the things I consider significant that I got.

SI: The RCA Laboratory Doctoral Study Award was the one for the PhD that we discussed.

RH: To get the PhD, yes, yes.

SI: You received two RCA Laboratories Outstanding Achievement Awards.

RH: One of those was for work I had done with what was called Video-Voice. That's the scan converting, ... to send a still picture over a phone line. The other one was for work in digital television, and, see, I was one of the early people involved in digital television; not the first, but one of the first.

SI: Just to go through some of the reading I had done, there was also this controversy between interlacing, scanning and progressive scanning. Could you explain your role in that?

RH: Yes. Throughout my time in Washington, what I was doing, I was not formulating a standard; I was a facilitator to get the different parties to agree on what a standard would be.

Often, I would try not to take a position. In fact, I had to be careful about taking a position, because, in a membership organization, ... it's hard to take a position opposing some of your members. Now, you might try to convince some of your members to do something different, but you've got to be careful when you do something like that, but my role more so was as a facilitator, to get an agreement for a standard. The standard that was adopted had both, had both interlaced and progressive in it, and rather than try to take positions, to side one way versus the other, the conclusion was to allow both.

SI: Is there anything else that you would like to discuss from your career, anything that we skipped over? Again, for the record, you have [your website](#) with a lot of this material on there, but I certainly do not want to skip over anything.

RH: Yes. When I decided to do the web site, it was about the time I was deciding that I was going to leave Sony Pictures and wasn't sure what I was going to do, whether I was going to continue working. I considered teaching, I considered working somewhere else, but I did not consider that as strong as I considered teaching, and I considered retiring. ... So, one of the things I started doing very quickly was taking a lot of things I had written before and putting them in a form that I could put on the Internet. I put my resume on the Internet. My documents page is a lot like a CV, but a CV usually just lists what they are. Here, you actually have them there. [laughter] ... It was during that time that I wasn't sure what I was going to be doing and I decided it's probably a good idea to put the papers out there. ... My decision was to retire, and I've never been unhappy that I put them there and, indeed, I've come across a couple other early papers that I'm going to scan. Initially, what I was doing was, anything that existed in an electronic form was easy to put on the site, but things that weren't in an electronic form were not easy, ... like my dissertation. I scanned that, and an early paper that I have found now, I will scan that. I'm not going to try and make an electronic reproduction of it, I'll just simply scan it and put it out that way. ... I put everything out as PDF files. Even the things that I have on electronic copy, I make a PDF file of it, or, if it's scanned, I have a PDF file, and so, I'll just scan that, put that out there, too, and I think I found, somewhere, an essay I wrote ... for my master's degree at Rutgers. I will probably do the same to it.

SI: That is great. If there is nothing else, I will say thank you very much.

RH: Thank you very much.

SI: I appreciate all your time. Thank you again for lunch.

RH: You're quite welcome.

[TAPE PAUSED]

RH: I'll just add some things that you might include or not. It's up to you. ... My father had taken many, many pictures, thirty-five-millimeter camera slides. ... I guess I sort of picked that up also, because, fairly early on, and this was also due to the influence of this guy that I called my mentor, he had Nikon cameras and got me interested in Nikon cameras, and so, even as a young engineer, where I shouldn't be buying that expensive equipment, I bought some Nikon

equipment, and I've been using Nikon cameras now for many, many years. ... I had a Nikon F, an F3, an N8008, which is one of the first autofocus cameras that Nikon made. I bought the D100, which was Nikon's first single lens reflex digital camera, that was at a reasonable price, let's say, and I have a D300 now also. I had a Nikon Coolpix 990. So, I've had digital cameras, I've had film cameras. I no longer have my original Nikon F, but I've kept all the other cameras. ... Just like I told you I like to keep books, I like to keep my cameras, too. Even though I don't use them, [laughter] I still like to have them, I like to hold them. ... So, after I had retired, I was in Indiana with my brothers and sister, the occasion was a funeral of an aunt or uncle, I think it was an uncle, and I asked who had our father's slides, because he had died a few years before that. ... My brother had them and I said, "You know, I would consider scanning them," and so, even on that trip, ... my brother and I met up, and he gave me all the slides. I brought them back here and, over a couple of years, I proceeded to scan them. As you might expect, I bought Nikon scanning equipment; I don't want this to be a commercial for Nikon. [laughter] ... So, a Nikon slide scanner, and, ... with some of the experience that I had picked up at Sony Pictures on color correction, it was easy for me to adapt myself to being able to do the color correction that I wanted on these slides, because I did not want the digital images to just look like the base slide, because, over time, some of them can fade. They may have been under exposed. I wanted them to ... all be good pictures. So, I do the best I can with each of these pictures. I've wrapped that up and I decided to start scanning my own pictures, and so, that's what I'm doing right now. I'm in the midst of scanning my own pictures. ... I've been interested in optics. This happened, I'm sure, somewhat because of my training. I can remember physics classes where we studied optics. I've enjoyed that. I like cameras, I like lenses. I just find all that interesting. Maybe it's a missed vocation. [laughter]

SI: Thank you very much.

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Reviewed by Maria Juliano 3/27/10

Reviewed by Shaun Illingworth 8/26/10

Reviewed by Robert Hopkins 10/19/10