THE BECKMAN CENTER FOR THE HISTORY OF CHEMISTRY

EDWIN J. VANDENBERG

Transcript of an Interview
Conducted by

Herman Skolnik

in

New Orleans, Louisiana

on

1 September 1987

THE BECKMAN CENTER FOR THE HISTORY OF CHEMISTRY

Oral History Program

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Edwin Vandenberg

(Date) 9/9/90

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Chemical Heritage Foundation
Oral History Program
315 Chestnut Street
Philadelphia, Pennsylvania 19106

EDWIN J. VANDENBERG

1918 Born in Hawthorne, New Jersey on 13 September

Education

1939 M.E., Stevens Institute of Technology

Professional Experience

1939-1944 Research Chemist, Hercules Incorporated
1944-1945 Assistant Shift Supervisor, Sunflower Ordinance Works

Research Center, Hercules Incorporated
1946-1957 Research Chemist
1957-1965 Senior Research Chemist
1965-1982 Research Associate

Arizona State University
1983- Adjunct Professor of Chemistry
Visiting Professor of Chemistry

Honors

1964 Best Paper Award, Delaware Section, American Chemical Society
1965 Industrial Research 100 Award
1965 D.Eng., Stevens Institute of Technology

American Chemical Society
1979 Delaware Section Award
1981 Award in Polymer Chemistry
1983 Polymer Chemistry Division Service Award
1991 Award in Applied Polymer Science

ABSTRACT

Vandenberg grew up in Hawthorne, New Jersey, where his father owned a grain and feed store. After talking about his schooling, where he learned the violin, Edwin Vandenberg recalls a friend and his home laboratory. Attending Stevens Institute of Technology, Vandenberg concentrates on chemical subjects, influenced by F. J. Pond. His first years at Hercules were with Spurlin's paper chemistry group, where he contributed to the understanding of paper sizing as a colloid phenomenon. After a spell working on the wartime production of smokeless powder, Vandenberg returns to the Hercules research center to work on a wide range of polymer syntheses, which he describes in some detail. The interview concludes with an account of his retirement activities at Arizona State University, and reflections on his family, colleagues and ACS activities.

INTERVIEWER

Herman Skolnik received the B.S. degree in chemical engineering from Pennsylvania State University, and the Ph.D. degree in organic chemistry from the University of Pennsylvania. He joined Hercules, Inc., as a research chemist in 1942, and served as a divisional research manager from 1952 until his retirement in 1979. He was the founding editor of The Journal of Chemical Documentation, and has published over 200 papers and four books, including A Century of Chemistry, the centennial history of the American Chemical Society.

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INTERVIEWER: Herman Skolnik

LOCATION: New Orleans, Louisiana

DATE: 1 September 1987

SKOLNIK: Let's start with the exact date of your birth and the place.

VANDENBERG: I was born on 13 September 1918 in Hawthorne, New Jersey.

SKOLNIK: What was your father's occupation at that time?

VANDENBERG: My father was a feed dealer. He sold grains and feeds.

SKOLNIK: Was it like a store?

VANDENBERG: He had a storefront for most of the deliveries--then by horse and wagon.

SKOLNIK: What sort of town is Hawthorne? Is it a small town?

VANDENBERG: It's about ten or twelve thousand.

SKOLNIK: You lived there for your primary education?

VANDENBERG: Yes. It's a suburb of Paterson, New Jersey.

SKOLNIK: What was your father's educational background?

VANDENBERG: He graduated from high school. I think he managed to spend a little time in business school. A year, something like that.

SKOLNIK: What was your mother's educational background?

VANDENBERG: I'm not sure. She may have only gone to grammar school as was common in those days.

SKOLNIK: Your father graduated from high school and that was unusual for that time.

VANDENBERG: Yes.

SKOLNIK: Were you their first child?

VANDENBERG: No. I was the second.

SKOLNIK: How many children were there?

VANDENBERG: Two.

SKOLNIK: Was your older sibling a brother or a sister?

VANDENBERG: A brother.

SKOLNIK: How much older?

VANDENBERG: One year.

SKOLNIK: Oh, so you were almost like playmates. Or was it a competitive atmosphere between the two of you most of the time?

VANDENBERG: Well...

SKOLNIK: Was he bigger than you?

VANDENBERG: A little bit.

SKOLNIK: He must have influenced you while you were growing up, being a year older.

VANDENBERG: Well, I don't know. I may have influenced him, too. But he never was inclined to study, whereas I was.

SKOLNIK: Was he more of a physical person?

VANDENBERG: Yes.

SKOLNIK: Helped your father a lot, did he?

VANDENBERG: He actually did work with my father for awhile after he left school.

SKOLNIK: How about when he was in school, like junior high school and high school?

VANDENBERG: Well, I guess he did a bit.

SKOLNIK: How about you? Did you help your father when you were in high school?

VANDENBERG: No.

SKOLNIK: But you did better in school than your older brother?

VANDENBERG: Yes. He actually was a very intelligent person and has been very successful in the building business.

SKOLNIK: Was he a contractor?

VANDENBERG: Yes, he was a contractor for most of his life.

SKOLNIK: You never got involved in that with him?

VANDENBERG: That is correct.

SKOLNIK: Obviously you were mechanically inclined, too.

VANDENBERG: Not really.

SKOLNIK: Well, maybe later on you can explain how you got a degree in engineering. What were your interests in elementary school, and what kind of a student were you then? And who were

your playmates? Is that stretching your memory too much?

VANDENBERG: Well, that's a pretty big stretch. I suppose I was a good student throughout grammar school and high school.

SKOLNIK: Were you always at the top of the class?

VANDENBERG: Yes, I was pretty much in the top 10%. I played the violin.

SKOLNIK: When did you start the violin?

VANDENBERG: I had violin lessons for seven or eight years. I quit when I went to college. I don't remember exactly when I started, probably at around nine.

SKOLNIK: So you started with a normal-sized violin and not a small violin.

VANDENBERG: Yes.

SKOLNIK: Did you practice an hour a day for day after day, week after week?

VANDENBERG: That was supposed to be the routine.

SKOLNIK: But did you do it?

VANDENBERG: Well, I did as best I could with my other responsibilities.

SKOLNIK: Were you a pretty good violinist? Did you play in the orchestra?

VANDENBERG: I played in the high school orchestra.

SKOLNIK: What chair were you?

VANDENBERG: I don't think we had those divisions. It was probably the first violin section. I played in college, too.

SKOLNIK: You were pretty good then.

VANDENBERG: Well, I was fair.

SKOLNIK: How far from the concertmaster were you? You were not the concertmaster?

VANDENBERG: No. I don't even think we had one.

SKOLNIK: Oh, the first chair of the first violins is always the concertmaster.

VANDENBERG: Well, I don't believe that was true for our college orchestra.

SKOLNIK: So you played in the pit, including Gilbert and Sullivan.

VANDENBERG: Yes, and they also created their own shows.

SKOLNIK: What were you reading in junior high school? By the time you were in sixth grade were you reading Horatio Alger or Tom Swift books or the Rover Boys?

VANDENBERG: I can't remember.

SKOLNIK: The interesting thing about the Tom Swift books is that there's a lot of science in that. It was more like science fiction, but it was still science.

VANDENBERG: I don't remember.

SKOLNIK: So that was not one of the influences in your life, this early reading.

VANDENBERG: I don't think so.

SKOLNIK: Did you have an encyclopedia at home?

VANDENBERG: Yes.

SKOLNIK: So your parents were literary oriented. Were they readers?

VANDENBERG: Not extensively. My father worked very hard, every day of the week and evenings and did not have a lot of free time.

SKOLNIK: Early in the morning and late at night.

VANDENBERG: Although he was successful at it, he worked hard all his life.

SKOLNIK: That's typical of that generation.

VANDENBERG: Right.

SKOLNIK: So whatever books you had in the house were essentially what you and your brother brought in.

VANDENBERG: To a considerable degree. We did have some current magazines (Literary Digest, Life) and newspapers.

SKOLNIK: In junior high school, did you bring home books from the library to read and what kind were they?

VANDENBERG: I suspect that I took home what was needed to do my work at school. I don't think I did extensive extra reading.

SKOLNIK: You picked up that characteristic later in life?

VANDENBERG: Yes, but I've always pretty much concentrated on reading things that relate to business interests, or what I had in hand at the moment.

SKOLNIK: Rather than curiosity about things that happened throughout the world?

VANDENBERG: I read business literature, newspapers and current events magazines.

SKOLNIK: You didn't read things like physics, chemistry, and biology until you took courses in those areas?

VANDENBERG: Well, not extensively.

SKOLNIK: What sort of friends did you have during elementary school and junior high school and into high school? Were you into sports at all?

VANDENBERG: Not in high school. I did play things like football.

SKOLNIK: You played football in school?

VANDENBERG: Local kids.

SKOLNIK: Sandlot.

VANDENBERG: Yes, and then I played some baseball.

SKOLNIK: Did you play in the line or backfield?

VANDENBERG: Line.

SKOLNIK: So you played the line?

VANDENBERG: Yes.

SKOLNIK: You were not one of these sure-footed people.

VANDENBERG: No, I definitely was not that. I was not atheletically inclined. Never was.

SKOLNIK: In high school, what courses did you have in science? Did you have biology in tenth grade?

VANDENBERG: No. I never had biology.

SKOLNIK: Did you have physics in eleventh grade?

VANDENBERG: No, I didn't take physics. I had to get physics at college. I took a summer course in physics. I was tutored in physics, just prior to entering college.

SKOLNIK: Was this by the physics teacher or by a college student?

VANDENBERG: Physics teacher.

SKOLNIK: How did you get interested in chemistry?

VANDENBERG: A very good friend who had quite a big influence on my ultimate career, a fellow by the name of Gordon Hoffman.

SKOLNIK: Hoffman?

VANDENBERG: I suppose he's the one who got me interested in chemistry. He had a chemistry laboratory in his home and probably when I was about thirteen or fourteen, I got acquainted with his chemistry laboratory and became fascinated by chemistry as a result of that.

SKOLNIK: So your curiosity was aroused?

VANDENBERG: Right.

SKOLNIK: What happened if you added A to B?

VANDENBERG: Yes.

SKOLNIK: What was your orientation interest? Was it the doing of chemistry or was it, "I wonder what would happen if?" or, "What's the meaning of?" Was it curiosity or was it philosophical?

VANDENBERG: Chemistry is a unique area of science. There's nothing quite like it.

SKOLNIK: It was more than just a desire to add information to your storehouse of knowledge.

VANDENBERG: Yes.

SKOLNIK: It was more related to curiosity.

VANDENBERG: Right.

SKOLNIK: And then you took chemistry?

VANDENBERG: I took chemistry in high school.

SKOLNIK: Did you have a good teacher?

VANDENBERG: No.

SKOLNIK: And how about the other students in class? Were they reasonably good?

VANDENBERG: I don't remember.

SKOLNIK: Well, how did you do in chemistry? Did you get your A?

VANDENBERG: I couldn't even tell you that.

SKOLNIK: You mean you weren't interested?

VANDENBERG: I did pretty well because I was in the top ten percent of the class.

SKOLNIK: How many were there in your graduating class?

VANDENBERG: There was about one hundred, maybe a hundred and thirty.

SKOLNIK: How were you in courses like English and history in high school? Did you enjoy them or were they a nuisance to you, especially the writing part?

VANDENBERG: I don't think I minded them. I got on all right with them.

SKOLNIK: How were you in the conversation part?

VANDENBERG: I think I was fairly good. I don't think I was outstanding.

SKOLNIK: Was there a school paper in your school?

VANDENBERG: Yes, we had one.

SKOLNIK: But you were not on the staff?

VANDENBERG: No.

SKOLNIK: So the orchestra was your only extracurricular activity?

VANDENBERG: Yes.

SKOLNIK: The orchestra from ninth period on or tenth period on?

VANDENBERG: I don't know.

SKOLNIK: So your chemistry teacher did not influence you to go into chemistry. Well, you didn't go into chemistry when you went to college?

VANDENBERG: I had decided that I was going to be a chemist. If you read the yearbook in my high school, it says that I was going to be a chemist.

SKOLNIK: What college did you enter?

VANDENBERG: I went to Stevens Institute of Technology in New Jersey.

SKOLNIK: Is that within commuting distance?

VANDENBERG: Yes.

SKOLNIK: Was that one of the reasons why you chose that school?

VANDENBERG: Well, I don't think I chose it at all. This was in the middle of the Depression, don't forget; I was lucky to go to college. My father paid for it.

SKOLNIK: When did you graduate from high school?

VANDENBERG: 1935.

SKOLNIK: Actually, it was better in 1935 than it was in 1932, 1933 or 1934.

VANDENBERG: I wouldn't know. I was too young.

SKOLNIK: I was there.

VANDENBERG: Yes, you were there but it may have been good in one business area but not in another. I don't know how it affected my father's feed business.

SKOLNIK: Is Stevens a state university or is it a private school?

VANDENBERG: It's a private school.

SKOLNIK: You entered Stevens in 1935 to major in chemistry.

VANDENBERG: Well, Stevens is an unusual school. It was my father's idea that Stevens was a good school; and it is a good school. I could probably get my chemistry there as well as in another school. I really wanted to learn chemistry. There was no question about that. Stevens gave a general engineering course; by tradition it gives a mechanical engineering degree.

SKOLNIK: They didn't begin engineering in your freshman year, did they?

VANDENBERG: No, not engineering. But there were the rudimentary courses in calculus, descriptive geometry, drafting, mechanical drawing, etc. So, it was a basic engineering curriculum with a lot of courses directed toward engineering mechanics and physics and chemistry. There was a lot of chemistry.

SKOLNIK: You actually didn't take calculus until your sophomore year though?

VANDENBERG: I had descriptive geometry first. I had about one and one-half years of calculus. It was a very strong mathematics program. I always liked mathematics and did well in it.

SKOLNIK: You had a general laboratory in your freshman year? Probably you took qualitative analysis during your second semester.

VANDENBERG: I had general chemistry for the first year. And the second year was quantitative. Then I took physical chemistry later in my junior year.

SKOLNIK: Did you take one year or two of physical chemistry?

VANDENBERG: One year.

SKOLNIK: What was your text?

VANDENBERG: I couldn't tell you at this point in time. I probably still have my text if I could find it. Not that I would remember.

SKOLNIK: What sort of engineering did you have by the time you were a sophomore until you were a senior? You really graduated as a mechanical engineer, didn't you?

VANDENBERG: As I say, that's the degree that was given to us for historical reasons. Senior year you had the option of getting one or two electives and I used them for chemistry. I took organic chemistry during my senior year.

SKOLNIK: You usually take organic during your sophomore year.

VANDENBERG: No, it was the senior year that I took organic from Professor F. J. Pond. He showed a lot of interest in helping me and was very influential in getting me established in chemistry. I showed great interest in organic chemistry and spent a whole summer between my junior and senior years doing organic synthesis and learning organic chemistry from Dr. Pond in one-on-one sessions.

SKOLNIK: Did you take anything beyond the two regular semesters of organic? Did you take organic quant?

VANDENBERG: No. I spent all summer between my junior and senior years on organic preps. Dr. Pond provided me with a laboratory and chemicals. The school didn't charge me for it. He would come in everyday and we would discuss organic chemistry problems. In fact, when the senior organic class was held, he told me that I did not have to attend the classes, although I did attend most of them.

SKOLNIK: Did he take the preps right out of the journals or the literature?

VANDENBERG: [Ludwig] Gatterman and [Heinrich] Wieland was the basic reference that we used for the preps (1). Later on, he gave me a little research problem that he had worked on many years before, based on various chalcones [parent compound: benzylidene acetophenone]. I did a senior project on it and wrote a thesis on it to obtain a degree with distinction.

SKOLNIK: Organic chalcones?

VANDENBERG: Yes. I did a lot of work on this during my senior year.

SKOLNIK: He was doing organometallic chemistry before his time.

VANDENBERG: No. These were not organometallics. These were benzal acetophenones. He had done some very early work in the field. Dr. Pond was a product of Penn State.

SKOLNIK: My laboratory work was in Pond laboratories.

VANDENBERG: Yes, I know. Named after his brother [Gilbert G.]. He was trained in Germany.

SKOLNIK: Pond at Penn State was not alive when I was there in the 1930s.

VANDENBERG: He was an older brother, I presume.

SKOLNIK: The one at Penn State?

VANDENBERG: Was the older brother. Dr. Pond was very dedicated to chemistry and was very helpful.

SKOLNIK: Do you recall any of your close friends in chemistry at Stevens who are still chemists?

VANDENBERG: Not too many. I suppose I was a little unusual because not many people did what I did.

SKOLNIK: That summer work.

VANDENBERG: Yes, the summer work and taking on a senior project. I did have some friends in my class who were good in chemistry.

SKOLNIK: Did they go to graduate school?

VANDENBERG: Some of them did. One got a doctorate in physics. Dr. Fred [Frederick] Reines.

SKOLNIK: Oh, the atomic bomb during World War II?

VANDENBERG: I'm not sure. I didn't keep in close contact.

SKOLNIK: You're talking about a student who's now a professor of physics? [University of California, Irvine, 1966-]

VANDENBERG: Yes. Well, he's probably retired now.

SKOLNIK: Any other professor besides Dr. Pond on the faculty?

VANDENBERG: Of course, I knew the chemistry professors very well. They were very helpful.

SKOLNIK: And the engineering professors? They must have influenced you somewhat, didn't they?

VANDENBERG: I had pretty good teachers in engineering.

SKOLNIK: Did that include mechanical engineering?

VANDENBERG: Oh, we had mechanical. And electrical and civil.

SKOLNIK: Steam tables and so forth?

VANDENBERG: Sure. During my senior year I had civil engineering. In fact, they had a summer camp which went for six weeks during the summer between the freshman and sophomore years. Surveying.

SKOLNIK: But you did nothing in chemical engineering unit processes--crystallation, extraction?

VANDENBERG: No. They had an industrial engineering course.

SKOLNIK: You didn't take that?

VANDENBERG: Yes, I did.

SKOLNIK: Oh, you did.

VANDENBERG: Yes.

SKOLNIK: So you had no unit process course in chemical engineering at college? As a chemical engineer would?

VANDENBERG: No, not as they do today.

SKOLNIK: Or even in my day. I had a whole year of unit processes. Mechanical engineering, electrical engineering, thermodynamics, and so forth.

VANDENBERG: Yes. Well, we had a great deal of thermodynamics.

SKOLNIK: Did you take differential equations as mathematics? I don't mean differential calculus and integral calculus, I mean differential equations. Did you have a special course in that?

VANDENBERG: As I said, I took about one and one-half years of calculus.

SKOLNIK: So you must have had differential equations.

VANDENBERG: I believe I did. Again, it's a long time ago and I haven't really used it.

SKOLNIK: On graduating, did you go into industry or did you go to graduate school? Did you have an opportunity to get an assistantship or scholarship or anything like that from a university?

VANDENBERG: Dr. Pond told me that I would be better off going to work and I kind of agreed with him.

SKOLNIK: You wanted the money?

VANDENBERG: No. I don't know. I was inclined to get some experience. I'm not sure that I could have afforded it either.

SKOLNIK: You would have been paid to go to graduate school if you had an assistantship.

VANDENBERG: I think I was pretty much inclined to go to work and Dr. Pond thought that was the best thing for me to do. He thought that I was a very competent guy. Mr. [George M.] Norman of Hercules was one of his students. He didn't think too much of Mr. Norman. Actually, I had an interview with someone from Du Pont, who told me that I should go on for a graduate degree. But Dr. Pond wrote to Mr. Norman, a Director of Hercules Powder Company, and gave me a high recommendation.

SKOLNIK: And you came directly to the research center?

VANDENBERG: I came down the spring of 1939 to interview with Mr. Oscar Pickett and Dr. Emil Ott.

SKOLNIK: This would be in 1938?

VANDENBERG: I graduated in 1939 so it would have been the spring of 1939. I was quizzed on terpene chemistry which I had been through. I had done plenty of terpene rearrangements. Dr. Pond was pretty good in terpene chemistry. So, I received a job offer and went to work 1 July 1939.

SKOLNIK: Your first assignment in Hercules was in paper chemistry?

VANDENBERG: Yes. Dr. [Harold] Spurlin had a long-range assignment on the mechanism of rosin sizing and the electrostatic theory of size retention. He wanted to explore this area and he thought that electrophoresis was the way to go about it. He had a simple Abramson electrophoresis setup to do this (2).

SKOLNIK: Naturally. He always designed what equipment he used. If he didn't design it, he would redesign it.

VANDENBERG: He read the literature. He knew the method. He was absolutely right, it was an ideal way of measuring the charge characteristics of the various colloidal materials involved in the sizing process. I worked on that for about two or two and one-half years.

SKOLNIK: Was this the sodium size, or potassium size or what?

VANDENBERG: Sodium soap or a high free rosin size plus alum.

SKOLNIK: It must be the sodium salt with some free carboxy groups. It's not one hundred percent.

VANDENBERG: It was a colloidal phenomenon and, depending on the pH, it was sodium resinate or free rosin. It was a nice piece of work that we did (3).

SKOLNIK: Hercules had a product called three and one rosin.

VANDENBERG: I think it's three and one salt.

SKOLNIK: Was that one of your products?

VANDENBERG: That wasn't a product. It was an undesirable, insoluble material which formed in some commercial sizes under some conditions.

SKOLNIK: But that's what they sold.

VANDENBERG: No. I can't remember now what the composition was. I guess it's three abietic acids to one sodium abietate which forms a very insoluble salt.

SKOLNIK: That was for paper sizing?

VANDENBERG: No. It was just a problem in size manufacturing.

SKOLNIK: At the time I got there I remember this was the product.

VANDENBERG: You may be thinking of something else.

SKOLNIK: Not in a three to one size.

VANDENBERG: I don't think so, Herman. Three to one salt was a nuisance. I did some work on that. Actually, the first thing I did at Hercules was to work for a week or two with Bill [William] Middleton on this problem. Middleton, a master chemist, was working on three to one salt. It's coming back to me now. He was working on the formation of three to one salt in size and added various resins and protective colloids. A couple of these things worked out pretty well in his experiments. I just did some routine follow-up on his findings. That was the first thing that I had to do.

SKOLNIK: By the time I got there in 1943, you were working on the theory of sizing.

VANDENBERG: Yes. That was the problem assigned to me. We did electrophoresis studies, a very powerful tool for studying surfaces. We proved the electrostatic theory of size retention. It didn't matter whether you had rosin or calcium resinate. If you had an anionic charge, it would react with aluminum to go to a aluminum diresinate salt which would have a positive charge. Cellulose, with its uronic acids in the surface, retains a

negative charge. It was a very powerful tool for doing that study. It was very useful, I think, in subsequent work by others on improving rosin and other sizing agents.

SKOLNIK: I thought you were working for [Peter] Vanwyck in 1942 or 1943.

VANDENBERG: No. I never worked with Vanwyck.

SKOLNIK: He was manager of Virginia Cellulose.

VANDENBERG: After I worked on the rosin size problem, I worked on soil stabilization which was related to the war, of course.

SKOLNIK: In what form?

VANDENBERG: Hercules got into the problem of soil stabilization, which is actually a phenomenon somewhat similar to rosin sizing.

SKOLNIK: That's where they used Vinsol?

VANDENBERG: Right. Somewhat like rosin sizing and which led to an improvement of water resistance of soil. I was assigned to that project and worked in the laboratory for about a year or so. At least until 1944, when I was transferred to Sunflower Ordinance Works in Kansas. I did a lot of work trying to understand the mechanism of soil stabilization. This was important for military purposes--for airfields, setting up quick runways.

SKOLNIK: Particularly for the Pacific.

VANDENBERG: Yes. But then I was in a critical age group. This was in the middle of the war now.

SKOLNIK: When you were sent to Sunflower, you were definitely deferred.

VANDENBERG: Well, I was twenty-six. Anyone under that age had to be in a vital activity. There was a whole exodus from the research center.

SKOLNIK: Werner Brown was one of these. He later became president of the company.

VANDENBERG: Werner Brown, right, and a whole bunch of others went to Sunflower at the same time that I did.

SKOLNIK: I remember that exodus.

VANDENBERG: And I debated at some length whether I should do that.

SKOLNIK: At Sunflower, were you assigned to the laboratory or to the plant?

VANDENBERG: I was in the plant.

SKOLNIK: I thought that you were in operations.

VANDENBERG: I was in operations.

SKOLNIK: This is for dynamite.

VANDENBERG: I was in smokeless powder. Shift work, I was an assistant shift supervisor.

SKOLNIK: Did you do the nitrating of the cellulose?

VANDENBERG: No. That was done in another area plant.

SKOLNIK: What was your area in Sunflower?

VANDENBERG: Smokeless powder; but we started out with nitrocellulose which was made in another part of the plant. It would come over in the water-wet form and we put it through what we called a 'dehyd', which involved replacing water with alcohol in a press. That product would go on to a mixer with ether.

SKOLNIK: Did you use acetone at all?

VANDENBERG: No. It went into a mixer with ether and alcohol and other ingredients, colloided and then it was pressed into a block.

SKOLNIK: After it left you, that's when it was pressed?

VANDENBERG: No, that was just a part of the whole operation to make smokeless powder.

SKOLNIK: Except for the nitration then.

VANDENBERG: Yes, we carried out the making of the finished powder. There were two sections. One was a finishing area where the final dry powder grain was made, and the first area where the nitrocellulose block in form was extruded and cut to the final grain size but still containing solvent.

SKOLNIK: Were there any accidents while you were there?

VANDENBERG: One day I worked a double shift and on the second shift four tons of NG went up.

SKOLNIK: You mean nitroglycerin.

VANDENBERG: Yes. The complete nitroglycerin plant. This part of the plant made nitric acid, sulfuric acid, and ammonia. It was a complete plant. A friend of mine, Gordon Hoffman, worked for Crane for a couple of years after college and he wasn't happy there. I got him into Hercules at the Research Center and he was finally sent to this plant. He was the nitroglycerin superintendent at this time.

SKOLNIK: So you nitrate the glycerin in a separate operation? Not like the cellulose, that is a different area?

VANDENBERG: Yes. Explosion of that four tons was like the atomic bomb--before it was known, of course.

SKOLNIK: It left a hole in the ground and toppled over some of the buildings.

VANDENBERG: And it killed two people.

SKOLNIK: You still had a rule there of no more than three or four in a building at a time?

VANDENBERG: Oh, yes.

SKOLNIK: Until what year did you stay at Sunflower?

VANDENBERG: 1945. Right after the war ended.

SKOLNIK: Then you came back immediately to the research center. When you worked at Sunflower, did you have to rent an apartment or house? Where did you live in Delaware? Were you married then?

VANDENBERG: I wasn't married. When I first went to Hercules, I stayed at the Y for about a month. Then I lived in a boarding house.

SKOLNIK: Until you went to Sunflower?

VANDENBERG: No. I moved to the outskirts of Wilmington, Alapocas, where I just had a room. Then I moved to another house that had two Hercules people in it. It was a boarding type of arrangement. Al [Alfred A.] Albert was there and Harold Weersing, also. Mel [Melvin L.] Moss who lived nearby had his meals with us, also. This was at 1411 Woodlawn Avenue.

SKOLNIK: Near Greenhill Avenue.

VANDENBERG: Yes.

SKOLNIK: You never moved to the Belafonte area house?

VANDENBERG: Yes, but much later--after the war.

SKOLNIK: When did you get married?

VANDENBERG: Not till 1950.

SKOLNIK: So you had other assignments at Hercules by then.

VANDENBERG: Oh, yes.

SKOLNIK: What was your assignment when you came back?

VANDENBERG: It was interesting. I wasn't thought of too highly at Sunflower.

SKOLNIK: Why do you think this?

VANDENBERG: I don't know. I was accused of seeking a postwar job, right after the war ended. Actually, the research center sent out a request for me to come back without any contact from me. I had a good reputation for the work that I had done there during my first five years.

[END OF TAPE, SIDE 1]

VANDENBERG: But anyway, I went back and I was ready to go back. Then I started working with Art [Arthur E.] Drake on emulsion polymerization. Art was being transferred to the home office.

SKOLNIK: That was near the end of the GR-S Rubber Program.

VANDENBERG: That's right, towards the end. The 731 resin emulsifier was pretty well worked out.

SKOLNIK: What was your assignment?

VANDENBERG: Well...

SKOLNIK: This was the Coke bottles? They capped the Coke bottles under pressure.

VANDENBERG: Right. I think that that had a big influence on my career. At that time Art suggested that I use a simpler technique which involved self-sealing rubber liners--one that the Firestone Rubber Company had developed and which Art pointed out to me. I took over the whole operation when Art left and evolved better procedures involving hypodermic equipment.

SKOLNIK: You ran the operation, then?

VANDENBERG: Yes, I ran it.

SKOLNIK: The emulsion polymerization?

VANDENBERG: Yes.

SKOLNIK: Did Chuck [Charles W.] Gould work for you then?

VANDENBERG: No.

SKOLNIK: He was independent?

VANDENBERG: Yes. I had the major thrust of the polymerization work.

SKOLNIK: What were your variables? What were you changing? What were your monomers?

VANDENBERG: Well, monomers, of course...

SKOLNIK: GR-S?

VANDENBERG: Sure. We were doing mostly scouting work and...

SKOLNIK: For the best emulsion, or what? Or for the best ratio of styrene to butadiene? Did you work on the isoprene job, too?

VANDENBERG: No.

SKOLNIK: That was dropped by the end of the war, I think.

VANDENBERG: Yes. Well, they had an idea to see what could be done to improve the performance of rosin soaps. They were not as good as fatty acids and were slower; how could you speed them up?

SKOLNIK: But during the war, the resinate made the difference in the GR-S program in emulsification.

VANDENBERG: Well, it gave a more tacky rubber. But it didn't speed it up.

SKOLNIK: So you were after increasing the reaction rate?

VANDENBERG: Right.

SKOLNIK: Now I get it.

VANDENBERG: Certain resin acids act as retarding agents.

SKOLNIK: Was it mostly the unsaturation in the rosin molecule that caused the trouble?

VANDENBERG: Mostly. You know, we looked at things like different pure resin acids to determine which ones were the retarders.

SKOLNIK: That was one of my jobs, to produce the pure rosin.

VANDENBERG: Yes, well Tom [Thomas F.] Sanderson and Bill [William P.] Campbell did a lot on that too, for that matter. But anyway, it was about that time that the PB [War Production Board] reports came out from Germany, right? And [Eero O.] Erkko's reports were issued.

SKOLNIK: That was my job, too. To get the information from the PB reports to people like you.

VANDENBERG: Well, no. You didn't get it to me, because...

SKOLNIK: No, I gave it to Erkko. Did he distribute it?

VANDENBERG: Well, this was on microfilm. I went down to the home office to read them.

SKOLNIK: You read the German?
VANDENBERG: No, no, it wasn't in German.

SKOLNIK: Well, we received it in German.

VANDENBERG: I think it was...no, I think these were in English. I think they may have come to us in English.

SKOLNIK: No, I got them directly from Germany.

VANDENBERG: Well, I remember going down to Erkko's office and looking at the microfilm. And noticing all the work being done in Germany on redox emulsion polymerization.

SKOLNIK: But you read it in English, not in German?

VANDENBERG: Yeah, I'm pretty sure it was in English.

SKOLNIK: That's because after I'd drawn the information, then Erkko put it on the microfilm for you people to read.

VANDENBERG: Why did he do that?

SKOLNIK: Because he knew most of you didn't read German.

VANDENBERG: But why did he put it on microfilm?

SKOLNIK: That I don't know, because I gave it to him in typed copy. I am so glad to hear that you read those Erkko reports.

VANDENBERG: No, it was later that those things came along.

SKOLNIK: That was in 1945.

VANDENBERG: This came out in about 1946, I think.

SKOLNIK: We had thousands of those reels. Were they 35mm or 16mm film?

VANDENBERG: I don't remember. I remember going down and looking at some of these things and reading the work on redox polymerization and then going back to the lab. Of course, at the time, cumene hydroperoxide (CHP) had come on the scene from Dr. [Eugene J.] Lorand. Actually, Art Drake had already done a little work on CHP in emulsion polymerization and it had shown some interesting behavior.

SKOLNIK: So had Chuck Gould by then.

VANDENBERG: We immediately tried a more or less German-type redox recipe with CHP. An iron pyrophosphate plus glucose, sorbose or sucrose, I don't remember exactly, but we used a reducing sugar and got fantastic reaction rates. We could polymerize SBR [styrene/butadiene rubber] in 15 minutes, you know, when it took 15 hours with persulfate or CHP alone. That was probably my first very important patentable discovery (4).

SKOLNIK: You had some patents in paper chemistry too, is that right?

VANDENBERG: Yes. This improved redox system made it possible to use ordinary rosin soaps, instead of resin 731, although that never came to commercial realization (4), (5).

SKOLNIK: Maybe you'd better explain what resin 731 is for the tape (6).

VANDENBERG: Well, it was disproportionated rosin which has a very high content of dehydroabietic acid.

SKOLNIK: Disproportionation did what to the double bonds in rosin?

VANDENBERG: Well, it eliminated the conjugated double bonds pretty much, not entirely.

SKOLNIK: You mean the one-three double bonds. It eliminated the one-three double bonds.
VANDENBERG: Well, the conjugated double bonds which were partly aromatized.

SKOLNIK: In other words, you had a benzene ring in one of the phenanthrene rings and other resin acids were either completely or partly hydrogenated.

\VANDENBERG: Thus, disproportionation gave more stable resin acids which didn't inhibit polymerization as much. But with our redox formulas, the inhibition of the ordinary resin acids was not critical and one could obtain good rates of polymerization. We patented many of these things, of course. Ultimately, the rubber and other companies, particularly Phillips Petroleum, developed these systems for 5 °C SBR polymerization [cold rubber]. Then [Izaak M.] Kolthoff came along and did the same things we did (7). We got the patent on it, actually. As a matter of fact, Hercules used our patents as a sales tool, but the patents did cover the basic processes to make cold rubber.

SKOLNIK: This was styrene and butadiene, right? I remember that.

VANDENBERG: Initially. Cumene hydroperoxide with an iron salt and a reducing agent.

SKOLNIK: What was the iron salt? Ferrous sulfate?

VANDENBERG: No, it was an iron pyrophosphate that we started out with. Of course, the rubber companies optimized these things. At one time, Phillips came out with these crazy unknown peroxides which were even better--called Diox. And in a few days, I found out that they were just higher substituted cumyl hydroperoxides which we had covered in our patent. We hadn't done a lot of work on them, but they were actually much better. Then we went on to do work related to why these hydroperoxides were so much better initiators in emulsion systems.

SKOLNIK: Were you responsible for the para-methyl-isopropyl-benzyl hydroperoxides? Or did that come out of Lorand's work?

VANDENBERG: Well, that came out of Lorand's work (8).

SKOLNIK: Also the para...

VANDENBERG: Also the para-menthane hydroperoxide. You know, all those things came out of Lorand's work.

SKOLNIK: You did not do any peroxidation.

VANDENBERG: I didn't do any...well, not much. I did some later on but...

SKOLNIK: I thought you did.

VANDENBERG: Just a little bit. But, of course, we tested a lot of these things.

SKOLNIK: Did you also study the peroxide as well as the hydroperoxide? Was that still in your days for the rubber program?

VANDENBERG: The dicumyl peroxide, that was done by Harold Boardman, who was working in the lab about that time (9), (11).

SKOLNIK: That was one of his studies.

VANDENBERG: Harold Boardman did that. Let me go on a little bit. In the course of studying the redox system, trying to find out why it was so good, we found we could reduce cumene hydroperoxide with ferrous sulfate--just one-half of the molecule--so that you would wind up with acetophenone and a free radical. In the course of doing that we ran an experiment in acetic acid and...

SKOLNIK: You got phenol.

VANDENBERG: We got phenol.

SKOLNIK: Is that your patent? Whose patent is that?

VANDENBERG: Well, I got some patents in the area but I didn't get any patent on...

SKOLNIK: Who got the first patent on the acid cleavage? Was that Lorand?

VANDENBERG: No. You know the basic cleavage was in the German literature, [Heinrich] Hock and [Shon] Lang, I believe (10). My contribution, however, was showing that the cleavage to phenol and acetone could go very readily and in high yield. As a matter

of fact, Dr. [George E.] Hulse wasn't even speaking to me when I was doing this work.

SKOLNIK: [laughter] He was your manager at the time.

VANDENBERG: He didn't think it was economic.

SKOLNIK: Oh.

VANDENBERG: "Never would be economic."

SKOLNIK: He thought the Dow and other current phenol processes were better? Today, of course, the CHP cleavage route is almost the sole route to phenol.

VANDENBERG: Until he saw Stan [Richard S.] George one day. [laughter] Then Stan convinced him that he was off the beam. I really didn't do a lot on that because Naval Stores was interested in that and they took it over, pretty much. I never got a great deal of recognition for it, but the Newsletter item I wrote on this work did stimulate a lot of interest. I did some other work on peroxide reactions, of course. Boardman went on and did the peroxides, and he saw that you could do these acid-catalyzed reactions between alcohol and hydroperoxide to make the peroxide, and he got patents on them (11).

SKOLNIK: By that time, Lorand might have been retired.

VANDENBERG: I don't think so. Do you want me to continue?

SKOLNIK: Oh, yes. I want you to get to the real polymer chemistry pretty soon.

VANDENBERG: Well, we carried out a variety of emulsion polymerizations. We made some copolymers containing rosin molecules. A few years later, we made some copolymers with rosin-based monomers with things like acrylic acid and with cationic monomers. These were pretty good at paper sizing; the paper chemicals people (Paul Aldrich) worked on them but finally dropped them.

SKOLNIK: Jerry [Gerald I.] Keim, wasn't it?

VANDENBERG: No, it was Paul Aldrich.

SKOLNIK: Oh.

VANDENBERG: Nothing ever happened with this work. In fact, Hercules never even patented it because the operating department would not approve it. In more recent years people have been looking at these hydrophobically-modified, water-soluble polymers as fairly interesting water thickeners. Analogous products are commercial. We should have patented them.

SKOLNIK: You are talking about acrylic polymers, now.

VANDENBERG: Yes, acrylic polymers with a monomer containing a rosin moiety. In recent years, there has been a lot of work on hydrophobically-modified cellulosic water-solubles which is very similar to the work I did many years ago, but which did not result in a patent. I think it was Jim [James W.] Davis who was opposed to patenting this work. We also did a lot of work looking for possible uses for redox polymerization reactions for Hercules. Sure, it was interesting for the rubber people, but it didn't make any bucks for Hercules.

SKOLNIK: I still don't understand how you copolymerized rosin. Was it with pimaric acid?

VANDENBERG: No, no, I made a rosin monomer, such as N-rosin acrylamide.

SKOLNIK: Oh, I see. It had a pendant group.

VANDENBERG: One other thing that was proposed--maybe we could polymerize ethylene at low temperature.

SKOLNIK: What year was this? It was before Ziegler.

VANDENBERG: It was. It was about 1951 or 1952.

SKOLNIK: Getting close to Ziegler. [laughter]

VANDENBERG: We spent a fair amount of time on this. Actually, Bob [D. Robert] Levering worked with me in the high-pressure lab, and we did a lot of work on polymerizing ethylene just below the

critical temperature, ca 5 °C. We kept the pressure down, below 200 psi, something like that.

SKOLNIK: The critical pressure must be pretty high for...

VANDENBERG: Below the critical temperature, just a little below. And we did develop some redox systems which would polymerize ethylene. The rates were very low, the molecular weights were low but...

SKOLNIK: This would be high pressure polyethylene you are talking about.

VANDENBERG: Well, it wasn't. It was low pressure. It was free radical polyethylene. It was low pressure.

SKOLNIK: Yes, but a higher pressure than Ziegler catalysis.

VANDENBERG: Oh, yes. But, well, you know. People run Ziegler catalysis at elevated pressures.

SKOLNIK: Now they do, but that's a different kind of catalyst.

VANDENBERG: Sure. We actually had made linear polyethylene before it was reported in the literature.

SKOLNIK: Before the Du Pont patent (12)?

VANDENBERG: Yes, I think before the Du Pont patent; I'm pretty sure. But the molecular weight was not very high, the yields were low, the rates were low, so there really wasn't much I could do about it.

SKOLNIK: So how low was the DP [degree of polymerization]? Very low? Pretty low?

VANDENBERG: Well...

SKOLNIK: Was it brittle? You had to have pretty low DPs for polyethylene to be brittle.

VANDENBERG: Well, it was a good size. I don't remember now. I may have published that (13). But I don't really remember. I think it would probably be in the range of 10,000 or so for molecular weight, I suppose. Not quite high enough.

SKOLNIK: What was the Du Pont high pressure polyethylene DP? Hundreds of thousands?

VANDENBERG: Yes, hundreds of thousands. But you don't need that. Even if you had fifty thousand molecular weight, you would probably not know the difference. Maybe twenty-five thousand, even. It was high melting.

SKOLNIK: How did you know it was linear at that time? One never thought of polymers being linear or non-linear in those days.

VANDENBERG: Well, I think it was known but, I'm not sure now. Probably the higher melting point.

SKOLNIK: What was your objective?

VANDENBERG: Well, it was a low pressure process for making polyethylene.

SKOLNIK: To be competitive with Du Pont's polyethylene? Wasn't that your objective? The objective was really not to get a Ziegler-type of polyethylene.

VANDENBERG: Well, I think we would have--it was well known that polyethylene was branched.

SKOLNIK: Somewhat branched.

VANDENBERG: Yes, and it certainly would not be as branched. It would certainly be expected that it would be more linear. And I think that the higher melting would indicate it to be more linear.

SKOLNIK: Or is that DP? Was the analytical method good enough to know how many pendant groups there were?

VANDENBERG: Well, we didn't pursue that.

SKOLNIK: You didn't like the properties of the product anyway.

VANDENBERG: Yes. Also the rates were so low and there really wasn't much point for extensive work on the product. Most of the effort was trying to improve the yield, rate and molecular weight. But we could never really do it. Actually, at that time, we did write in our notebook a concept that was really right on the Ziegler catalyst.

SKOLNIK: It really was not a Ziegler catalyst. The product was more like a Ziegler polymer.

VANDENBERG: No, no. I said we had written in our notebook a catalytic system which was similar to a Ziegler-type catalyst. [Morris S.] Kharasch had worked on some reactions based on ferric chloride with organometallics which generated free radicals.

SKOLNIK: That was a mixture of the ferric chloride with an organometallic?

VANDENBERG: If we had tried it, it might have worked, although iron does not give a very good Ziegler catalyst. It is conceivable that this could have worked, but we did not try it. We were considering it as a free radical source, but we never had the organometallic and did not try it.

SKOLNIK: Now we're up to about 1950?

VANDENBERG: Well, no, we're in 1952 to 1954. Some of this work on the rosin copolymers was around 1953 or 1954.

SKOLNIK: I know they were still oriented to rubber, though.

VANDENBERG: No, no. This was scouting work.

SKOLNIK: For other polymerizations?

VANDENBERG: This was when I worked on synthesizing various copolymers.

SKOLNIK: The ethers and so forth? Vinyl ethers?

VANDENBERG: No. I think we were making copolymers of rosin monomers with acrylic acid, acrylates, etc.

SKOLNIK: So you were still thinking in terms of paper chemicals?

VANDENBERG: No, I wasn't. It was just one particular area, but my background in paper sizing caused us to do that. It did look pretty good, really. But, that brings us up to the time Hercules took a license out for the Ziegler catalyst.

SKOLNIK: You were assigned to a particular project right away?

VANDENBERG: Yes, I was.

SKOLNIK: Were you one of the first?

VANDENBERG: Well, I was not the first, but was assigned after two or three weeks; it was in October 1954.

SKOLNIK: Who else was on that program with you?

VANDENBERG: Well, I think Dave [David] Grant might have been one of the first. [Herbert] Mahlman and Dave [David S.] Breslow were also assigned early.

SKOLNIK: Good organic chemist--probably never touched a polymer before in his life, had he?

VANDENBERG: Well, I think he had by that time, sure. Well, they were just assembling the team then. They were assigning people in chemical engineering for the scale-up, that kind of thing.

SKOLNIK: That was from [Karl] Ziegler's work. Not from your work yet.

VANDENBERG: Yes, that's right.

SKOLNIK: So that was just a matter of following Ziegler's instructions, as far as engineering people were concerned.

VANDENBERG: Yes. First, Dave was trying to do the laboratory work which related to the polymer work, again, following Ziegler's general procedures.

SKOLNIK: But you were in the research end of it.

VANDENBERG: Yes, my assignment was general. I had pretty much a free hand, scouting the entire system.

SKOLNIK: What other kinds of polymers? Ethylene or propylene?

VANDENBERG: Ethylene and, of course, propylene. There wasn't much information available on propylene.

SKOLNIK: It was hard to obtain that in 1955 and 1956.

VANDENBERG: There wasn't too much available on monomers other than ethylene. How widely useful these catalysts were was not well known.

SKOLNIK: We had polypropylene in the plant by 1959.

VANDENBERG: Yes, I know. But--one day in October, I guess it was--I used a Ziegler catalyst on some propylene and also used hydrogen with ethylene with the Ziegler catalyst.

SKOLNIK: You took this hydrogen right out of the cylinder?

VANDENBERG: Yes.

SKOLNIK: And did you make the catalyst <u>in situ</u>, I want to make sure of it. You added it from the cylinder?

VANDENBERG: Again, we did a lot of our work with the pressure-bottle technique.

SKOLNIK: That figures. You just filled the bottle up with the hydrogen until it had reached the right pressure.

VANDENBERG: I put a partial pressure of hydrogen in the bottle. We had a stream of hydrogen from the cylinder passing through rubber tubing and then just sampled with a hypodermic syringe through the tubing and injected the hydrogen into the system. So we knew how much hydrogen was added. Three experiments with three levels of hydrogen were run.

SKOLNIK: And this was still before 1955.

VANDENBERG: Yes. The viscosity results came back and...

SKOLNIK: Of the polyethylene.

VANDENBERG: Of the polyethylene. With a small reduction in viscosity which increased with increasing hydrogen content. Thus, hydrogen did have an effect, but it was quite small.

SKOLNIK: But you saw an effect.

VANDENBERG: Yes, I believed the effect was real and I went on later to do more work and, of course, with propylene, hydrogen was even more effective than with ethylene. Ultimately we filed a patent application on using hydrogen to control molecular weight with Ziegler catalysts (14).

SKOLNIK: What was the year you filed the patent on using hydrogen to control molecular weight of olefin polymers?

VANDENBERG: Oh, about June of 1955.

SKOLNIK: Oh.

VANDENBERG: We covered all the possible catalyst and monomer combinations.

SKOLNIK: Did you inform Ziegler of this after you filed the patent?

VANDENBERG: I did not. Whether someone else in Hercules did, I do not know.

SKOLNIK: That would have been up to [Arthur L.] Glasebrook?

VANDENBERG: That was up to Hercules management; I don't know what the agreement was, whether we had to do that or not.

SKOLNIK: You never got involved with Ziegler yourself, then?

VANDENBERG: No, not really.

SKOLNIK: Did you ever get to know [Giullo] Natta at all?

VANDENBERG: Yes, sure.

SKOLNIK: Personally, you knew...

VANDENBERG: Oh, sure.

SKOLNIK: But you never knew Ziegler personally?

VANDENBERG: Not really, no.

SKOLNIK: On a first name basis?

VANDENBERG: No, no. He did come to Hercules to give a lecture, you know.

SKOLNIK: I was there.

VANDENBERG: And that was my only association with Ziegler, if you can call it that. I did not even get to meet him, frankly. I can even remember when [Hermann] Staudinger visited the research center. Again, it was, I can't remember when that was; 1946, maybe?

SKOLNIK: That's about right.

VANDENBERG: Again, I never met Staudinger either, but I did see him and heard him give a talk.

SKOLNIK: He was a great man.

VANDENBERG: Yes, I saw the great man. And you know how it is, and I started thinking, you know, in a lifetime I have seen Staudinger, Herman Mark and [Carl S.] Marvel--pioneers in the field. Well, of course, the first experiments on propylene gave only milligrams, something like that. We had fibers made out of it, and I recognized it as a pretty important discovery. Anyway, we went on to develop catalysts to make isotactic polypropylene in high yield and better rates.

SKOLNIK: Using Ziegler catalysts?

VANDENBERG: Yes.

SKOLNIK: What did you do, use a different ratio of aluminum and so forth? How did you change your catalyst to make better yield of polypropylene?

VANDENBERG: Well, that was a kind of evolutionary process, running many experiments, different catalysts, etc.

SKOLNIK: Was it a difference in titanium or in the aluminum or a difference in the alkyl group? Or all three?

VANDENBERG: Well, I should emphasize here that, I didn't get this point across before, that a lot of my success in this area came from running multiple experiments.

SKOLNIK: Simultaneously?

VANDENBERG: Simultaneously. The pressure bottle and hypodermic syringe technique made that possible. I think I did a lot more work, you know, than most people who worked in the field.

SKOLNIK: In other words, you ran more experiments per hour than anybody else.

VANDENBERG: Right, I had a lot of help, technicians and lab assistants, and I was always given plenty of help because they knew I was productive. Anyway, I found there were certain ways of putting the Ziegler catalyst together. Ziegler had mixed the ingredients <u>in situ</u> and we found that it was better to mix them outside, age them, and then put them into the system. Then I would look at the different compositions such as catalysts made

of very low amounts of alkyl, from triethyl, and diethyl, and monoethyl aluminum, and using these Ti precipitates, with added organometallics. We found that the reaction of monoethyl-dichlorides with $TiCl_4$ gave a $TiCl_3$ which, with added Et_3Al, gave a high yield of isotactic polypropylene (15).

SKOLNIK: Did you have problems with the titanium trichloride?

VANDENBERG: Well, you know...

SKOLNIK: Particularly, the form of the titanium trichloride?

VANDENBERG: Yes, it is the crystal form of titanium trichloride that is a critical factor.

SKOLNIK: Is that one of the things you worked on? Besides the ratios...

VANDENBERG: Actually, the titanium trichloride that you make from reaction of titanium tetrachloride with ethyl aluminum dichloride was finally shown by Natta to have an unusual crystal structure which he called the delta form. We, of course, recognized that we had an unusual crystal form, and actually filed a patent on it (16). Actually, the particular technique and the delta crystal form that I used was the basis of all commercial processes for making isotactic polypropylene.

SKOLNIK: Now, was the form of titanium determined while the titanium was still in the metal stage, or as the titanium trichloride stage?

VANDENBERG: Well, titanium trichloride...

SKOLNIK: It was not a matter of treatment of the titanium before you made the trichloride?

VANDENBERG: No. You start out with titanium tetrachloride.

SKOLNIK: So it is reduced...

VANDENBERG: You reduce that with aluminum alkyl.

SKOLNIK: How you reduce determines the crystal structure of the titanium?

VANDENBERG: Right, right.

SKOLNIK: So it is the reduction conditions?

VANDENBERG: That's right.

SKOLNIK: Did you get involved in a lot of reaction rate studies of these reactions?

VANDENBERG: No.

SKOLNIK: Did you run reaction rate studies?

VANDENBERG: No.

SKOLNIK: Did anyone else at Hercules?

VANDENBERG: Well, these are heterogeneous systems.

SKOLNIK: Well, what was Breslow doing at this time, while you were doing this? Was he working parallel to you or was it a different area?

VANDENBERG: Well, Dave was also interested in this kind of work but his work was mostly on ethylene. You know, there were problems with making polyethylene, molecular weights etc.

SKOLNIK: Yes.

VANDENBERG: He had discovered the bis(cyclopentadienyl) titanium dichloride homogeneous catalyst for ethylene polymerization (17).

SKOLNIK: But that was in the literature too, wasn't it?

VANDENBERG: Well, the compound was.

SKOLNIK: The compound was, but not for ethylene polymerization.

VANDENBERG: Not as a component of the Ziegler catalyst. Of course, it might have been implied that it might be useful but, you don't know until you try it. It's such an unusual compound; you couldn't predict that it would necessarily work and...

SKOLNIK: Of course, he got that idea from ferrocene, didn't he?

VANDENBERG: Right, he had done much work on ferrocene.

SKOLNIK: Well, there were a lot of publications on ferrocene before he started working with ferrocene. Well, how about other people at Hercules involved in the polypropylene problem? [Eugene D.] Klug got involved. Also [Walter] Thomas, [William M.] Schilling, and [Benjamin C.] Repka for a while?

VANDENBERG: That came later. I worked on polypropylene about a year and a half before Hercules saw the light of day. They did nothing on it for at least a year after I did my work.

SKOLNIK: They were sold on polyethylene.

VANDENBERG: Yes, they were pushing polyethylene and...

SKOLNIK: Parlin was the first plant for polyethylene.

VANDENBERG: That's right. It wasn't until Paul [L.] Johnstone started pushing that the operating part of the plant started to work on it; Bill Schilling worked on it.

SKOLNIK: That's right, Bill Schilling worked in the laboratory on polypropylene.

VANDENBERG: Yes, Bill Schilling, Walt Thomas, Gene Klug, and Ben Repka worked on the catalyst for polypropylene.

SKOLNIK: And that was separate from you completely?

VANDENBERG: Well, you know, I wasn't working on it anymore. I found other things.

SKOLNIK: What other things?

VANDENBERG: Well, I was trying the Ziegler catalyst for polar monomers. It was my intention to work on vinyl ethers using coordination catalysts to make isotactic polymers.

SKOLNIK: They were new? Was that a new polymer, actually?

VANDENBERG: Well, they were known. [Calvin E.] Schildknecht did work on these things. In fact, they were the first stereoregular polymers and were reported in 1947 (18).

SKOLNIK: But they weren't isotactic.

VANDENBERG: Well, they may not have been recognized to have been isotactic at the time--but they were, really. However, his polymers were not highly isotactic and so we were able to make them more isotactic and give them different solubility properties.

SKOLNIK: That's because of the kind of Ziegler catalysis you were using...

VANDENBERG: Well, we weren't, really. We started out with Ziegler and did develop a particular and unusual combination which worked fairly well, but the Ziegler catalysts weren't that good. We did discover a whole host of other catalysts.

SKOLNIK: That's what I remember.

VANDENBERG: We were making isotactic vinyl ether polymers, and a Hercules operating department got interested in poly(methyl vinyl ether) which, in isotactic form, was a water-swellable but water- insoluble polymer. A fair amount of pilot plant work was done on that polymer, but it was not developed commercially. After that we went on to the epoxide polymers, again starting out with a Ziegler kind of catalyst, but we found that there were other things that were a lot better than Ziegler catalysts e.g., using various aluminum, zinc, magnesium, organometallic-based catalysts. That was very early in our work.

SKOLNIK: Still using alkyl groups? Was the organo group alkyl, or something else for the epoxides?

VANDENBERG: We started with organometallics. Actually, we started with a Ziegler catalyst based on an aluminum trialkyl related to our vinyl ether catalyst. In checking out the system on epichlorohydrin with the aluminum trialkyl alone, we got much better yield to a fairly high amount of a new polymer, a rubber, actually. By the way, we used an old bottle of epichlorhydrin because it was around the lab, since we wanted to run this experiment right away.

SKOLNIK: Was that safe, was that smart for you to use an old bottle of epichlorohydrin?

VANDENBERG: Well, in this case it turned out to be the very smart thing to do.

SKOLNIK: You mean it already had hydrolyzed? To the glycol?

VANDENBERG: When we went to do it over again with a fresh bottle, it didn't work.

SKOLNIK: Oh, Lord. [laughter]

VANDENBERG: So we hypothesized and...

SKOLNIK: You needed some hydroxyl groups in there?

VANDENBERG: We needed some water in it. And so we reacted the aluminum trialkyl with 0.5 mole of water per Al and, sure enough, it was a very good catalyst.

SKOLNIK: So actually this was serendipity on your part.

VANDENBERG: Right. That was the discovery of a whole new family of catalysts.

SKOLNIK: And products, too.

VANDENBERG: Indeed. The first one we developed was an epichlorohydrin elastomer. Did a lot of work on this and other polyepoxides.

SKOLNIK: I assume that you are more proud of that work than anything else you ever did.

VANDENBERG: Well, it was one thing that we had discovered and developed independently of others.

SKOLNIK: It's really yours.

VANDENBERG: I stuck pretty much with it from beginning to end.

SKOLNIK: You fought pretty hard for it too, I remember.

VANDENBERG: Yes. A hard row to hoe too, as you know. Bob [Robert W.] Cairns decided to sell it and worked out a licensing deal with Goodrich. And we cooperated with them and I was involved in the whole thing.

SKOLNIK: You had to go to Avon Lake to visit Goodrich?

[END OF TAPE, SIDE 2]

VANDENBERG: We went out to Goodrich at Avon Lake, Ohio; myself, a chemical engineer and...

SKOLNIK: Who was the chemical engineer?

VANDENBERG: Joe [Joseph] Aid; also some of the people working on the applications areas, Lyle [O.] Amberg, [W.] Dean Willis. Then on some occasions, Goodrich came to Hercules and saw the pilot plant operations, etc. We helped Goodrich with the business and told them all we knew, and they finally got in the business and we kept working on the areas that needed to be developed. Goodrich had pointed out a variety of deficiencies. A lot of work was done on improving stability, improving the process, and a variety of things. We continued looking for applications and did much work looking at the elastic thread area. We had a cooperative arrangement with a company up in New England, the United Elastic Thread Company. We did a lot of work on that, and it looked like a pretty interesting elastic thread and this was a potentially big market. Because, I think, of this work, Hercules became interested in producing this rubber and ultimately the operating department took it over and developed their own process information.

SKOLNIK: To be in competition with the people we licensed it to?

VANDENBERG: Right. Ultimately, Hercules went into commercial production. And actually...

SKOLNIK: Where did Hercules make the rubber?

VANDENBERG: Hattiesburg.

SKOLNIK: Was there any reason for Hattiesburg, other than something else for Hattiesburg to do? They had no raw materials there to speak of.

VANDENBERG: No, the plant was available with all the accessories, steam, land, water, etc.

SKOLNIK: Gibbstown was probably overloaded with other things then, too.

VANDENBERG: Well, this was in the operating department in Hattiesburg.

SKOLNIK: Still made in Naval Stores.

VANDENBERG: No, the paper chemicals department took over and decided to commercialize this rubber; and, of course, it was the department that dealt with the rubber industry for many years.

SKOLNIK: Gibbstown was the big plant for most of their stuff, but not for Naval Stores.

VANDENBERG: Gibbstown wasn't paper chemicals. It was the paper chemicals department that handled the emulsifier and hydroperoxides throughout the rubber industry.

SKOLNIK: So it was the salespeople who determined it went to Hattiesburg--sales and marketing people.

VANDENBERG: The Hattiesburg operation actually was in the paper chemicals department with the various rosin derivatives, etc.

SKOLNIK: Hattiesburg was not known for having a lot of real good chemists and chemical engineers.

VANDENBERG: Well, I think it was a mistake. However, recently Hercules sold that business to Goodrich.

SKOLNIK: I know.

VANDENBERG: So now Goodrich has the entire business. Actually, Hercules did a very good job developing the market for these elastomers, and I think they wound up with a better process and better product and a large part of the market.

SKOLNIK: That's amazing since Goodrich knew more about the customers than we did.

VANDENBERG: Yes, I think they did a very good marketing job, and I found out later that Goodrich hadn't really put a lot of effort into it, you know. Of course, now they have a different philosophy and it could work out. (In 1989, Goodrich sold their specialty elastomer business to Nippon Zeon, and now the epichlorohydrin elastomer plant at the Hercules Hattiesburg plant is owned by the Japanese!)

SKOLNIK: Now, we're in the 1960s with the epoxy rubbers. It could be early 1970s, couldn't it?

VANDENBERG: Well, you know, I continued working there throughout the seventies and did related studies.

SKOLNIK: Were you playing around with different kinds of monomers?

VANDENBERG: Well, I continued scouting for other areas and looking for possible new polymers.

SKOLNIK: Like what? How did you broaden your interests?

VANDENBERG: Well, one of the substantial programs that we initiated was to make some rigid chain water-soluble polymers. This was probably started around 1979.

SKOLNIK: This was different from Jerry Keim's kind of polymers?

VANDENBERG: Oh, yes. In fact, we just gave two papers on that at this meeting (19). Hercules released the information a year or so ago and decided not to pursue it or patent it.

SKOLNIK: What area is this? What are we talking about now?

VANDENBERG: Well, these are water-soluble polymers that were designed to be very unusual.

SKOLNIK: Based on what monomers?

VANDENBERG: Well, one is like a sulfonated Kevlar, i.e., a sulfonated aromatic polyamide. We made it by a condensation type of polymerization. We used terephthaloyl chloride and a ring sulfonated 1,4-diaminobenzene.

SKOLNIK: You couldn't sulfonate the Kevlar itself?

VANDENBERG: Well, that was in the literature but they hadn't tried to make water-soluble polymers like we did.

SKOLNIK: You wanted more sulfonate groups than you could do by sulfonation of Kevlar.

VANDENBERG: We tried, but it was difficult to control. It's possible that one might do it in a limited way, but once you knew what the results are...

SKOLNIK: It is better to get it by copolymerization or co-condensation?

VANDENBERG: This was a sizable program, two or three Ph.D.s working on it for a while. We had cooperation with the University of Lowell, via a contractual arrangement. We did come up with some interesting products but Hercules did not feel inclined to further develop the area.

SKOLNIK: Not enough for Hercules?

VANDENBERG: Hercules didn't feel that they were good enough, you know.

SKOLNIK: For a scientist it isn't always necessary to come up with a commercial product. Some new chemistry makes it interesting.

VANDENBERG: I think it was a very interesting piece of work that conceptually was, and potentially still is, of interest for further study. It's possible that Dr. [Joseph] Salamone and I might decide to pursue it, I'm not sure.

SKOLNIK: He's in textile chemistry, isn't he?

VANDENBERG: No. He has done a lot of work on water-soluble polymers.

SKOLNIK: For what, textile treatment?

VANDENBERG: No. He works at Lowell. Actually, he is the inventor of the Boston contact lens. That was work done at Lowell University. He set up a separate company and developed it commercially.

SKOLNIK: That's a soft lens you're talking about or a hard lens?

VANDENBERG: Hard lens. And it has been very successful.

SKOLNIK: Except that it is being replaced with the soft lens, now?

VANDENBERG: Well, I don't know. They're both being marketed. And what the outcome will be, I'm not sure. But that company was finally sold to Bausch and Lomb.

SKOLNIK: That was quite a few years ago.

VANDENBERG: A couple of years ago.

SKOLNIK: Okay.

VANDENBERG: Over the last ten years at Hercules, I did a fair amount of work on water-soluble polymers at one time or another.

SKOLNIK: Can you classify the type of work you did?

VANDENBERG: Well, part of it was on the hydroxy polyethers. I did fundamental work on glycidol polymerization, and discovered a new rearrangement polymerization of glycidol which I actually wrote up after I retired.

SKOLNIK: I remember that.

VANDENBERG: Came back for a while, sometime after I retired. Wrote that up and then I used that work, with Hercules permission, as a basis for a proposal to NSF and ARO [Army Research Organization] to get money for research at ASU. And we did get the funding.

SKOLNIK: Arizona State University is the reason you moved to Arizona? I know you talked about the beautiful area out there when you were much younger.

VANDENBERG: No, we had been going out to Arizona for many years.

SKOLNIK: Before retirement.

VANDENBERG: Before retirement. We owned property out there and actually, we went out every year for two or three weeks.

SKOLNIK: You owned land or you owned the house on the land? And the land?

VANDENBERG: We actually owned a lot of things.

SKOLNIK: Oh.

VANDENBERG: We had a trailer court adjacent to Arizona State University which we operated.

SKOLNIK: You went into the real estate business.

VANDENBERG: Yes, I owned a fair amount of real estate. My daughter helped to manage some of it while she was out there. My son had been there.

SKOLNIK: Maybe we had better get to your family.

VANDENBERG: Married in 1950 to Mildred Elizabeth Wright.

SKOLNIK: She was from Delaware?

VANDENBERG: She was born in New Jersey, as I was. But a different area of the state.

SKOLNIK: How did you meet her?

VANDENBERG: Her family had moved to Delaware in, I suppose, the late 1930s. She worked for Du Pont as secretary.

SKOLNIK: Oh. She didn't go to college.

VANDENBERG: No. She went to business school.

SKOLNIK: To be a good secretary?

VANDENBERG: I was living out in Belmont at the time, I guess, with one Du Ponter and a couple of Hercules fellows. The Du Ponter introduced me to her.

SKOLNIK: You met her in Delaware, not in New Jersey.

VANDENBERG: About 1949 probably.

SKOLNIK: Then you married in 1950. How many children do you have?

VANDENBERG: Well, we have two. A boy and a girl.

SKOLNIK: Was your son the kind of student you wanted out of a son; and also your daughter?

VANDENBERG: Well, my son was a fair student, he really didn't apply himself until toward the end of his college career when he realized the importance of it.

SKOLNIK: He majored in what in college?

VANDENBERG: Well, it was a liberal arts college.

SKOLNIK: Where, in Delaware?

VANDENBERG: No, Lynchburg College in Virginia.

SKOLNIK: What's the difference in their ages, your son and daughter?

VANDENBERG: Two years. My daughter went to the same college.

SKOLNIK: What did she major in?

VANDENBERG: She had a business orientation.

SKOLNIK: Is she married or still working?

VANDENBERG: Not married and manages a bookstore in Sun City.

SKOLNIK: So you see her practically every week then.

VANDENBERG: Yes, we see her frequently.

SKOLNIK: Your son's in Arizona, too?

VANDENBERG: In Nevada.

SKOLNIK: Oh, that's pretty close.

VANDENBERG: Well, 750 miles. We do see him three or four times a year; he has two children. Both my children are divorced, unfortunately.

SKOLNIK: Oh, that's normal today. Well, now I would like to get into the honors you received in your life. What was your first award? Is it the one in Delaware, the Best Paper Award?

VANDENBERG: Well, I guess my first honor was being elected to Tau Beta Pi, in college.

SKOLNIK: That's the honor fraternity.

VANDENBERG: Honorary engineering fraternity. But the first chemistry award was that one in the Delaware section.

SKOLNIK: Best Paper Award.

VANDENBERG: Yes, Best Paper Award, about 1965, something like that.

SKOLNIK: The next award, I think, was the Polymer Division.

VANDENBERG: No, I got another Delaware Section Award when they changed the nature of the local section award.

SKOLNIK: You gave a talk on your award.

VANDENBERG: The next one, I guess, was the ACS Polymer Chemistry National Award.

SKOLNIK: You had an honorary doctorate from Stevens. You were chairman of the section too, in 1976.

VANDENBERG: Yes.

SKOLNIK: You had another office in the section too, secretary or treasurer, I can't remember.

VANDENBERG: Never secretary.

SKOLNIK: Then you were also chairman of the Polymer Chemistry Division.

VANDENBERG: Yes, and a variety of posts in the Polymer Chemistry Division.

SKOLNIK: How about the Gordon Research Conferences?

VANDENBERG: I was chairman of the Gordon Polymer Conference.

SKOLNIK: Who would you say, throughout your scientific life, had the most influence on you? Or was it a series--a lot of good people that came along at the right time?

VANDENBERG: [laughter] Well, I guess a whole host of people influenced me.

SKOLNIK: Was Spurlin near the top of the list?

VANDENBERG: Certainly, Harold helped me a lot.

SKOLNIK: How about your colleagues? Like Boardman, Breslow, or Keim, or Bob Cairns--did they have any effect on your outlook on science? Help you in any way? With discussions and so forth--or arguments?

VANDENBERG: Well, I don't know. These things certainly have some influence, no question about it.

SKOLNIK: You were in a hell of a good environment, and that helps.

VANDENBERG: Sure, sure.

SKOLNIK: There were a lot of people at Hercules that affected you; also your friends at Du Pont and also from the Polymer Division.

VANDENBERG: I was on the ACS patent committee. Actually, it was through my auspices that the Creative Invention Award was formed.

SKOLNIK: You promoted that. That's a good award.

VANDENBERG: Yes, that's a very important award.

SKOLNIK: Most awards go to academic people and not to industry.

VANDENBERG: That's an area that is sadly neglected. But it wasn't too hard to get it through.

SKOLNIK: Your appointment at Arizona State was after you retired--or was it simultaneous?

VANDENBERG: Well, you asked me before why I went there.

SKOLNIK: Well, you mentioned your real estate.

VANDENBERG: Well, I didn't pick ASU but I did pick the area, and I wanted to continue working professionally so I went to the chairman of the chemistry department--before I retired, actually.

SKOLNIK: Oh. During the vacation period.

VANDENBERG: I was encouraged with my contact, and I was appointed an adjunct professor about three months after I retired. I worked out the fine details and was appointed in July 1983. But it was pretty contingent on my getting support.

SKOLNIK: Oh, I see. You had to get your own support funds.

VANDENBERG: I wasn't receiving any monetary support.

SKOLNIK: As an adjunct.

VANDENBERG: That's right.

SKOLNIK: With adjuncts--they tend not to receive monetary support, correct?

VANDENBERG: Well, that's what I found out recently, because I'm now called visiting professor.

SKOLNIK: Oh. A permanent visiting professor.

VANDENBERG: Because of not getting paid from university funds.

SKOLNIK: Through the NSF?

VANDENBERG: It's not their money, it's the government's money. They don't look at it that way, but, anyway...

SKOLNIK: Because the university gets a cut out of whatever grants you receive.

VANDENBERG: Well, they get all the money, you know. I'm paid as a regular employee. If I hadn't gotten research funds, I wouldn't be there.

SKOLNIK: You'd be consulting--perhaps not at the university, but you would still be in Arizona.

VANDENBERG: Still in Arizona.

SKOLNIK: Are you still consulting?

VANDENBERG: I'm doing a little, yes. Patent litigation, and at present I'm consulting with Goodrich and Nippon Zeon on the epichlorohydrin elastomers.

SKOLNIK: Quite a few of the retired chemists in Delaware are in these patent litigation suits; that seems to be the most fertile field.

VANDENBERG: No question. If you get involved in patent litigation, it is usually quite a lengthy consulting job.

SKOLNIK: The lawyers like to extend those things. That's where their money comes from, by extending them.

VANDENBERG: Very worthwhile activity.

SKOLNIK: What do you spend, five percent of your time as a consultant, or less?

VANDENBERG: Probably less.

SKOLNIK: That's the way it is for my friends in Delaware.

VANDENBERG: I haven't really worked very hard on getting consulting activity.

SKOLNIK: You are busy enough without that?

VANDENBERG: Oh, yes. I have plenty to do.

SKOLNIK: What do you do besides the university?

VANDENBERG: Mostly look after my business interests.

SKOLNIK: Your real estate.

VANDENBERG: Real estate, stocks and bonds, and things like that. Investment is probably a major part of my activities. We have traveled around the world, mostly professionally-related, depending on what I am doing. I've been to Russia as a guest of the government.

SKOLNIK: Is that to lecture?

VANDENBERG: To lecture and visit.

SKOLNIK: You lectured, of course, in English.

VANDENBERG: Yes, and then we went to China on the same basis. That was after I retired. Guest of the Chinese government; thought I would collect some postdocs.

SKOLNIK: Oh. You have to go to Japan for that.

VANDENBERG: Well, I thought that too, and did visit Japan.

SKOLNIK: Or Taiwan.

VANDENBERG: I had one Japanese interested, but it was a question of monetary considerations and I didn't get anyone.

SKOLNIK: As a graduate student or a postdoc?

VANDENBERG: No, as a postdoc. The company would have sent him to me.

SKOLNIK: Oh.

VANDENBERG: I thought the company should pay. Which, I gather, is the usual way of doing it.

SKOLNIK: Did Howie [Howard G.] Tennent ever have an influence on your work at Hercules?

VANDENBERG: I suppose he did, to a certain extent. We were all given pretty much a free hand.

SKOLNIK: You were more independent than most, I think.

VANDENBERG: Yes, I was pretty independent. That's kind of the way I operated.

SKOLNIK: Okay. If there is something else you can think of that you could add that would be of interest to polymer history, in terms of people you knew in polymer chemistry and their effect on you or their effect on the area of polymer chemistry.

VANDENBERG: It's just an interesting little sidelight that, when it became obvious that I was going to get a government grant for this work at ASU, the first person I contacted to get a postdoc was Carl Marvel. Called him up on the phone and he recommended someone he had interviewed a year or so before. I contacted him but--I won't give you all the details--he wasn't immediately available, but after a while became available; after going through maybe two ads in Chemical & Engineering News and 30 candidates, we finally hired this fellow, Dr. Jeffrey C. Mullis, that Carl Marvel recommended. He has been excellent.

SKOLNIK: He was from the University of Arizona.

VANDENBERG: No, Marvel had just interviewed him.

SKOLNIK: Isn't Marvel at the University of Arizona?

VANDENBERG: Yes. But my postdoc, Dr. Mullis, didn't go there.

SKOLNIK: Well, I guess that's the end of the interview.

VANDENBERG: Okay.

[END OF TAPE, SIDE 3]

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