WILSON GREATBATCH

An Interview Conducted by

Frederik Nebeker

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Interview: Wilson Greatbatch
Interviewer: Rik Nebeker
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Nebeker: You were born in Buffalo, New York on September 6, 1919. Would you tell me a little about your family?

Greatbatch: My father was an English immigrant who came over about 1900. In England they separate the grocery business between selling green goods and selling canned goods and so on, and he had been a green grocer there. He lived in the Midlands, a little town called Shiffnel near Wool born Hampton, Upland, England. He was involved in union organization in England. Ultimately his efforts put him in the position of being politically incorrect to the point of being unable to get a job, so he came over to this country.

My father worked in the U.S. as a carpenter. His first wife had died, and a year after he came over here he brought over his son by that marriage. My half brother died some years ago. My father was also a singer and got involved in a singing society. He met my mother, who was also a singer, there. They married sometime around the time of the First World War and my father built houses, garages and whatnot. I grew up on the south side of Buffalo and went to West Seneca High School. West Seneca is a suburb of Buffalo.

Nebeker: I understand you were interested in radio as a youngster.

Greatbatch: Yes. We had a crew of kids that traveled together. Our interests ranged from stamps to radios to girls. We went through the Boy Scouts program and then into a Senior Scouts program, the Sea Scouts. The Sea Scouts had a base in Buffalo

down at the foot of Porter Avenue, right on the Niagara River. They had three sailboats down there we used to sail.

We were also interested in radio and convinced the Scout Headquarters to give us a loft to build a radio transmitter. It didn't have much headroom, so our fathers came down and lifted the roof for us. It turned into a beautiful little place. We built a radio transmitter working on 160 m.

Nebeker: Was this in the early thirties?

Greatbatch: Yes, it was about 1936. I lived about twelve or fifteen miles from there. One evening I went down there on my bicycle and threw on the receiver and heard traffic coming over from New England. It was the big hurricane that hit there around 1936. I started taking traffic going west. A couple of fellows heard me on the air and brought blankets and food. We kept the station on and handling that traffic for 26 hours.

Nebeker: Were you relaying?

Greatbatch: Yes, I was relaying messages back and forth. We got a citation from the American Red Cross for that. We were pretty pleased with our homemade transmitter. The Sea Scout group grew and we trained younger fellows and taught them how to copy code and helped them get their amateur radio licenses. About that time the winds of war began to blow. Someone in our group lived next door to the Naval Reserve and joined up with them. We got more training that way and went on a cruise every summer.

Nebeker: Was this after high school?

Greatbatch: Yes. By that time I was working as a radio serviceman at a place downtown. That was how I got to go down to Cuba, the Caribbean and other places at the government's expense.

Nebeker: That's very nice.

Greatbatch: I went on a heavy cruiser to the 1939 World's Fair in New York and got free tickets to all of that. Then when the winds of war got stronger a couple of us volunteered for active duty. As we left the Sea Scouts, new kids came into the group. The fellows we had trained then began to train the new kids so that they learned the code got their radio licenses. Before the war was over that Sea Scouts group had put fifty radio operators in the service. Four of us became professors of electrical engineering, ten became senior technicians in places like the FAA and Police Department, and about twenty became radio servicemen. That was pretty good for a Boy Scout outfit. It had no government support whatsoever, yet it generated all that support and those kinds of professionals.

Nebeker: Has that group kept in contact with one another?

Greatbatch: We have kept in contact through the years. Our girlfriends back then didn't like our spending so much time down at the Sea Scout base. They organized a sorority they called Mu Alpha Delta. The letters for the sorority were MAD, and they said it really stood for "Men Are Dogs." The first thing they decided to do was to make curtains for our radio shack. We didn't like that idea. As it turns out, though, most of the fellows finally married most of the girls. And I did too. That was quite an experience.

Nebeker: Did you go into the Navy as a radioman?

Greatbatch: Yes. The fact that I had a ham radio license entitled me to a rating as a Third Class Radioman. That was about the equivalent of a sergeant in the Army. I was a Navy radio operator on commercial ships going up to Iceland for the first year or two, and was on a destroyer tender for a while as well as an actual destroyer.

Nebeker: What year did you join the Navy?

Greatbatch: I guess about 1938.

Nebeker: You joined before the war broke out then.

Greatbatch: Yes. I was in the Naval Reserve for a couple of years and went into active duty in 1940. Then I got transferred into something brand new and secret. It turned out to be radar. I was sent up to Canada to study in a Royal Air Force school that was located not far from Buffalo. I appreciated getting to be near my hometown. We trained up there and then set up a radio school at Annapolis near the Naval Institute there. However it was not connected with that Institute.

Nebeker: Were you a part of the training staff?

Greatbatch: Yes, I was an instructor. Then we were all transferred to a large naval base in Corpus Christi, Texas where pilots were trained. Wart Island was near there, and it became one of the Navy's chief schools for aviation radar. I taught in classrooms there for a while and was later transferred to the Navy base where I continued to teach. We had British equipment in that school. All of the first radar equipment was British. Then a bunch of PBY planes came in from Dutch Indonesia that the Dutch had managed to get out before the Japanese came. They were equipped with the racks for radar. They too were British airplanes.

We made a deal with Corpus Christi, “If you’ll fly our students, we will put radar in your planes.” Thus we had the first radar patrols down in Texas with Mexico as the backdrop and I became a flying instructor. The Germans had been sinking a lot of Mexican freighters down there, but that stopped the day we started. I suspect they heard our radar and cleared out because they didn’t want to get caught in the shallow waters.

Nebeker: They certainly had radar detectors.

Greatbatch: I think they must have, because we ran the radar all the time. We had radio silence. The planes were interesting. They didn’t have big enough generators on the airplanes to run all the radio equipment, so we’d fly all the way from Corpus Christi to New Orleans, turn around, come all the way back to the Mexican border, and then go back to New Orleans. We flew thirteen hours at a stretch. We’d take off, run the radar until we got to Corpus Christi, and then shut down the radar, turn on the radio transmitter, and check in. They were very nice airplanes that had four bunks and a cook stove. We’d turn on those electric stoves and cook steaks. That was the hottest and best flying. Then I got transferred to a dive-bombing squadron.

Nebeker: What year was that?

Greatbatch: This was after the war started. The war started while we were going up to Iceland and back. The attack on Pearl Harbor happened after I came back from my first trip to Iceland. Coming back, two of the ships in our group were torpedoed. The dive-bombing squadron into which I was transferred trained in Philadelphia and New Jersey. We were stationed at and flew out of Wildwood, New Jersey. We

went out on the Monterey, which was fast one of the first of the small carriers. They weren't a jeep carriers. They only carried about thirty-six planes. Gerald Ford, who was later President, was a Deck Officer on our ship.

Nebeker: Is that right?

Greatbatch: Yes. And our sister ship was a San Jacinto on which another future President, George H. W. Bush, was a torpedo plane pilot. We were in good company. I later got the opportunity to talk with both Ford and Bush about our war experiences. That was sort of fun.

Nebeker: Where were you sent after the dive-bombing training?

Greatbatch: I stayed with the dive-bombers and torpedo bombers for the remainder of my Navy career.

Nebeker: Where was that unit sent?

Greatbatch: We trained mostly in the northeast and went on training cruises down in the Caribbean and so on. One tour lasted six months. We had a little nine-plane squadron, and in six months of combat we used up about twenty-seven airplanes. It was tough, and we lost about a third of our crews.

Nebeker: Did you fly regularly?

Greatbatch: Yes, I was a senior enlisted man on the squadron and had charge of all the enlisted gunners. I also had to do most of the radio and radar maintenance work, and flew as a skipper's gunner on two-place airplanes. With those airplanes, one is outside all the time.

When I told my kids that we used to go 125 miles an hour my oldest boy said, "My Triumph will go faster than that." And I tried to tell him about the wooden

ships and the iron men, but he didn't buy that. He was in the Korean conflict, so I got him back. I told him, "Well by gosh, at least we won ours."

When I came back from serving as a skipper's gunner I began to train another squadron. Right about the time we were ready to go out, the bombs were dropped on Hiroshima and Nagasaki and the war ended.

Nebeker: Do you remember where you were when you heard the bomb had been dropped?

Greatbatch: Vaguely. I was in San Diego with that new squadron. I remember exactly where I was when Pearl Harbor was attacked. I had been developing pictures I had taken in Iceland. I had just come out of the YMCA in Stamford, Connecticut. It was about 7 o'clock in the evening and when I got out in the street someone told me, "Pearl Harbor's been bombed." I don't remember specifically where I was when I heard the bomb was dropped.

Nebeker: Was the cruise canceled with the end of the war?

Greatbatch: Yes.

Nebeker: Where did you go from there?

Greatbatch: The people who had the most points were the first to be let out of the Navy. I was a Reservist and probably had more points than most of the others, so I was out by September. I went home and worked for a year for the telephone company. That was interesting. Then I decided to go back to school. I quit the telephone company and applied to and got accepted into the Electrical Engineering Department at Cornell University. However when I went over to housing to arrange getting a place for my family, (I already had one child at the time), they said they had no place to put families and reneged on their decision to let me into Cornell.

I went south of town six miles, bought a small farm and I came back and said, "Now I'm a local – a county resident," and they let me into Cornell. My mother always told me there is always a way, and I followed that. Cornell was very interesting. It was so wonderful to walk around that campus and learn and participate in things. I have tried to imbue my kids with that appreciation for education, but I don't think I have been very successful in that regard. It meant a lot to me however. I have a Bachelor's in Electrical Engineering from Cornell, but the only real honor I had was that I had more kids than anyone else in the class. By the time I graduated I had three children.

Nebeker: Quite a few veterans sponsored by the GI Bill must have been at Cornell back then.

Greatbatch: I'd say all of Cornell's Engineering students at that time were on the GI Bill.

Nebeker: Were many of them married?

Greatbatch: Yes. They had separate facilities for married couples and there were whole trailer camps full of them. They rented an old hotel, which had formerly been a school building, in Watkins Run. That was about thirty or forty miles away and kids were bused in from there. I lived there for a while. I think the GI Bill is the most wonderful thing the government ever did. Every engineer I know that is my age got his education on the GI Bill. These are the same people that created the economy we have today.

Recently I had the opportunity to go to Washington and participate in a videotaping of the anniversary of the GI Bill. I believe the GI Bill was written on the top floor of the Washington Hotel located by the American Legion down

there. I believe that America's excellence in engineering and physics came as a direct result of the GI Bill. Going into our ghettos today and saying, "If you'll serve four years in the service we'll put through college for free," would be the best investment our country could ever make.

The GI Bill didn't pay enough to feed my family, so I had a number of jobs during those years. I got a First Class Radio Telephone License while in the service that allowed me to run any radio station in the country, so I got a weekend job running WCU's transmitter up on the top of the mountain. I also had a job helping build some of the early radio telescope equipment that eventually went down to Arecibo in Puerto Rico. At that time it was set up at the airport and the Electrical Engineering Department was building it. There was another wonderful thing. Cornell made it possible for undergraduate students to participate in this very high level research as a part of our education and we appreciated that.

Nebeker: I read that while you were at Cornell you started working with some instrument for animals for the Psychology Department.

Greatbatch: Yes. At that time Cornell's Psychology Department was one of the country's foremost centers of Pavlovian psychology, which is a physiological psychology. I got a job building amplifiers for a hundred sheep and goats measuring their heart rate and blood pressure and so on. I also participated in conditioned reflex experiments. My experience there turned out to be quite useful. Because I knew what conditioned reflex was and had made a lot of good contacts, a few years later I got the opportunity to build all the amplifiers for one of the first monkeys

shot up into space – though the Air Force had done it before. That was what really got me into the field of medical electronics.

Nebeker: Had you decided that electronics was your interest when you were studying Electrical Engineering at Cornell?

Greatbatch: Yes. They had only two majors: Communications and Power. I took Communications. However one could get a great breadth of education there, and I was very much interested in information theory as well. Cornell had some very good people in that field. The professors at Cornell at that time were wonderful and there were a number of people who had formerly been at Bell Labs. There was a German fellow who was one of the original people in information theory. He was the one who had learned that entropy was a good thing in communications but a bad thing in the mechanical regard because of turbulence. Right now his name escapes me.

Nebeker: What did you plan to do with your Electrical Engineering degree?

Greatbatch: I was convinced I would like to design antennas. I had a lot of experience with radar and knew what slot [sic] lines were and all that sort of thing, but after graduating I went to work for a year at the Animal Behavior Farm. Then I got a job at the Cornell Aeronautical Laboratory working on airport computers. There I worked on things like flight line computers. That work was interesting, but my interest in the biomedical work continued. Ours was the first local chapter of the Biomedical Engineering Group of the IEEE in the country. At that time it was called the Professional Group of Medical Electronics (PGME) and the IEEE was still called the Institute of Radio Engineers (IRE).

Nebeker: I read that you joined the IRE as a student member in 1949. Was there a student chapter at Cornell?

Greatbatch: I think I was the one who started the group, but I can't guarantee that. My memory is not that good, but I seem to remember that a bunch of us GIs got together and organized a chapter for the IRE.

Nebeker: Have you remained a member ever since?

Greatbatch: Yes. I'm a Life Fellow now. I still pay my dues every year.

Nebeker: I'd like to hear more about your instrumentation for these animals. Were you first building amplifiers for the EKG?

Greatbatch: Yes. The heart generates a signal which is about a millivolt of heights [sic], so this has to be amplified by a factor of something like a thousand before it can get up to the point where it will record. At that time we didn't have transistors yet, so all our work was done with vacuum tubes – which is not the right way to do this sort of thing.

While I was building that instrumentation a couple of surgeons came down from Boston to do experimental brain surgery on some of our goats and I worked with them on that. They brought brown-bagged their lunches like I did, and we'd sit out in the Ithaca sun and talk shop. I learned about this disease where a nerve in the heart that runs from the auricle to the ventricle quits functioning. The auricle continues beating nicely, but the ventricle doesn't follow. Occasionally the ventricle will beat at its own much slower rate. The blocking of that nerve is called complete heart block. Sometimes the ventricle stops completely. When that happens, it's called Stokes-Adams syndrome, which is really a fainting attack. If

the heart stops completely in a people having this trouble, they go on for 15 seconds not realizing that anything is about to happen. They fall flat on their faces. Obviously this fainting attack is a pretty serious thing. About 50 percent of the people that have complete heart block with Stokes-Adams syndrome die in the first year.

Complete heart block is a communications problem. The signal is not getting from the top to the bottom. As communications engineers we should be able to do something about that, and it turns out we can. If I sew a pair of wires anywhere in a heart and bring them outside of the body and then touch them to a flashlight battery for a thousandth of a second, that heart will beat once. If I follow that guy around the rest of his life touching that wire to that battery, he will return to a normal life expectancy for someone his age and he can go back to work.

Nebeker: What was the objective of the surgeons who were interested in that?

Greatbatch: It was pretty hard to find an interested surgeon. It was a disease that was recognized as incurable and cases were underreported. Few surgeons or cardiologists were interested. We didn't do any of our work until a couple of years later. When I heard about this disease I knew we could fix it, but I also knew that it could not be done with vacuum tubes and storage batteries. That would look sort of funny, trying to sew an automobile battery inside of somebody. There were external pacemakers at that time. Dr. Paul Zoll in Boston was building big TV-sized boxes that were plugged into the wall with the end of the wires running over to the patient. That patient's world was the length of that extension cord.

A friend of mine in Minneapolis, Earl Bakken, was building pacemakers that could be worn on a belt. They had wires going right through the skin. That was only marginally satisfactory though some people lived a long time with those. We engineers have not to this day learned how to run a wire through the skin and have it seal. It's always an open wound. Therefore the people have to put antibiotic jelly around it every morning and every night. They can't bathe, go swimming or take showers. They can take a sponge bath, but that box is always there. They roll it over at night and they can never forget that it's there.

Nebeker: The sequence of events then was that you first encountered these surgeons because they were doing brain research on goats. And when they talked about this disease called complete heart block you thought, "Here is something electrical technology can fix."

Greatbatch: Yes, that's right. Some of the grad students in psychology were pretty well trained medically. I was amazed to learn that this disease existed, and they assured me, "Yes, it's true. They're right." Then I put it all in the back of my mind. Five years later when transistors had been invented and had become readily available I thought, "Now I can make a pacemaker."

Nebeker: Can you recall dates?

Greatbatch: It was somewhere between 1949-51 when I learned about the disease. We built our first pacemaker with transistors for implantation into an animal in 1958. Much to my wife's consternation, when I realized I could actually make pacemakers I quit all my jobs. I had two thousand dollars in cash, which was enough to keep

my family going for two years. I gave the family money to my wife and went up in the barn behind my house. In two years I made fifty pacemakers.

Nebeker: You made them by yourself?

Greatbatch: Yes.

Nebeker: Did you make any attempts to interest a medical equipment manufacturer? I would think a young engineer might go that route with a good idea like that.

Greatbatch: I considered that and I did talk to some people, but no one was really interested in it. Of course we hadn't implanted our first patients yet. Once we had our first patients with the device successfully implanted, there was a great deal of interest. We worked fairly closely with the Medtronic Company at that time. We were familiar with them and I knew about the wearable pacemaker they manufactured. They helped us with some of the materials we used and helped us learn how to use silicone. We used their electrode systems in our first pacemaker. When we had ten successful patients, it was time to talk to a commercial company. We licensed the pacemaker to Medtronic.

Nebeker: Was it more than you?

Greatbatch: There was a team of two doctors with which I worked. Dr. William (Bill) Chardack was active in the engineering design of the electrodes. The electrodes were all his patents. Dr. Andrew Gage, with whom I had gone to grammar school West Seneca, was also part of the team. There is a picture of us with a patient where all three of us were wearing bowties. We were called "The Bowtie Team."

Nebeker: How did the connections with Drs. Chardack and Gage come about?

Greatbatch: Our local chapter of the PGME in Buffalo had a meeting every month. We tried very hard to get an equal number of doctors and engineers to attend the meetings, and sometimes we had as many as fifty people at a meeting. The engineers offered that we would send a team of engineers to help any doctor that had a research problem – for free. Quite a few doctors took advantage of that offer. In fact, about five different medical doctor-engineer teams that resulted from that stayed together for quite some time. I went up with one of those groups to see Dr. Chardack at the Veterans Hospital regarding a problem he had. It turned out that we couldn't help him much.

While I was there I told him about this pacemaker idea and he seemed interested. This was after two years of talking to other doctors around Buffalo who showed no interest whatsoever. They would all say, "Well, these people die in two years. There is nothing you can do about it. Why don't you work on my project?" Later I saw Dr. Chadrack in the dog lab and we talked about it again. I remember he walked up and down the lab a couple times and looked at me and said, "If you can do that, you could save ten thousand lives a year."

Three weeks from that day we did our first run on an animal. It worked about four hours. We were so naïve that we thought we could seal it by wrapping it in electrical tape and putting it in the body. That didn't work, so we spent the next couple of years working on that. Then we found a method of casting a solid epoxy block and worked on the electrodes, and we finally used the Medtronic electrode.

Nebeker: How did your connection with Medtronic come about?

Greatbatch: We knew about their external unit. They had stopped in to see us when they were trying to sell us some of their other equipment, so we knew some of their people. They had helped us with the use of the silicone and rubber we thought we needed at the time. They also helped us with the electro-structures they were using on their wearable pacemaker. It turned out those electrodes were inadequate, but we didn't know that. They got us started working on those as well as the mercury batteries. However the mercury batteries turned out to be inadequate too.

Nebeker: Was that something you got from Medtronic?

Greatbatch: No, we got that right from Mallory. The mercury battery was designed by Sam Ruben during World War II, and the Ruben-Mallory battery had become commercialized. They decided they could make a better battery by going from a potassium hydroxide electrolyte to a sodium hydroxide electrolyte. And there were some other changes they were going to make that were needed for a long-life battery for electronic wristwatches.

We developed a very close relationship with Mallory and had their batteries in our pacemakers even before they got them in wristwatches. That turned out to be a limiting factor, but those first batteries were in our first unit. One was in our first patient for eighteen months, so that was the first successful pacemaker. That was in 1960.

Nebeker: Where was Mallory based?

Greatbatch: They were in Tarrytown, just north of New York City.

Nebeker: Did you contact them because you needed their type of batteries or because you needed small batteries?

Nebeker: Yes. We first contacted their local representative, and he put us in contact with the people down at the plant. Then we made trips down there almost every month. They had a lot of problems with those batteries. They worked very hard, but it turned out that the whole zinc-mercury system was simply not adapted to working in a warm saltwater environment. A lot of people today don't realize that a mercury battery runs at about 300 psi of hydrogen pressure. They claim it's a balanced reaction, but it really isn't. A pacemaker that has got a mercury battery in it cannot be hermetically sealed because that gas has got be able to get out. We cast ours in a solid epoxy box. That was all right because the gas could permeate through the epoxy and get out. This was true with the sodium hydroxide too. However the problem was that all epoxy materials, all plastic materials, are permeable to gases. Unfortunately water vapor is a gas. Hydrogen came out, but water vapor got into it.

We finally learned that we had to operate all our electronics under distilled water. Salt ions don't go through plastic, but water vapor does. That's not the best way to run a pacemaker, but we ran pacemakers under that environment for years. We recognized the battery as the limiting factor, but under Mallory's insistence we published that those batteries should be expected to run six years. Few of them ever ran more than two years however. The patients lasted an average of six years, and that meant that getting three pacemakers in one lifetime was common. We saw that if we could design a battery that would last ten years then 80 percent of the patients would only need one pacemaker in a lifetime. And that is what we eventually did.

Nebeker: It sounds like you became very interested in battery design.

Greatbatch: Yes. Once we realized that the battery was the limiting factor, we started looking at all sorts of power supplies. We even looked at rechargeable batteries. However we found out that the life of a rechargeable battery with recharging was not as long as the life of our primary cells without recharging. That knocked out that idea.

Nebeker: Would this have been a kind of recharging that could be done through the chest?

Greatbatch: Yes, through the skin. That would have been no problem. The quality of the rechargeable batteries or NiCads was just not good enough, so they didn't make it. Then we looked at nuclear batteries using plutonium-238 [sic; plutonium-239?]. Over a long period of time this would decay into helium. And of course plutonium is one of the most toxic materials in the world. One microgram in the blood system would be fatal. Therefore the plutonium could be kept only in a hermetically sealed container. Additionally, the helium generated by the plutonium would have to be retained, and that would ultimately reach up to 300 atmospheres. Worse yet, the plutonium was a controlled material under the Atomic Energy Commission. This meant that theoretically the doctor would have to know the location of every patient at all times. We sold plutonium batteries for a while and found that they were the most reliable, efficacious batteries ever made for pacemakers. Those requirements were a deterrent, but if we hadn't come up with a lithium battery everything would have gone nuclear.

Nebeker: Is that right?

Greatbatch: We came up with the lithium battery in 1970. The lithium battery had a much longer life. And it didn't generate gas, so it could be hermetically sealed. The fact that it didn't have gas was a big deciding factor. The fact that it could be hermetically sealed was an even bigger factor, because that meant we were no longer running under water. One of the first pacemakers that ran on a lithium battery was implanted in a patient in Australia. That patient went out into the outback and got sort of lost from civilization. Last year they finally caught up with him and discovered that his pacemaker had been running for twenty-two years.

Nebeker: Is that right?

Greatbatch: Yes. They replaced it. However a doctor friend of mine in Australia has that same battery in his pacemaker and it's still running. I'd say that was a lousy design job. We designed that battery for six to ten years, but it lasted twenty-two.

Nebeker: Was the implantable pacemaker designed in 1958?

Greatbatch: The first time a pacemaker was implanted into an animal was in '58.

Nebeker: Was the first implantation into a human in 1960?

Greatbatch: Yes. That was the first successful implantation into a human.

Nebeker: What year did you quit your jobs and begin building those fifty pacemakers?

Greatbatch: That was 1958 to 1960.

Nebeker: Were you still on your own when you got to the point of making this first successful trial?

Greatbatch: I was working with the doctors.

Nebeker: You didn't yet have Medtronic or anyone else?

Greatbatch: No. There was no outside financial input. In fact when we signed an agreement with Medtronic in 1960 we essentially gave them patients. Then we built four working pacemakers and sent those out. It was a good deal for them because they had no research and development expense. Their only expense was in designing it and putting it together. Our agreement was set up in such a way that they didn't pay us until after they got paid. They were not very well off at that point and were still operating out of a garage.

Nebeker: Was that an exclusive license to Medtronic?

Greatbatch: Yes. However with our battery factories we have don't sign exclusive contracts anymore and are very careful to treat all alike. That contract with Medtronic was exclusive, however, and lasted for ten years.

Nebeker: Was that because they were the only ones in the business of building pacemakers at the time?

Greatbatch: They became the leaders in the business, but I think that is primarily because we put them there.

Nebeker: They were already building wearable pacemakers.

Greatbatch: Yes. The reason we went with them in the first place was because they had experience manufacturing the wearable pacemaker.

Nebeker: Did you know Earl Bakken personally?

Greatbatch: I did not get to know Bakken personally until after we signed the agreement. We visited out there in 1960, and I guess the agreement was signed a little before that. I knew the two people that flew into Buffalo. We had worked with several of their people and were quite familiar with the company. They built a new plant to do

this, and we were there the day they opened the plant. It was so new that they had to lay planks across the mud so we could walk into the front door.

Nebeker: They clearly expected this to be an important product.

Greatbatch: Yes.

Nebeker: How was it made known to the medical and other communities?

Greatbatch: It was primarily made known through papers given at meetings and published papers. I think Dr. Chardack was the best salesman. He published the first paper in *Surgery* in 1960, and that really opened up the thing. Once the world found out this disease could be treated cases came in from out of the woodwork. Last year 600,000 new units were implanted in people all around the world.

Nebeker: In one year?

Greatbatch: Yes.

Nebeker: Did the paper published in *Surgery* and other publications create an immediate demand?

Greatbatch: Yes. Of course we also went to all of the shows. Medtronic had a booth at every show. I published in the IEEE journal, and I published any new battery developments. Bill Chardack and I published jointly in the medical journals. I used to accompany a Medtronic salesman and visited a lot of hospitals, and I gave talks at the research seminars. We gave a very strong educational push in those first five years. It is interesting to me that it took only five years for the pacemaker to become universally accepted as the way to treat complete heart block. That was almost unheard of in the industry.

Nebeker: From the first announcement that a successful trial of this pacemaker had been made in 1960 to 1965 was all the time it took to become universally accepted as the way to treat complete heart block?

Greatbatch: Yes.

Nebeker: Were there opponents to this treatment or those who were skeptical?

Greatbatch: There were some doctors that wouldn't go along with it. Traditionally the disease had been treated with drugs as much as possible. Our first big necessity was to train cardiologists in what could be done. Interestingly enough, our next big challenge was to train general practitioners to refer these patients to cardiologists. This was done primarily through papers given at conferences, published papers, and so on.

Nebeker: What about the engineering side of things? Did you continue to work with Medtronic as they got a model for production?

Greatbatch: For the first ten years, from 1960 to 1970, I had complete design control over all of the implantable units they made. I went up and down their production lines every month with a magnifying glass. I'd wait until the employees went on a coffee break and then go see what they had been doing. We did all the design work and every pacemaker design had to have my signature on the drawing. I had to approve of all their sources and they couldn't make any change without my authorization. It worked quite well. After doing that for ten years, however, it got to be a bit of a nuisance. They had developed some pretty good engineers who sometimes wanted to do things in a way that I opposed. It's not that I was right and they were wrong, but I was the one with the responsibility.

Batteries were the real problem in 1970. I finally went to Earl Bakken and said, "You've got to make your own batteries. Mallory will never do it for you. You are never going to get a better pacemaker until you make it a better battery." He said, "No, I'm not going to do that. I'm not going to jeopardize my only source." I said, "Well then, I've got to leave," and I canceled the contract I had with them. I sold them all the patents, and all under very friendly circumstances. They became free to do their own engineering and we're still good friends.

Nebeker: The initial agreement, then, was not for any particular period of time?

Greatbatch: No, it was not.

Nebeker: It was open-ended?

Greatbatch: Yes.

Nebeker: You decided to terminate the agreement.

Greatbatch: It was a mutual decision. They were sort of tired of me too.

Nebeker: Did you want to go into the battery business?

Greatbatch: I didn't really want to go into the battery business, but I knew we had to have a better battery. I had hoped we could talk Mallory or another battery company into doing what was needed, but the market was not big enough to interest them in that. Then when there came to be a series of liability cases, General Electric left the picture. As long as GE got good publicity in their annual reports for their pacemaker work they were all for it, but when they started getting some bad publicity they stopped making pacemakers altogether.

Nebeker: How were they in the business? Did they have their own designs for pacemakers?

Greatbatch: Yes. They were working with Adrian Kantorwitz and had people up in Syracuse designing pacemakers. They did some of the very early work. I think the biggest companies in pacemaker manufacturing from 1960 to 1962 were General Electric, Medtronic and Electrodyne. Electrodyne was Dr. Zoll's group in Boston.

Nebeker: Did Electrodyne also make implantable pacemakers?

Greatbatch: Yes.

Nebeker: I'm very interested how in the early days of pacemakers this business got started.

Greatbatch: We were paid on a percentage of Medtronic's gross. They were in very poor financial shape the first couple of years. I didn't know enough to read and interpret their annual statement, but after I signed the agreement with them I took it to a friend of mine who did. He said, "Did you know they are bankrupt?" I said, "No, I didn't know that." He said, "Their liability exceeds their assets. They are technically bankrupt." I said, "What do I do now? I've already signed an agreement with these people." Sure enough, the first year they couldn't pay their license fees and asked me if I would take stock in the company. I thought about it and put it to the Lord in prayer and decided I would do it. I knew that at least they would do what I said.

I took the stock, joined their Board of Directors, and got to be a gadfly in the company. The first thing I did was make them sell their airplane. Then I made them re-price a lot of their products, making sure that they either sold at a profit or dropped the product. And of course we pushed the pacemaker really hard. I even tried to guide them out of the monitoring business. That wasn't a good business for them. We turned the company around until it turned quite a profit and

became number one in the business, so it worked out very well. That took about two years, and they are still number one today.

Nebeker: In retrospect, do you think that was the right kind of arrangement?

Greatbatch: I have to say yes, though I have taken a lot of criticism for it. I can't feel that it was a mistake. People point at what is called Medical Alley in Minneapolis and say, "There are between twenty-five and fifty companies that have spun off from Medtronic. You could have done that here in Buffalo." Maybe that's true. I don't know. On the other hand, I wasn't ready for this. I didn't know enough about business to run a company like that, and I still don't. I'm not that good of a businessman.

Nebeker: I suppose there might have been another company with the skills required.

Greatbatch: I don't think so. We looked at one other company out of Long Island. They wanted a pretty big piece of the piece. The president of the company was interested because he had a heart problem. At the very last minute I decided against it, and it really upset him. He died the next year, though. I don't think there was any other company with which we could have worked. And certainly none of the big companies would have been as flexible as Medtronic.

Nebeker: You had a lot of influence in developing the device with Medtronic.

Greatbatch: Yes, I did. Earl Bakken had to put up with a lot of guff and says to this day that Bill Chardack and I were the toughest people with which he's ever had to work. However we say the same thing about him. All I can say is, they survived those first ten years at the top of the heap and stayed there.

Nebeker: What influence did the Medtronic pacemaker have in other countries?

Greatbatch: Medtronic was always active through Picker. Picker was their international representative and through Picker they were selling external defibrillators and quite a bit of electronic equipment overseas. We exhibited at foreign meetings and worked with Picker on selling pacemakers. I speak French and German, so I did a lot of that myself. After the meetings we would make the rounds in Europe, stopping in at the hospitals with representatives. At that time Medtronic worked almost entirely through manufacturers' representatives. I thought that was a good way to go at the time. I think we were very influential in pushing up foreign sales. Medtronic has always had a heavy foreign market. Now they have factories all over the world. No company overseas can really compete with them.

Nebeker: In 1970 you decided that better batteries needed to be designed. Where did things go from there?

Greatbatch: I got a telephone call from someone down in Baltimore who talked about a new battery he had. He said that they had been building batteries for the military using lithium and molten salt. This was a battery on which a firecracker would be set off which would melt the salt, creating a very, very powerful battery for about a minute. They were used in proximity fuses. He had asked himself, "Where can we use this?" He went to the NIH, and of all the people he talked to Bob Bowman, who was a friend of mine. Bob suggested that he call me, and he did. I listened to him for about 15 minutes. Then I went and got a ticket and took an airplane down to talk to him.

Nebeker: What was the man's name?

Greatbatch: This was the Catalyst Research Corporation. We set up an agreement with them. It was a very restrictive agreement with which we weren't too happy. The agreement was that they would build the batteries and we would sell them. Unfortunately, they weren't packed in hermetic seals and they had to be in hermetic seals. They said, "We'll build the battery if you seal them and sell them." In shipping them to us unsealed moisture got into them, so that didn't work well at all. They finally set up a prototype facility so that we could work out how to make and seal the battery. That factory was near a stream, and just about that time the factory flooded. When the water hit the lithium and sodium the whole factory blew sky high. They say it was like 10,000 Fourth of Julys. That put that factory clear out of business.

There was nothing we could do except go into production ourselves, so we expanded our own facilities. By the time they rebuilt their factory, this time on a hill, we were in business and getting too big to stop. Finally they agreed to let us make and sell the battery provided we would let them make and sell it too, which they did. However, Catalyst Research was owned by a very big company called Mine Safety Appliance. They decided they didn't want to be in this very small battery business, so they dropped out. That left us as the sole supplier.

Nebeker: When you say "we," to whom are you referring?

Greatbatch: Wilson Greatbatch Ltd. (WGL), our company. We were up to fifty or sixty people at that time. It was entirely owned by employees and family.

Nebeker: Was Wilson Greatbatch Ltd. established in 1970?

Greatbatch: Yes. It has expanded ever since with new models and more people until today we either make or license over 90 percent of all the batteries in the world that go into pacemakers and implantable defibrillators.

Nebeker: Was that always your market? Were you always exclusively aimed at these implantable devices?

Greatbatch: We have diversified somewhat, but it took just about all of our abilities to satisfy this one market. We also make batteries for use in outer space. Anytime that the astronauts go outside of their berg they carry with them a television camera, a life support system and communication equipment – all of which run off of our batteries. We make a battery that will run at 150°C. They are also taken down to the bottom of oil well holes to log up the results. We have specialty markets like that, but our biggest business is in implantable medical batteries, implantable power. Now we are into implantable power for artificial hearts. That's the next big market.

Nebeker: There were also implantable defibrillators.

Greatbatch: This was all our own design and development. That was a real challenge, because we were going from a battery that delivered 30 microamperes to a battery that would get up to 5 or 6 amperes. It required a whole new chemistry, a whole new manufacturing method, and a whole bunch of PETs.

Nebeker: When did that device prove itself?

Greatbatch: It started going into significant medical usage about five or six years ago.

Nebeker: Did that battery have to be of a different design?

Greatbatch: Yes. The battery was a limiting factor and there was nothing that would satisfy it. There were also some problems with the capacitors. Defibrillators have to charge capacitors up to a pretty high level and then fire into the heart. They can't be charged until the time at which they are needed. There is a window of only 15 seconds to charge and fire. The capacitors that were available had a memory. The Lumina electrolytic [correct two words?] was the one that was most used. The problem was that the first time they were charged up from a dead start they didn't recognize the capacitor and wouldn't take the charge. That's not a very good situation for a defibrillator. We had to put a clock on it and set it to build up a charge once a month and fire it into a dummy load. That's hard on the battery, but that's the way just about all the defibrillators run today, with a couple of exceptions.

We have just introduced a new 10-on [sic] capacitor that is lighter and smaller than the aluminum [inaudible word], and it doesn't have that memory problem. We're just starting to show that at the shows now, so that's something for the next decade.

Nebeker: Were you personally involved in the design of the defibrillators?

Greatbatch: No, we have never done any electronics work on defibrillators. It's always been our customers who have done that.

Nebeker: Has Wilson Greatbatch Ltd. always been a battery company?

Greatbatch: Yes.

Nebeker: Has that occupied your time from 1970 until recently?

Greatbatch: It until about ten years ago. Between 1985 and 1990 I sort of dropped out of things. I have turned that over to other people.

Nebeker: That was something of a change that you were first in electronics circuit design and then into battery design.

Greatbatch: It has always been involved with chemistry. Take the example of the chemistry of electrodes in a heart. Electricity flows through layers of tissues and fluids by means of ions. To get an ion from an electron there must be a chemical reaction. That chemical reaction takes place within a millionth of an inch of the surface of the metal that is put on the heart. It's a different reaction at the end node than it is at that cathode, the two electrodes, and the reaction that takes place is entirely functional and [inaudible word] use. The same pacemaker drives the same heart through one of four different electrode metals – titanium, stainless steel, platinum and silver. These are the reactions that cause that ion to form. Those four metals go through four different stages of electrochemistry. On the stainless steel electrode, on the positive electrode, the reaction is a corrosion reaction that is not good on heart electrodes.

Nebeker: That means that it's corroding the electrode.

Greatbatch: Yes. We learned this from bitter experience.

Nebeker: Did the need to deal with these electrodes direct your attention to these chemistry problems?

Greatbatch: Yes. I guess you could say that my whole career has been involved with the chemistry of electrodes and batteries, plus some biomass energy work. I am also now interested in nuclear energy. I believe that all of the sciences are coalescing

somewhat. Most of the work of people like myself is very interdisciplinary. One is working in nuclear physics one day and molecular biology the next.

I spent twenty years working on a cure for AIDS in molecular biology. I tell the kids at school, “Things don’t always work. Nine times out of ten the things I try don’t work. The tenth one will pay for the other nine.” I tell them that failure is a learning experience and that there is nothing wrong with failing. I tell them not to worry about failing, because the guy who has never failed is the guy that has never done anything.

Nebeker: You felt that the battery was the limiting factor with implantable pacemakers and needed to be improved. What were the tangible results of having the lithium battery available in the early seventies?

Greatbatch: The tangible result is that probably 80 percent of all patients with implanted pacemakers get one pacemaker for their lifetime instead of three.

Nebeker: I read that the lithium/iodine battery was first offered for sale in 1973. Did the lithium/iodine battery have a six-year lifespan from the very beginning?

Greatbatch: Yes, six to eight years.

Nebeker: That was a remarkable improvement over what was previously available.

Greatbatch: A lot of people say that was a greater development than the pacemaker itself, and some say the fact that it enabled the pacemaker to be hermetically sealed was a greater development than either one of them. Certainly every battery in every pacemaker today is lithium/iodine. It was a major development.

Nebeker: Did that come about because of the particular need in this application and because you heard of a new type of battery you thought might be adapted to this?

Greatbatch: I have to give Catalyst Research credit for the concept. They invented it and they patented it. We picked up their work and carried it on.

Nebeker: Tell me a little bit about your company from the seventies into the eighties.

Greatbatch: It was pretty much a steady upward climb. Our sales increased every year.

Nebeker: Did you start with about fifty people?

Greatbatch: We started with three people, really. Then when we bought the battery operation of the Wurlitzer Company up in Buffalo – the company that used to make organs – we took some of their very good people who had already been in the battery business for a long time. And we got their dry room. The dry room was a mixed blessing because when it first rained we found out had to put buckets in it to catch water where the roof leaked. They really put us in business. Within a couple of years we were up to twenty people, and we've kept moving up from there. Now we're up to about 800 people.

Nebeker: Do you license production of these batteries?

Greatbatch: Yes. We freely license our patents to any company that wants to make their own battery. Medtronic for example makes a lot of their own batteries, but they pay us a license fee on every battery they make.

Nebeker: What was the patent situation? You said that Catalyst Research had the original patent on the battery.

Greatbatch: Yes. They had the original patents on the battery and we licensed from them to use those patents. Subsequently we got so many improvement patents ourselves that they came back and licensed from us. Of course most of the older patents have run out by now.

Nebeker: You said they got out of the pacemaker battery business.

Greatbatch: Yes.

Nebeker: Were these patents useful for their other applications?

Greatbatch: They never did much patenting after their first couple. They closed down their entire Baltimore operation and moved it back to Pittsburgh where Mine Safety Appliance is headquartered. They took their people back there and went into other branches of electrochemistry. Gas sensors and the like were more along their line of work. I suspect they found that it wasn't as profitable as other things they could do.

Nebeker: What was the rationale for freely licensing rather than selling your own patents?

Greatbatch: Building confidence in the field was our main objective. We didn't want to have an image like that of Microsoft. We wanted our customers to be good friends. We are very careful in quality control and look for and find the one bad battery in 10,000 before it gets out of the factory. People like that, and the FDA is agreeable to it too. We are very careful. If there is a problem, our customer finds out from us rather than from their customer. We've built a good relationship with our customers, and part of that goodwill is from freely licensing. We have had more than one customer who said, "We want to make our own batteries. We don't want to be totally dependent on you." We say, "Fine, but make half your own and buy the other half from us." Usually what happens is that once they start making the batteries they find out that it's not as easy as they thought and that it's costing them more to make them than it would to buy them from us.

License income is nice. There is no overhead to it and it's nearly 100 percent profit, though we do have to maintain our license and keep working on it. In the early days I always wrote all of our contracts to say, "We are licensing you this and subsequent patents." That makes the contracts nearly immortal, because by the time the patent has run out we've got a bunch more for them to register and they register those.

Nebeker: You said there were many improvement patents on that.

Greatbatch: Yes. We're very heavy on patents. I personally have over 200 patents, and the company has many more than that.

Nebeker: Did you establish some kind of R&D unit?

Greatbatch: Yes. The company spends about 10 percent of its gross on R&D for new batteries.

Nebeker: When did that begin?

Greatbatch: From day one.

Nebeker: Is that right?

Greatbatch: Yes. In fact I'd say that in the beginning we were spending about 90 percent of our gross on R&D.

Nebeker: Were you giving most of your own time to that or to running the business?

Greatbatch: It's pretty hard to separate. I was spending time in the lab and also going to the shows. I did booth duty then and still do. I visited customers and made a lot of overseas trips. Most of our foreign salesmen are trilingual, and we try to send our department heads to do booth duty in foreign countries. This has worked out very well.

Nebeker: Did you oversee the daily operations of the business?

Greatbatch: Early on I did, yes. I did all the accounting and had an accounting system where at the end of the month I would write down all the expenses and pay all the bills. I had a practice of paying all bills that came in by the 1st of the month by the 10th and we carried no accounts payables. Our creditors liked that. Many times we took in less than we spent and then we'd try doing something differently the next month. When my kids got interested in the business they said, "That's old fashioned. You should use more deficit financing." I said, "Well, maybe it's old fashioned, but that's the way we do things." That's gone by the board now. We're a big company now and things are done differently. Today we've got a bunch of high-flown accounting systems but we don't know until a month later what we did.

Nebeker: Did you prefer the design development to the business work?

Greatbatch: I like both sides of it. Both are challenges. And I like the sales work too. I like contacting people. I also like the bench work. I rarely use technicians to build things. I still build my own things with my own hands. I have trouble now because I have one eye that is pretty bad. To have depth perception two eyes are needed. I catch myself with the soldering iron down here and the wire up here and the solder somewhere else trying to get all three together to make them join. It just takes me longer.

Seymour Furman [sic], a very early pacemaker doctor from New York City, is putting together an exhibit for the North Atlantic Society for Pacing Electro-stimulation (NASPE) this May in New York and Washington. He asked me if I would put together one of my circuits. If I need to make a new circuit I'll draw the

circuit diagram on a file folder. Then I [inaudible word] parts next to the component. Then I wire them up. The whole thing is a working pacemaker. Hook a battery on the left side and a heart on the right side and it'll drive a heart. It can be heard on a transistor radio or seen on the meter. Sigh asked me to build a pacemaker like the first one made in 1961 [sic; 1960?] for exhibit, so I built it. I ran into a problem, though. After I got the thing built I couldn't make it work. Turned out one of the main troubles was that the old transistors were doing well if they hit a beta of 20. Today the minimum beta of that same transistor is 200. When I put those high-powered transistors on my old circuit and oscillated all over the place and I couldn't quiet it down. I think I had to do more work adapting my old circuit to these new transistors than I did designing the thing in the first place.

Nebeker: Has the company grown fairly steadily from 1970 until now?

Greatbatch: Yes, almost linearly. It's still growing today.

Nebeker: Is that a reflection of a growing need for these batteries?

Greatbatch: Yes. This is true even in the pacemaker market, which is old and fairly steady. The East Coast has the greatest density anywhere in the world with roughly one per 1,000 of the population getting pacemakers. It's not as heavy in the Midwest or the West, and it's much lighter than that in England. Sweden and Italy are pretty heavy. When you look around the world and realize the number of people that could use a pacemaker but aren't getting one, the market is still barely touched.

Nebeker: I see.

Greatbatch: I think I'll see further growth for my lifetime. The market for artificial hearts is going to expand and blow sky high. It's all a matter of availability of equipment. The reason artificial hearts aren't used more today is because we still haven't figured out how to keep blood from clotting on the materials out of which the hearts are made. Some people are spending all of their time getting the power in there, but that's not a problem. That's pretty simple. We know how to do that. However the concept of the relationship of blood in contact with a foreign body is something on which we are still working.

Nebeker: You say there were improvement patents all along the line. Were any big improvements made in the battery design?

Greatbatch: The lithium battery was a big improvement. The original lithium batteries were made with only one side to them. By doubling the sides – putting lithium in the center and on each side – the area was doubled. This cut the current density in half, which in turn cut impedance down by a factor of four.

Nebeker: What that sandwich structure a major design change?

Greatbatch: Yes, more or less. Then we started building the lithiasis or ripple to get more area. That was another design change.

Nebeker: Have these batteries gotten smaller and more reliable?

Greatbatch: Yes. The first battery was about the size of half a pack of cigarettes. Today the entire pacemaker unit is not much larger than a wristwatch. The battery accounts for half of its size, and it lasts longer.

Nebeker: What were the major design goals?

Greatbatch: My first goal was reliability. I wanted to see a ten-year pacemaker. The minute we got there, the doctors wanted smaller size and started cutting down on the size of the battery. I think that's really gone too far now.

Nebeker: Then getting things smaller was the next big push.

Greatbatch: Yes.

Nebeker: Was there ever a problem with having the right current? Was there any problem with the changeover time and the voltage?

Greatbatch: There was a problem with mercury, but not with the lithium battery. In fact, ever since we went into lithium the battery has not been a limiting factor in the pacemakers in any way. It's always something else. Whether that is going to be true with the artificial heart I don't know. We'll have to wait and see.

Nebeker: Did the company face any crises or challenges?

Greatbatch: A few doctors have been caught filing false claims with Medicaid. When there is an investigation the pacemaker companies get worried and the doctors stop putting in as many pacemakers. The pacemaker companies say, "We already have a year's supply of batteries, so we won't buy anymore batteries right now," and all of a sudden our shipments stop dead. We run into things like that, but we know that with the number of people that have heart block every year that the demand will return. We have to face the tide during those times, and we have always done that.

Nebeker: Have the foreign sales been there all along?

Greatbatch: The same thing happens over here. It is a cyclic business, but we can't complain. Medtronic's stock has doubled every other year for forty years now.

Nebeker: Is that right?

Greatbatch: We're still a private company. We're not public.

Nebeker: And in the mid-eighties you started to give your attention to some other things?

Greatbatch: I got strongly interested in biomass energy for a while and got very interested in molecular biology and spent twenty years in AIDS research. When the company got big enough that the problems were in administration rather in the technical I drifted away. I did not get involved with any of the later designs on the lithium batteries. We wound up with a whole team of Ph.D. chemists that knew a lot more about it than I did.

In 1982 I wrote the book *25 Years of Pacing.* That is going to be republished this year. Most of its twelve chapters are still pretty current. The chapter on the electrochemistry of electrodes in the heart has not changed. Some of the batteries that are talked about in there are just now working their way into the market, so we're not seeing the radical changes in technology we saw in the early days. Each new thing now is harder to come by and costs more.

Nebeker: Do you feel that the medical establishment or the business of medicine in this country has slowed things?

Greatbatch: No. My opinion of medical doctors in general is quite high. Practically all of the doctors I have met are very dedicated people and far more interested in their patients than their own financial welfare. I am a Fellow of the American College of Cardiology along with just two or three other engineers. I think very highly of these people. People like Sigh Furman and Victor Parsonet at Beth Israel Hospital

in New Jersey are really wonderful people and good friends. I have a great deal of respect for them.

Nebeker: Do you think the medical community has been willing to accept technological advances when they have been made available?

Greatbatch: Oh yes.

Nebeker: One can imagine conservatism toward new techniques on the part of the medical establishment.

Greatbatch: There are always some ultraconservative medical people that are not anxious to see new things, but that hasn't been a problem. I think I've developed my own way of fighting that. When I want to work with a doctor I tell him, "If we're going to work together, we are going to work as equals in this." Then he will say, "Yes, that's the way it's got to be." Then I say, "And when we publish we are going to publish as equals." This is where I lose a fair number of them. Publishing is pretty important to doctors. However a few of them will say, "Sure, I want you to publish with me." Then I get to the end and say, "If we publish in medical journals then you publish as senior author and if we publish in engineering journals then I will publish as senior author." That cuts them way back. Dr. Chardack said, "I don't want it any other way. I don't want to put my name on an engineering paper." We've published engineering papers in purely medical journals where Dr. Chardack practically wrote the whole paper. I'd say, "Gee, this is largely yours. You'd better put your name on it," and he'd say, "No, it's your paper. It's an engineering paper. You'd better be sure what is in there is what you want, because your name is on it."

Nebeker: How many papers did you co-publish with William Chardack?

Greatbatch: Dozens.

Nebeker: How long did your collaboration with him last?

Greatbatch: We had a really solid collaboration for over ten years.

Nebeker: Did that start in 1958?

Greatbatch: Yes. We published together up until about the seventies. He retired and hasn't published anything in quite a while.

Nebeker: It sounds like he was probably an exceptional physician.

Greatbatch: He was an exceptional physician and an exceptional person. I've seen him sit up all night with a patient on the rocky edge and titrating a drug in, and then realizing it wasn't helping and titrating a new drug in them. There are a lot of people walking around that owe their lives to that man.

Nebeker: I was also thinking of his knowledge of electronics. You said that he was also involved with that side of it.

Greatbatch: He was pretty sharp. I remember I had some problem with a pacemaker once – I've forgotten just what it was now – and he looked at it and solve the problem right away. I hadn't spotted it. When staphcillin, a type of penicillin particularly effective in combating staph infections, first became available I read about it a medical journal. I told him about it. He didn't even know about it yet, so I felt pretty good about that.

Nebeker: You got back at him.

Greatbatch: He is very difficult to get along with, and we had some great fights, but I have tremendous respect for him.

Nebeker: Who else stands out among those with whom you have known or worked?

Greatbatch: I knew all of the chief engineers of all of the companies when I working with Medtronic, and I had a lot of respect for them. Barough Berkovits came out of Buffalo. Some outstanding people were Walter Keller, Mac Cortis [sic], who was chief engineer there, and Arnold Kantorwitz [sic].

Nebeker: You worked with Kantorwitz?

Greatbatch: Not too much. I talked to him a lot.

Nebeker: Who were the most outstanding there [at Medtronic?]?

Greatbatch: One of the more outstanding people there was Robert (Bob) Anderson. There always seemed to be a controversy going on between Cortis and the boss at Medtronic. Medtronic. Dr. Chardack didn't get along with the boss there either. They were always fighting one another. I spotted a problem in one of Walter Keller's designs one time and I called him and told him about it. He thanked me. Then he found one of our patients on the beach down in Florida who had been lying out in the sun. The sun on the pacemaker had caused a problem, and he saw to it the patient got in the hospital and got help. While the two presidents were fighting each other, the engineers were working together. I think in general the engineering profession and medical electronics has always cooperated pretty well.

Nebeker: You were Secretary-Treasurer of the Professional Group of Medical Electronics for several years in the early fifties.

Greatbatch: Yes. I was heavily involved with the group in the early years, going to all their meetings. I was involved with the international group too.

Nebeker: To which international group are you referring?

Greatbatch: The International Federation of Biomedical Electronics.

Nebeker: And you organized the Buffalo Chapter.

Greatbatch: Yes.

Nebeker: You said that was a large group.

Greatbatch: Yes. It didn't stick together too long. I think the San Francisco group is still together, but I'm not sure. We actually got organized before they did, but they both came up for approval on the same day. Ours was passed a few months before theirs.

Nebeker: You were officially the first then. It sounds like that was a very fruitful in bringing the medical and engineering communities together during those years.

Greatbatch: Yes, it was fruitful. At that time the PGME was the engineering medical group and they had interplay between doctors and engineers. Later the Association for American Medical Instrumentation (AAMI), which was started by doctors, became pretty important. However it was pretty much taken over by companies and has regressed now somewhat into being a standards writing organization. I was on the [inaudible word; board?] of the National Standards Institute for some time.

Nebeker: You have remained a member of IEEE. Have their publications and conferences been useful to you?

Greatbatch: I still get their publication.

Nebeker: Did you continue to attend IEEE conferences?

Greatbatch: Not very often. I've been to a couple.

Nebeker: Was there another group with which you were more closely affiliated?

Greatbatch: I got quite active with and am a member of the Electrochemical Society. Again it was the battery work and our hard work. I was going to the meetings of the Poplar Association for a while with our biomass energy project. That was one of the ten that didn't work.

Nebeker: Would you mention briefly a couple of the other things in which you have pursued an interest?

Greatbatch: We've spent twenty years on AIDS work, trying to block the replication of the AIDS virus. It was a rather unique process of realizing that on the long term of the repeat that is on each end of the virus there are about five sites necessary for replication. We worked on a method of blocking those sites. Unfortunately we never had anyone like Dr. Chardack with which to work. We worked with a lot of people who left after they got their post doctorates or post doc out of the drug company. Were never really able to really tie it down until recently. Now it looks as though we may do it after all. It wouldn't be a cure for AIDS, but it is looking like we might be able to put some of this back together again. Some of the early patents have already expired.

Nebeker: Who is "we"?

Greatbatch: I'm now working with an entrepreneur from Rochester, Michael Minor, Wiener. He's a business type, and he's taken on our AIDS project. I've finally gotten to the point where I've had two patents granted that deal with the AIDS and I have two more in the process. I've never got a nickel out of it, but I've spent a lot of money on it – probably a million dollars. I also got very active in lobbying Congress against the changes in the patent bills. The IEEE was against me on that,

incidentally. Our opposition was the large international conglomerates, and they pretty much predominate the IEEE. Mike has put together a group which encompasses our AIDS work as well as some other work he's picked up from NIH that relates somewhat to what we have been doing. There are a couple of other interested people, and maybe we'll get it all put together into a company and something with it.

Nebeker: Would you talk briefly about the biomass interest you had?

Greatbatch: We were interested in a type of poplar tree that produces more energy than any other plant between the Hudson River and the Mason-Dixon Line. It's a kind of poplar tree that grows very fast. We had a variety growing nine feet in one year. Every two years we'd go through with a big cutter like a corn chopper, cut it up, chip it, dry it and burn it in turbogenerators. With two fields of 15,000 acres of land too poor to grow corn apart from every other year, enough electricity for a town of 50,000 people can be generated. However we engineers have never learned how to make turbogenerators very well. We're stuck with a Carnot cycle, a heat engine in which 60 percent of the energy comes out in the form of heat. I took that heat and put it in the stills and make wood alcohol for all their cars. I had an old '67 Dodge running on 100 percent ethanol.

The hot water of the stills can be run to the town to heat all the water. For the trees to grow that fast they have got to be heavily fertilized. Therefore the sewage sludge from the town is composted put back fertilize in the trees. We actually composted 200 tons of sewage sludge from Akron, New York. That's the town

next to us. I shoveled the first 15 tons with my own hands. I really got in knee-deep in my work.

Nebeker: Were you able to demonstrate this whole cycle?

Greatbatch: No, but we demonstrated pieces of it. We had the truck running and we demonstrated that we could run up these piles of sewage sludge to the necessary temperature to make them compost.

Nebeker: Did you get the trees to grow that fast?

Greatbatch: Yes. There are still 40,000 poplar trees growing not far from us. What really stopped us, however, was when the Arabs dropped the price of oil so low. There should be a law against burning oil. We should not waste it burning it for fuel. We should save it for chemical feedstock, which is what we are going to need. As long as the Arabs are willing to sell their birthright for a fraction of its worth there's not much we can do. As a result, we sort of dropped out of that picture.

Nebeker: What about your interest today in the helium III fusion energy source?

Greatbatch: Yes, that is a strong interest of mine and it's my major enterprise right now.

Nebeker: How long have you been involved with that idea?

Greatbatch: I've been on the fringes for several years. It's just in the last couple of months that I've gotten really deeply involved and spent some money on it. I was on the phone this morning tracking down a 200,000-volt power supply. It's made up in Brewster, New York just north of New York City. I'll buy that and give it to Helsinski [sic].

Nebeker: Thank you very much.