WILLIS ADCOCK

An Interview Conducted by

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Interview: Willis Adcock
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Morton: You were chairman of the Professional Group on Electron Devices or Electron Devices Society (EDS) in the early sixties. Were you involved in that group before you became chairman?

Adcock: Yes, I must have been. I was very active in electronics and was the liaison between Texas Instruments (TI) and Bell Laboratories for a long time. Jack Morton got me involved, though I don't remember it well.

Morton: What kind of a liaison was there between Bell Labs and TI?

Adcock: TI had a patent license from Bell Labs and paid a royalty on the patents. I was at TI, and Jack Morton would come down and see how we were doing.

Morton: That's interesting.

Adcock: It seemed funny to Bell Labs that this little company with no reputation called Texas Instruments wanted a license, but Pat Haggerty – who was the brains and driving force behind TI – insisted upon it and they relented. Haggerty was also very active in getting the IRE to merge with the IEEE. I was a sort of handy boy for Pat Haggerty much of the time and used to carry his suitcase around Washington and other places.

Morton: Who was the EDS chair before you?

Adcock: I have no idea. When did I become chair?

Morton: It looks like '61.

Adcock: Maybe I can find some material, but I cannot remember.

Morton: One way or another you got involved in that group.

Adcock: Yes.

Morton: Just before that there was something called the Emporium Chapter of the Professional Group on Electron Devices. Do you have any recollection of what that was?

Adcock: No, I have no idea.

Morton: I understand that right before you joined in 1960 there were five divisions of the group, Some of them sound familiar, such as electron tubes and solid-state devices. In 1960 they added microwave devices and there was one called energy sources. Did you know anybody working in that area? I'm not even sure what that involves.

Adcock: Solar energy – but no, that doesn't ring any bells with me.

Morton: I think there was also some work in thermionic conversion.

Adcock: That's interesting.

Morton: It's a bit of a mystery to me. I haven't been able to find anyone who was directly involved in it.

Adcock: My files aren't organized that way. I was in the solid-state division.

Morton: Okay. From your perspective, what was happening to the group in those years? What really exciting things were happening?

Adcock: The biggest thing that happened was the total rise of silicon transistors or transistors, and the integrated circuit which came out of that and revolutionized all of electronics. It also revolutionized our Defense system, especially with radio and the Minuteman missiles. Texas Instruments demonstrated a radio and IBM took an interest. TI made an exclusive agreement with IBM and helped them

make the transistors for their computers. Transistors and their evolution, especially the silicon transistors, revolutionized all of electronics – radio, entertainment, computers, everything.

Morton: Did you get the sense that the IRE was following those developments or conducting activities important in leading them?

Adcock: They provided a publication for that, and we had annual meetings that were very interesting. Bill Shockley was very active in getting those meetings started. The Electron Devices Society had special issues of their publication. The July 1976 issue was a special with historical notes on tubes and devices. You have probably seen that one.

Morton: Yes. Is Shockley in that issue?

Adcock: No, but he published a lot of papers in the *Proceedings* of the IEEE. When did they change the name to the IEEE?

Morton: The merger was in 1962.

Adcock: Yes. The December ‘64 issue was a special on integrated electronics. Those two publications were major in terms of electronics.

Morton: Were there any interesting stories that came out of those years of the Electron Devices Society?

Adcock: No. I don’t really remember serving on the Society. Isn’t that amazing?

Morton: That’s understandable. It was a long time ago.

Adcock: The EDS was not a big part of my career. It was just part of my job. I was so busy with other things. I was Principal Investigator in charge of integrated electronics and integrated circuits at TI.

Morton: I saw in your biography that you were born in Canada.

Adcock: Yes. I'm an immigrant.

Morton: Would you tell me a little about your early years?

Adcock: I was born in Canada very near the U.S. border in 1922. A lot of my relatives left the United States when things broke **[inaudible words]** wouldn't pay taxes and all that. **[Inaudible phrase]** Empire Loyalists. I went to grade school in a small Canadian border town called Clarenceville **[spelling?]**. They didn't have a high school, so in 1936 when I was fourteen years old I went across the border to live with my uncle and went to high school in Champagne, New York. I used bicycle to my home in Canada, so it was no problem at all. From there I went to Hobart College in Geneva, New York. Hobart William Smith is what they call it today. It was the first college to be established west of the Hudson River, back in the 1820s. It was college of the Episcopal Church in New York City and founded by Bishop Hobart. Its mission was to educate the Indians. It has an interesting history. It was first college to drop Greek and Latin requirements – because the Indians had very little training in Greek and Latin.

Morton: And probably very little use for it.

Adcock: That's right. It was in the lake region. Geneva is on Seneca Lake, which is where the Indian tribes were located. The reason I went there is because my principal from Champagne High School had graduated from there. He sent me there, so to speak. I didn't know one college from another. I graduated in 1943, though I was in the Class of '44. Then the Army thought they would like to have me.

Morton: I'll bet they did.

Adcock: In the Army I ended up in Oak Ridge, Tennessee. When I showed up there, they looked at my papers and said, “Uh-oh, you’re an alien. You can’t be here. This is a secret project.” That was the atomic energy project. I said, “Well, I *am* here,” and they decided to put me to work and keep me quiet.

Then I wanted to apply for citizenship. I hadn’t stayed long enough in the city before. They said, “You can’t do that, because it’s a secret project,” but I said, “No, the Army regulations say that in 90 days I can apply for citizenship.” And I applied for citizenship. My Captain told me I could not reveal anything other than my serial number, but I said, “I’ll answer all of their questions.” It was kind of crazy, because they ask questions about the Senate and Congress and all of that. However I had my college education in the States. It worked out. I became a citizen, and I was in Alabama when I was discharged several years later. Then I went to Brown University and graduated from there in 1948.

I graduated in physical chemistry. I didn’t have an engineering degree. Later on I’ll tell you how I became an engineer. It’s strange how things just become a pattern of life and where one ends up is a matter of chance. The head of my chemistry department took a job doing research out in Stanlow Gas **[correct two words?]** in Tulsa, Oklahoma and wanted me to go with him. I thought it would be wonderful to go out there, though none of my classmates would consider a job west of the Hudson. This was 1948. Interviewed in places like New Jersey, but I took the job out in Tulsa and just enjoyed myself. In those days National Gas was widely used out there, but there were no pipelines. We tried to convert natural gas

into gasoline, but a year or two later when they built pipelines to the east coast it wasn't as economical and that project was abandoned.

About that time was when little TI was in the geophysical business and wanted to get a license from Bell Labs to build transistors. After Pat Haggerty persuaded Bell Labs to give TI a license he realized that TI had better get some research going. They hired Gordon Teal from Bell Labs. Teal went to Brown University many years before I did, but when he went to Brown looking for some people to hire he was told, "Adcock is out there wasting his time. Why don't you go get him?" and he came and talked to me. I got interested in electronics when I was in the Army – because nuclear work is electronics.

After Gordon Teal approached me, I was so interested that I went down and talked to Pat Haggerty, Bob Olson and a few others at TI and took a job with them in 1953. The company was geophysical and GSI then, making about $25 million a year. The head of research at Stanlow said, "You're out of your mind. Electronics is nothing. Go get it out of your system and come back. We'll always be using gasoline," but I never went back. TI was wonderful, and I stayed there thirty years. The first thing they wanted me to do was work on transistors. The nice thing about being a chemist was that semiconductors were a chemistry problem though vacuum tubes are a mechanical problem. I started working with silicon because Gordon Teal was interested in that. Working at Texas Instruments was fascinating. They built on crystal polars **[correct three words?]** and I worked on silicon transistors. Soon, with a lot of help from others, I developed a silicon transistor. That got TI started in silicon transistors.

Morton: Is that the work cited in your Fellow Award?

Adcock: I'm sure it is.

Morton: Contributions to the advancement of silicon material and—

Adcock: Yes.

Morton: What exactly was that project all about and what was your role in that?

Adcock: Up until then, germanium was the primary material used in transistors. Silicon that melts at 1400 is a white heat that is very hard to control. We built crystal polars with wonderful control of temperature. If crystal polars are pulled too fast it just leaves a melt **[correct word?]**; if pulled too slowly, the whole thing freezes up. The right pulling speed and temperature control are needed. Then dopelets **[correct word?; spelling?]** must be added to the material to make a junction. When all that has been accomplished it must be cut up and bonded. Being a chemist these things were fairly simple, so it wasn't a big deal. In about a year or so we got a silicon transistor going. That's pretty well described in Electron Device's papers.

Morton: Yes.

Adcock: It was fun, really.

Morton: It sounds like it.

Adcock: Then I was put in charge of transistors and all that kind of thing under Gordon Teal. He was a wonderful boss and let me have plenty of freedom to do anything I wanted. Then we got interested in making more complicated devices, such as exploring different ways to make silicon devices at higher frequency. Then TI got

involved in manufacturing silicon transistors and we made the little Regency radio.

Haggerty was wonderful at promotion. He said, "You've got to find a market, and the only way to find a market is to interest somebody in it." The reason we made the Regency radio was to get someone interested in our electronics. We gave a bunch of them to the Board of IBM. If we could make radios, we ought to be able to make computers. Soon we got very active with IBM in making transistors for computers.

Morton: Were they trying to make these devices before they had a market for them?

Adcock: Yes. There was no market for transistors at first. Radios were the first market. We established radio because it was going out with the arrival of television. I think Texas Instruments' pocket radios reestablished the radio business.

Morton: Sort of transformed the product.

Adcock: Yes, transformed into something portable. You've seen those, haven't you?

Morton: Sure.

Adcock: When we first came out with them we wanted to make them longer because it would take a longer antenna, but Haggerty insisted we make them shorter so they would fit in people's pockets. It was Haggerty's influence that made the Regency radio practical, desirable and marketable. We tried to sell the radios to companies like Raytheon and Sylvania but had no luck at all. Pat knew the people at Regency, and they helped us design and market it. The big companies didn't want a radio like that because it cost more. It came down from $50. In those days radios could be purchased for $10 or $20.

Morton: Regency was in another state, wasn't it?

Adcock: There was a Regency Division of Industrial Development and Engineer Associates, Incorporated (IDEA) in Indianapolis.

Morton: That's right. The connection was that Pat Haggerty knew someone there?

Adcock: Yes. It was just amazing.

Morton: That's interesting. I haven't heard much about that company before or after that. I don't know what happened to them.

Adcock: I don't think they stayed in business for very long.

Morton: On what transistor developments did you work after that?

Adcock: We then worked on the silicon transistors. The military got interested in that because germanium couldn't run at higher temperatures. We developed a whole range of military transistors that would run at higher temperatures. That changed electronics for the military. We got heavily involved in that. Just about that same time, people got interested in microelectronics, those little RCA micromodules, and the Navy wanted thin film circuits. The problem there was that we needed smaller electronics because the Russians had launched their Moon flight. They had big missiles, but we needed small, compact electronics for our missiles – such as the Atlas and the Minuteman. The big quest was to make compact electronics. RCA's micromodule was one of the things being pushed.

Morton: Was the micromodule the thing with the stacked up things?

Adcock: Yes. And the Navy was pushing thin film circuits. The stroke of luck and thing I did that really established me was that I hired Jack Kilby. The reason he was so good at it was because he was deaf and worked on hearing aids. At Central Lab he

developed the hearing aids with small capacitors like that, so he got interested and I hired him. The funny thing is, I was in research and in those days a Ph.D. was a wonderful thing. It was sort of magic. Jack didn't have a Ph.D., but I said to hell with that crap.

Morton: Did he come to you or did you know him beforehand?

Adcock: No, I just got interested in him. I guess I met him at one of the EDS meetings or something like that and talked to him about it. He got me interested, and I thought Jack would be an ideal person for micromodules. I was given the job of doing the microcircuitry, and I thought he'd know about that. When I got him he didn't want to work on micromodules. He didn't think that was very good, so over the holidays he innovated the integrated circuits. That story is well covered in the IEEE *Transactions* of July 1976. He wrote a paper that gives the history. Bob Noyce did the same thing a year later when the planar transistor was developed.

Morton: Those are very famous stories, but I hadn't heard about how Jack Kilby came to TI.

Adcock: It was one of those lucky deals where our paths crossed. We are still good friends and he still lives in Dallas.

Morton: I take it you were overseeing the laboratory there at that point.

Adcock: Yes, in semiconductors.

Morton: What else was TI working on at that time? Were there things that didn't have much success?

Adcock: Yes. We always had a big apparatus division working on military systems, but I wasn't involved with that.

Morton: Were there any interesting projects within the semiconductor business at TI that of failed, things we never heard about?

Adcock: Not really. IBM was our big customer. All our production was selling the big transistors for IBM. They were big in those days – line after line for IBM. But we didn't do any development work except in the transistor area.

Morton: I see.

Adcock: Then I hired a fellow named Jay Lathrop. He developed the photolithography techniques for us. It was very important for integrated electronics to have photolithography. Up until then it wasn't needed.

Morton: I interviewed him a couple of years ago in South Carolina while working on another project.

Adcock: Yes. When he left TI he went down there to teach. He is a wonderful fellow. Jay was one of the pioneers. He did the process development work for Jack Kilby, growing the silicon, growing the wafers, and developing a method to oxidize them uniformly. It was very important that the integrated circuits be uniform. Jack was the one in charge of that process work.

Morton: What did you work on after that? I guess it was the middle sixties at this point.

Adcock: Yes. We needed money for research and finally talked the Air Force into sponsoring us. Do you know Dick Alberts? **[spelling?]**

Morton: No.

Adcock: Jack Kilby's paper talks about Dick Alberts. The Air Force was talking about molecular electronics.

Morton: Right.

Adcock: Westinghouse was strong on that, so we talked them into sponsoring us.

Morton: What was that? Now they are again talking about molecular electronics, but these days they are talking about something completely different.

Adcock: Yes. Back then it was just an idea. They had no idea what it was physically. It was just a nice word. Everything was molecular, so it sounded good, but it wasn't realized in practice. Small detail. We got Dick Alberts out in Dayton to finance us. Then the lucky thing for us was the North American Minuteman program. We got them interested in Minuteman. RCA was trying to sell micromodules, but the Minuteman people got interested in our project. We made special devices for them and that was a big market, and thus we had success with molecular electronics in the form of integrated circuits. As radios made transistors possible, the Minuteman made integrated circuits feasible.

Morton: Were the actual devices you manufactured and sold digital devices for computers?

Adcock: Yes. They were all digital and for computers.

Morton: What kinds of circuits were those?

Adcock: There is a list of them in the paper by Jack Kilby and Patsik **[spelling? first name?]**.

Morton: I guess there were logical circuits and those kinds of things.

Adcock: Yes. The name of the paper is,"**[inaudible word]** Integrated Circuits" by Patsik and Kilby. It's in the IEEE publication, 1964, pages 60 and 69. It tells about all the different circuits – flip-flops, memory circuits and so on. And that made the market for integrated circuits.

Morton: Today when people talk about integrated circuits they always talk about how it lowered costs. Were those things really cheap?

Adcock: Not back then, but there are curves in those papers about how the price went way down. I think they started off about $100 apiece. Now they are $2 apiece or less.

Morton: Did the military care more about cost or performance?

Adcock: They were more interested in reliability.

Morton: Do you think the military market would have disappeared in time if the price had not gone down?

Adcock: It would depend on what would compete with it. They needed the missiles. The price went down because we were competing with Fairchild who was also making them. And they got easier to make. They also got smaller so that more and more circuits were on a full chip. That's Moore's Law. It's unbelievable how many circuits are on one little chip nowadays. Now they even make them small enough to be put in the ear or eye. It's just amazing. There is no end to it.

Morton: Pretty soon we'll be full of those things.

Adcock: That's right.

Morton: Moving on with your career, did your work with integrated circuits lead into anything? What happened after that?

Adcock: It just got bigger and bigger and more of it. Then we got into photoelectronics and invented the charge-coupled device (CCD) for electronic cameras. Texas Instruments never entered the business, but got patents **[inaudible word(s)]** people.

Morton: Who was directly involved with the CCD work?

Adcock: Walt Matsen **[spelling?]**, myself and another person that worked in my group whose name I cannot remember. We started selling CCDs but never took it to the limit. It's amazing how many CCDs there are now.

Morton: Was that a technology that TI licensed from someone?

Adcock: No, we developed it. All of these things can be done with photolithography and diffusion, and it came out of that work.

Morton: What was your role at that point? In the early days you were heading up a laboratory. Did you keep the same position?

Adcock: Yes, and eventually I was made a vice president or assistant vice president, something like that. I kept doing the same things – promotions, hiring people and so on.

Morton: Did you enjoy that more than the technical work?

Adcock: I enjoyed it all. It was all fun, and we had some wonderful people. Then I got older, and TI had a rule that managers had to retire at 65. For me that was around 1986 or '87.

Morton: You went back and got an MLA at some point.

Adcock: Yes. That's kind of a funny story. TI wouldn't support me in that because they didn't think I needed another MLA. I never had a Masters degree and had always focused on science, not liberal arts.

My first wife died in 1970 from an aneurysm. She woke up one morning and was dead by noon. Gosh, what a shock that was.

Morton: That's terrible.

Adcock: Then I met another woman, Sarah Wooden **[spelling?]**. We went to the same church and her family and my family were in the scouts together, so we knew each other well. And the church sort of pushed us together. We'd go to a meeting at church and the only vacant seats would be side by side. Sarah had married young and her first husband died in 1968 in a Braniff airplane crash. She had never finished her degree and needed to get her Masters because she wanted to be a teacher. I said, "I'll go with you." We went to Southern Methodist University (SMU) every Wednesday night and together we each got an MLA. It was wonderful. We took a course on that history of Peru and then traveled together to the Galapagos Islands and different parts of Peru. We took courses like that and then took trips. It worked out beautifully. Two years of that and I got an MLA. I thought, "Why wait? Get married." We've been married thirty years now. Isn't that amazing? I was married to my first wife for twenty-six years. I married Sarah on her graduation.

Morton: That's interesting. You took all your classes at night?

Adcock: Yes. Wednesday nights.

Morton: Weren't you also a professor at some point?

Adcock: Yes. I had to retire from TI at 65, but I still felt young and thought it would be fun to go teach. My first idea was to get a professorship at SMU, but I made a mistake when I applied there. One reference I used was a professor at the University of Texas (UT). He said, "Willis, you're out of your mind. Why don't you come down here and teach at the University of Texas?" He refused to recommend me

for the job at SMU, but he got me a chair at UT and I became a professor of engineering. That was 1986.

Morton: That must have been quite a change for you after so many years at TI.

Adcock: TI let me go early because the chair was offered to me a year before I would have had to retire. Another funny story is a meeting I attended here at UT back then. We went around the room, and people said their names and what they did. I said, "I'm Willis Adcock. I'm a chemist." The Dean said, "No, no, you're an engineer." I said, "Okay. I'm an engineer." I became an engineer by learning semiconductors. I learned how to do electrical engineering, but I was really trained in chemistry, so never thought of myself as an engineer until then. I retired again in 1993. It's funny. I didn't have much choice. I just went along and did what I did each step of the way and have enjoyed it all.

Morton: Those were more or less all of my questions. Is there anything you would like to add?

Adcock: My greatest enjoyment today is my great grandchildren. A lot of my friends only have grandchildren, but I've got great grandchildren.

Morton: That's nice.

Adcock: I married my first wife in '43. My wife was an only daughter and her mother thought it would be better we waited to marry after I graduated and got a job and all that, but we looked at it differently. We didn't know what was going to happen tomorrow. We had a child the first year. When I went in the Army I sent her home to her mother, pregnant and with a dog. She had never had a dog before. My poor

little mother-in-law. Anyway, we had children early, and now I have two lovely great grandchildren. I take great pride in those.

Morton: How old are they?

Adcock: One year and three years.

Morton: That's wonderful.

Adcock: Yes, it's wonderful. It's something to look forward to experiencing. The other thing I am really enjoying is working on an invention.

Morton: Oh really? What's that?

Adcock: It's a triscopic **[correct word?]** transmission. I've enjoyed that and gotten obsessed by it.

Morton: For automobiles?

Adcock: Yes. I'm just now doing a patent search and hoping to file a patent.

Morton: Now you are moving into mechanical engineering.

Adcock: Yes. It's different. I have so many patents in other areas.

Morton: Now you are not only an engineer, but changing fields in engineering.

Adcock: Yes, in a way.

Morton: You've had several different careers.

Adcock: ***Yes. It's sort of fun – but don't mention my current invention. That's between you and I.***

Morton: Okay.

Adcock: What's your area of interest?

Morton: I'm an historian. I work for the IEEE, but I was trained in the history of technology.

Adcock: Where?

Morton: At Georgia Tech in Atlanta. I was hired here to work on various history projects for the IEEE.