CHEMICAL HERITAGE FOUNDATION

A. DONALD GREEN and WILLARD C. ASBURY

Transcript of an Interview
Conducted by

Peter J. T. Morris

at

Westfield, New Jersey

on

9 December 1985

(With Subsequent Additions and Corrections)

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

A. DONALD GREEN

1905	Born in Boston, Massachusetts on 24 October
1988	Died in Mountainside, New Jersey on 26 April

Education

1926	S.B., chemical engineering, Massachusetts Institute of Technology
1927	S.M., chemical engineering, Massachusetts Institute of Technology

Professional Experience

1927-1929	Chemical Engineer, Atmospheric Nitrogen Company
1929-1930	Chemical Engineer, Solvay Process Company
1930-1935	Chemical Engineer, Standard Oil Company
1936-1954	Director, Development Division, Esso Research and Engineering Company
1955-1958	Deputy Coordinator, Chemical Research, Esso Standard Oil Company
1958-1966	Vice President, Enjay Chemical Company

WILLARD C. ASBURY

1900 Born in Portland, Maine on 16 December
1986 Died in Westfield, New Jersey on 27 April

Education

1925 S.B., chemical engineering, Massachusetts Institute of Technology

Professional Experience

1925-1927 Research Assistant, Laboratory of Applied Chemistry, Massachusetts Institute of Technology
1927-1929 Chemical Engineer, Standard Oil Company of Louisiana
1929-1930 Chemical Engineer, Standard Oil Development Company
1930-1933 Chemical Engineer, Hydrogenation Engineering and Chemical Company
1933-1935 Chemical Engineer, Standard Oil Development Company
1935-1936 Chemical Engineer, Standard Oil International Company
1936-1940 Executive, Standard Oil Company, International Associates Ltd.
1940-1941 Assistant to Vice President, Standard Oil Development Company
1941-1947 Manager, Research and Development, Standard Oil Development Company
1947-1964 Vice President and Director, Esso Research and Engineering Company
1964-1965 Executive Vice President, Esso Research and Engineering Company

ABSTRACT

Peter Morris starts this interview by asking Donald Green and Willard Asbury about the early years at Standard Oil Development Company and the influence of Frank Howard and Eger Murphree. The arc process is discussed as well as the level of assistance obtained from IG Farben; Green and Asbury recall the IG research organization. The wartime pressures during the development of GR-S, and the problems at the Baton Rouge plant are discussed by Green, while Asbury tells of his visit to Germany with the U.S. Strategic Bombing Survey. The political recriminations of the prewar cooperation between Standard Oil and IG Farben are recollected as are visits to Germany in the 1930s and 1950s. The interview ends with a survey of the postwar move into chemicals, the Ziegler process and the future of the oil and petrochemical industries.

[NOTE: Both Donald Green and Willard Asbury died before this interview was edited and annotated.]

INTERVIEWER

Peter J. T. Morris is currently a Senior Curator at the Science Museum, London, where he looks after the experimental chemistry collection. He was the Royal Society-British Academy Research Fellow at the Open University, Milton Keynes, between 1987 and 1991, and Edelstein International Fellow in 1991-92. Morris was educated at Oxford University [B.A., chemistry (1978); D.Phil., modern history (1983)], and was a Research Fellow at the Open University from 1982 to 1984. During the period 1985-1987, Peter Morris was Assistant Director for Special Projects at the Beckman Center. He is author of Polymer Pioneers (1986), and The American Synthetic Rubber Research Program (1989) and co-author (with C. A. Russell) of Archives of the British Chemical Industry, 1800-1914 (1988). Morris also co-edited Milestones in 150 Years of the Chemical Indusrty (1991) and The Development of Plastics (1994).

TABLE OF CONTENTS

INTERVIEWEES: Willard C. Asbury and A. Donald Green

INTERVIEWER: Peter J. T. Morris

LOCATION: Westfield, New Jersey

DATE: 9 December 1985

MORRIS: Mr. Green, you mention your recollections of MIT in your memoirs (1). Now, of course, you went to MIT in a very important period when Warren K. Lewis was building up a tremendously important school of chemical engineering; you also mentioned Norbert Wiener. Is there anything about these two men that you would like to mention?

GREEN: Lewis, of course, was a consultant for the New Jersey company [Standard Oil] for many years and he was a very dynamic figure. A very interesting man, a very capable man with a lot of originality.

MORRIS: Did he have any influence on your career? I mean did he point you in any one direction while you were a student?

GREEN: I don't think so.

MORRIS: What about the later years when you were working for Jersey Standard yourself and he was consultant?

GREEN: I had some contacts with him then, but not too many. He was more involved in the petroleum end of Jersey's business than in the chemical side. Isn't that right, Bill?

ASBURY: He made many inventions in the petroleum field, most particularly in catalytic cracking using the fluid technique. He and Dr. [Edwin] Gilliland produced some very fine ideas. He gave us great help on fluid crackingusing catalytic techniques.

MORRIS: What was your recollection of Dr. Lewis?

ASBURY: Well, he was a very dynamic man and very inspirational, because he always had ideas which came out spontaneously. He had tremendous enthusiasm.

MORRIS: Would you say that he had a material effect on the research quality at Standard Oil?

ASBURY: I think that he had quite a lot of influence, yes. I think that [Robert P.]Russell and [Eger V.] Murphree were much impressed. Even before them, Mr. [Frank A.] Howard, who was the head of Standard Oil Development Company, got a lot of help from Dr. Lewis.

MORRIS: Of course, Frank Howard himself was a mechanical engineer.

ASBURY: Right. And a patent man, and a lawyer. Yes.

MORRIS: What was your recollection of him, Mr. Green?

GREEN: Mr. Howard? Well, I admired him. He was very far-seeing and he recognized about 1930 or even earlier that this country had to get into synthetic rubber. The price of rubber kept going up and down--it would go from a nickel a pound up to a dollar a pound. Rubber is very important to the automobile industry, as much as gasoline. So that's how we got into the electric arc process because that was the only way known to make [acetylene for conversion to] butadiene for Buna type rubber (2).

MORRIS: To what extent did Frank Howard control the direction in which the Standard Oil Development Company moved? The electric arc process, was that his personal desire to move into this field?

GREEN: No, I don't think so. He visited the IG [I. G. Farben-industrie Aktiengesellschaft] in the late 1920s, about 1926 or 1927, and was tremendously impressed by them. At that time they showed him their synthetic rubber, which wasn't of very good quality.

MORRIS: What were your personal impressions of Frank Howard? I mean when you first met him in 1930.

GREEN: As I said, I admired him a great deal. He was a sort of a cold person, as far as personal relations go.

MORRIS: Would it be true to say that Frank Howard never received the backing from Jersey Standard as a whole that he perhaps felt that his ideas entitled him to? I get the impression that, to some extent, he was going ahead of the pack and he didn't always get full support.

ASBURY: Well, I think they gave his ideas a lot of support in the early days, from the 1920s on. I was in Germany with Mr. Howard when we met with the IG and visited their plants. Then Mr.[Walter C.] Teagle and others from the New York office came over, had several meetings with IG Farben and cooked up the beginning of a deal with them. We were very impressed with their work, their techniques, their equipment and the way they were going about things. We wanted to get their help. Also, you have to realize at the time there was a shortage of gasoline. [This was before the East Texas field was developed.] The price of gasoline had gone to a dollar a gallon and it looked as if we were in for a big shortage. We visited their synthetic oil plant at Leunawhere they obtained oil from coal [via hydrogenation over a nickel catalyst at 4000 psig] and we considered that this would be a way to avoid an oil shortage in the United States. We wanted to get their background on handling oil and coal and converting them into usable petroleum products.

MORRIS: I was thinking of a somewhat later period, maybe the late thirties, when you were trying to persuade the government to develop synthetic rubber. I wonder how much support he was getting from them for that?

ASBURY: I think he was still getting their support. I think the trouble came in later, after he ran into all the difficulties with the government on the IG connection.

MORRIS: What was his reaction to the public attack on his motives? Was he very surprised by the reaction?

GREEN: I think I mentioned in there (1) that I heard him say once that he felt that the company shouldn't have agreed to that consent decree.

MORRIS: I think in 1945 Howard left the Standard Oil Development Company.

ASBURY: Yes, he was made a vice president of Jersey Standard around that time. We can check the date if you want to know.

MORRIS: I never heard a great deal about how his career ended. His book came out in 1947 and the account finished at about 1945 (3), so I never really learned much about what happened to him at the end of his career.

GREEN: Well, it's a very touchy subject. I will say generally that with all the troubles and with the bad publicity, they were a little cruel to Frank Howard. Before that they had made him a vice president so that he could have more status and prestige when he was dealing with foreign groups, but after all the troubles in 1947 and 1948 he ran into trouble with the people at the top.

MORRIS: Let me turn back a bit. You met Murphree at Solvay and I get the impression from what you wrote about him, that he was a person who hankered after theoretical physics. Do you think that, given the opportunity, he might have gone into theoretical physics?

GREEN: Well, I don't know. I don't think so, because he was more of an engineer. But he used theory to help the engineering.

MORRIS: He seemed to be a very remarkable person.

GREEN: He really was. No doubt about it. He was a real scientist. I worked for Murph when I was at Allied Chemical. He took the job with Jersey in connection with this IG Farben business and he offered me a job. [Osgood V.] Tracy and Bob Carrier also came and we were in Elizabeth for a while designing the plants. Then we all went to Baton Rouge, ran the plants, and then I guess he became head of the laboratory then, didn't he?

ASBURY: Yes, at Baton Rouge.

GREEN: There was a laboratory that was mainly working on hydrogenation as a consequence of this material that we bought from IG Farben. There were three hydro plants under construction and I drew the plans; I guess I mentioned that in my memoirs.

MORRIS: How did Murphree come to be connected with the Manhattan Project? He didn't seem to be an obvious candidate for the program.

GREEN: He was an outstanding engineer and he knew a lot of people who were connected with the Manhattan Project; [Harold] Urey, for example. He had a lot of contact with Urey and other people such as [Charles D.] Compton so it was quite natural for them to get him to work for the Manhattan Project. He went to a lot of their meetings and did a lot of work for them. He worked on the theoretical aspects of the diffusion process that was used to separate the uranium isotopes. Apparently he worked out the basic equations for the diffusion process and he was also interested in the centrifuge approach. We did a lot of work on the centrifuge approach. He had other people working for him on the diffusion and they made the uranium hexafluoride to make the separation.

ASBURY: Karl Cohen did.

GREEN: Yes, Karl Cohen did.

MORRIS: It's interesting in a way because Murphree was a key figure in the history of chemical engineering yet it's indicative of the lack of respect or recognition that chemical engineers get, that high school and university students probably know much more about someone like Urey.

ASBURY: Well, it's the same old story: scientists get a lot more publicity than engineers. That's the way it is. [laughter]

GREEN: Murphree was called to Washington, you know, after Sputnik. They called him a "missiles czar" for a while. He tried to straighten out our missiles, tried to get our own sputniks.

MORRIS: It is amazing how someone ends up with jobs quite unrelated to petroleum technology. Did he die at a relatively young age?

ASBURY: I think he was sixty-two.

MORRIS: What position did he hold then?

ASBURY: As I recall, he had been taken back to New York, and was vice president of Exxon.

GREEN: Yes, in charge of the scientific effort.

MORRIS: I see. He still liked to be on the scientific side?

GREEN: Definitely.

MORRIS: I think Clifton C. Garvin was the first chemist or chemical engineer to become president of Exxon.

GREEN: I'm not sure of that.

ASBURY: Well, we have a lot of people from the production end of the business as a consequence.

MORRIS: Let's move on a bit.

GREEN: We have had a lot of chemical engineers from MIT on the board over the years.

MORRIS: Yes, I was thinking of within the company.

Let me ask about the arc process. I don't quite know how it worked, nor the pros and cons of the process. It was used in Germany from 1940, and it worked pretty satisfactorily during the war, but afterwards, although various high temperature processes were on the market, with the exception of one Italian company that needed it briefly, no company has ever invested heavily in the arc process.

GREEN: Well, Chemische Werke Hüls did.

MORRIS: Wasn't that because it was installed back in 1940?

GREEN: Well, I don't know about that. At that time, the only way to make synthetic rubber was starting with acetylene. A few years later, it was realized--both they and us--that starting from butene or butylene was quite a lot better.

MORRIS: I'm trying to compare the arc process with the carbide or other high temperature processes.

ASBURY: Well, we compared them and the arc process was favored.

MORRIS: Aren't there three basic problems with it? First, you get a lot of carbon black.

GREEN: Just enough to cause a little trouble if you go right into the compressors without washing out the carbon particles. That was not a major problem at Baton Rouge.

MORRIS: The second problem, that I heard about from the Germans, was that the process does tend to produce a certain amount of vinyl acetylene and divinyl acetylene.

ASBURY: Diacetylene.

MORRIS: Which is explosive and therefore can cause problems at the firing end.

GREEN: Well, it didn't give us any great problems. What we did at the Baton Rouge plant was to wash the hot gas with oil and take out those heavy compounds. As I remember, we used natural gas that we treated with the arc to strip out those materials. So, we didn't really have any problems with that.

MORRIS: The last problem (it's not really so much a problem as a barrier) is that although the process itself probably used only about two-thirds as much electricity as the carbide process, a lot of this advantage is lost in refining. Carbide acetylene can be used directly while with arc acetylene a purification stage is necessary. Would you like to comment?

GREEN: Depends on what you are going to use it for.

MORRIS: At Baton Rouge you weren't trying to refine it very much, were you?

GREEN: Well, we washed it with oil to get out the heavy compounds and we got out the carbon black, then we converted the dilute gas to acetaldehyde, but it wasn't a very good process. It used an impregnated pumice catalyst but we found cuprene as a by-product, because of copper contamination (4). Otherwise, the more usual mercury process, mercury and ferric sulfate, could have been used, but that was kind of messy.

MORRIS: At Hüls they said that the consumption of electricity was still quite good, even when taking the refining into account, but the co-formation of by-products such as ethylene has to be considered (5).

ASBURY: Who were you talking to, did you say?

MORRIS: The engineers at Hüls.

GREEN: Remember who they were?

MORRIS: I cannot recall offhand. They commented on the balance of electric power used for various processes.

ASBURY: This is fairly recent, isn't it? Your talking with them?

MORRIS: Oh, yes. About three or four years ago.

GREEN: Well, we wouldn't know anybody still there. [Paul] Baumann has retired, I understand. He was the head man.

MORRIS: Anyway, they pointed out that my thesis didn't take into account the co-production of other species.

GREEN: Of course, using ethane or propane consumes a lot less power.

MORRIS: Would you like to sketch the difficulties you had in developing the arc processat Baton Rouge?

GREEN: Well, the first difficulty was the carbon black, which can be washed out with oil. The Germans hadn't told us about that.

ASBURY: No, you developed that in Baton Rouge, didn't you?

GREEN: That was rather a surprise. Well, we just put in a couple of towers and washed the stuff out. And we went to reciprocating compressors, I remember, reciprocating compressors which have valves which can get plugged up with carbon black, but it wasn't too bad.

MORRIS: You didn't ever have to put the tubes out of action to clean them?

GREEN: To clean the compressor?

MORRIS: No, the actual arc tubes. The Germans had a policy of putting some tubes out of service in order to clean them.

GREEN: Well, we had a spare set. We had two arcs, and used one at a time, you see. But the arc itself didn't have to be cleaned. The flame tube would burn out once in a while.

MORRIS: I may be confusing two different things here. The tubes burning out and carbon black deposits.

GREEN: Our main problem at Baton Rouge was with the acetaldehyde plant because of the catalyst. It had a poor efficiency and it became obvious that it was not satisfactory, so I was sent over to Germany to look at their plant at Knapsack for converting acetylene to acetaldehyde using the mercury process (2). We built a pilot plant, we worked it all out and felt we had a good process. The acetic acid plant worked fine. We had no trouble with that at all. We reached a point, I would say in about 1938 or 1939, that we could have built a big plant.

ASBURY: We didn't really need one.

GREEN: The economics didn't look too good.

MORRIS: You solved the carbon blackproblem. Did you give the results to the Germans?

GREEN: Oh, sure. Paul Baumann and his crew. We had three or four good engineers there.

[END OF TAPE, SIDE 1]

MORRIS: What help did the Germans give you in developing the process? Apart from you actually being there and working with them, did significant help come over from Germany? I suppose the mercury process is the best example of the technical help that you got from Germany.

GREEN: Yes, I went over and got the information that was necessary. We built a pilot plant although it's a good thing we didn't build a big plant because handling mercury is a lousy job.

MORRIS: What were the plans in the early thirties? What was the ultimate aim as far as using the arc process in Germany was concerned? Was it only in connection with synthetic rubber, or for other kinds of acetylene chemistry as well?

GREEN: Well, that was considered the main purpose in the literature. I'm sure the Germans were interested in other uses for acetylene and they got into the Reppe process.

MORRIS: That was later. Standard was basically interested in the process for synthetic rubber?

GREEN: That was really our only interest. We weren't interested in selling acetic acid and all that sort of business.

MORRIS: I got the impression from one or two sources that • Standard developed the arc process at Baton Rouge simply as a sign of good will for the Germans. That there was never any serious intention to use the arc process in America; it was to do the Germans a favor.

GREEN: Well, we reached a point where we recognized that the arc process was not the best way to make synthetic rubber. By 1935, it was pretty clear it was not the way to do it.

MORRIS: As early as 1935?

GREEN: As I mentioned in the memoirs, it seemed better to go for the dehydrogenation of C_4 compounds. We didn't do anything to make the Germans feel good. There wasn't any point in that.

MORRIS: What was your impression of Paul Baumann in this period? How did he enjoy his stay in America?

GREEN: Well, he was one of my very best friends, ever since I first got to know him. I taught him how to drive an automobile.

MORRIS: What did you think was the difference between America and Germany in that period?

GREEN: Well, he came over here in 1930, about the time Hans Beller came, I guess. He lived in the same boarding house in Elizabeth as I did. His wife and little daughter were there, and we got very chummy. I taught him how to drive a car then. When I went over to Germany in 1933, he went with me. The two of us went together to get information on Knapsack and other things too, and Baumann was conducting me around when I talked to a lot of the laboratory people on the various new projects they were working on.

MORRIS: You got free access?

GREEN: Free access. There must have been ten to fifteen different projects. I would talk to the chemist and Paul Baumann would then write a memorandum as a paper record, so that I would get it straight. I brought the memoranda back to this country, so that there was no holdup in information at that point.

MORRIS: I was interested that you said in your memoirs that Paul Baumann was interested in chemical engineering in America. There's been a great deal of recent work on the fact that there have been few developments in chemical engineering in Germany. There, chemists are supposed to be able to handle the things done here by chemical engineers. Now, you yourself came from one of the great centers of chemical engineering. Did you sort of perceive that difference at the time?

GREEN: Yes. A hundred percent different. Germany didn't have any chemical engineers.

MORRIS: That's right even now.

GREEN: They did things by trial and error.

MORRIS: Do you think that was a great weakness of the German chemical industry?

GREEN: Probably was, but they got along all right. When I saw some of the plants, the plant to make soda ash, for example--I'd just worked for Allied Chemical on the biggest soda ash plant in the world, you know--what the Germans had was kind of childish.

MORRIS: In Germany did you get the feeling that the engineering was sometimes shoddy, not up to the same high standards you would have expected at Baton Rouge?

GREEN: Well, I think the machinery was pretty good.

MORRIS: Perhaps that was an indication of the part done by mechanical engineers. The things that were done by mechanical engineers were fine, and the things that were done by chemists were fine, but that in the middle wasn't so good.

GREEN: Well, Baumann was very interested to see how we did the engineering. He sat with me and observed what I did when I designed the equipment for the aldehyde plant and the acetic acid plant. I designed the equipment completely, even the heat exchangers.

ASBURY: I think the German chemists used to down-rate the engineers. I've heard them do it in the plants.

MORRIS: Let me ask two other quick questions. In your memoirs, Mr. Green, you say that the arc--the actual arc itself--is the temperature of the sun.

GREEN: Five thousand degrees, the Germans said, five thousand degrees Celsius. The surface temperature.

MORRIS: And how do you think the arc process compares with other forms of pyrolysis of hydrocarbons like the Ruhrchemie process?

GREEN: We looked at some of those later, the Wulff process. I don't know whether it's still used; I think it's dying out.

MORRIS: What about the Sachsse process? Where you have actual burning of hydrocarbon in situ, the BASF process?

GREEN: Hydrocarbons burning in oxygen?

MORRIS: Yes.

GREEN: I don't know.

MORRIS: I visited the German companies in 1980. It was interesting that the arc--the same arc--is still in the same equipment that was installed in 1940.

GREEN: Were they running the arc?

MORRIS: Yes, they were running the arc.

GREEN: In 1980?

ASBURY: Where was that?

MORRIS: In Hüls. Vintage 1940 equipment. A great deal of equipment that you wouldn't expect in a modern plant, and the equipment was massive, no miniaturization. I noticed the tremendous noise, a great knocking noise.

GREEN: From the compressors?

MORRIS: I couldn't pin it down, but a noise in the arc house itself.

GREEN: I guess there was a lot of noise.

MORRIS: Of course, you've got to remember that there were about twelve going at once.

GREEN: Yes.

MORRIS: One was altered so it could be opened to show the arc inside.

Now, perhaps you'll let me ask a general question about your impressions of the IG Farben laboratory at Ludwigshafen.

GREEN: A fascinating place to go to. The way they worked there was different from us. They would have little teams on a project. Baumann had four engineers working under him, maybe he had more, but all working on the arc process. And Beller and his crew were working on the oxidation of paraffin wax. They also had groups working in competition with each another, with the same general objective but working out different process routes.

MORRIS: It has been claimed that there was a deliberate policy of competition between laboratories— at any one time two laboratories might be working on competitive processes. I think that a lot of the competition was simply because Ludwigshafen would report some work on synthetic rubber, and then Leverkusen would point out that they had been doing something similar for ten years and that they were not going to give it up. So both would agree to carry on with it. A lot of this competition was really an attempt to mollify established interests in each of the laboratories, rather than some great master plan.

GREEN: Yes, I guess so, but I was thinking that, at Oppau, there was competition even within the laboratory. The people working in these groups knew about it and it didn't bother them. They were friends.

MORRIS: Could you give a specific example? It's very interesting.

GREEN: Well, acetaldehyde. I wish I had kept the files on that but I don't have them any longer. They were working on zinc chloride as a catalyst to convert acetylene to acetaldehyde. Acetylene and water and zinc chloride. That was supposed to compete with the solid catalyst.

MORRIS: Right.

ASBURY: Oh, I can give you an example in Oppau. Dr. [Martin] Müller-Cunradi had a little group working for him and they came up with the polymerization of isobutylene to polyisobutylene. On one of his visits, Mr. Howard was shown a sample of it. But it was a separate little group working on this thing. One of the reasons they did this, you know, was that the chemists were very

anxious to get patents in their own name. There was a competition for patent recognition which was very important in IG Farben.

MORRIS: That wasn't the case at Esso?

GREEN: Well, we had people who were competing to get patents but it was a little different there because they got remuneration for their achievement. They got some kind of share in the proceeds of the patent.

MORRIS: Two different points which I'd like to deal with briefly. The first concerns the patenting of isobutylene, because I read in Howard's book (3), that Müller-Cunradi and his group achieved that in the spring of 1932, or it might have been even earlier. When did they first polymerize isobutylene?

ASBURY: It must have been earlier than 1932, because I think we developed the process in a pilot plant here at Linden.

MORRIS: The earliest patent I could find in Chemical Abstracts was dated 1933 (6).

GREEN: Well, it takes time to get a patent issued, you know.

MORRIS: About Martin Müller-Cunradi, did you know him well?

ASBURY: I knew him quite well.

MORRIS: He's a bit of a mystery character, because...

ASBURY: I took him to Baytown, Texas once. [To Green] You weren't there.

GREEN: No, no, I wasn't there.

ASBURY: It was very interesting. He was a very nice guy.

MORRIS: What kind of person was he? What was his position in the IG, for example?

ASBURY: It's really hard to tell. He had an elevated position, but I couldn't exactly tell what it was.

MORRIS: That's one of the strange things about him. He was important in the development of synthetic rubber in IG Farben--perhaps more elevated than important. Perhaps he was the group leader rather than the inventor on some of his patents, but in the German histories he is noticeably downgraded.

ASBURY: Well, he was not really the inventor of polyisobutylene, but it seemed to me that he must have been pretty important. He made a special trip down to Baytown, Texas. I took him down there, and the chief engineer of Humble, Ernie Voss, and I took care of him. Ernie showed him all over the Humble plant, showed him everything. We didn't go for any special reason, as far as I could see. Just a general idea of the way things were done in the oil industry.

MORRIS: He died in 1945.

GREEN: Oh, he did?

MORRIS: I have never been able to find out how. Given the date I wondered whether it could have been suicide. His reputation is definitely downgraded. I wanted to find out more about this person when I went to Germany. I talked to some people, including some who might have been associated with him. When I mentioned him to people of his generation, they all said that he wasn't terribly important. "Let's move on to something else." [laughter] I really wanted to know more about him because in 1933 and 1934 he was the connection, the avenue of communication if you like, between the company and the government regarding synthetic rubber.

GREEN: Oh, was he?

MORRIS: He was the one who wrote the letters. Now, that seems curious for someone who was in charge of an ammonia laboratory. Certainly he had a lot to do with synthetic rubber, but even within the IG Farben framework, he seems far from being the obvious person.

GREEN: Where was he located?

MORRIS: Oppau.

GREEN: But synthetic rubber was a Leverkusen project.

ASBURY: Dr. [Otto] Ambros was quite important on synthetic rubber. He was with us when I was at Ludwigshafen.

MORRIS: Ambros is someone I want to ask about in a moment. Of course, he wasn't that important yet--until a little later.

ASBURY: He was quite an important man. I could tell that. I went out with him socially with a group of people. I was living in Germany in 1931 and 1932, and it was during that period.

MORRIS: I heard this story about him in Germany. He was the youngest director of IG Farben when the war ended in 1945, and that he owed his rise to power to the fact that he married the daughter of the factory chief of Ludwigshafen.

GREEN: Yes. Now, the reason we brought up Müller-Cunradi and polyisobutylene was that really helped us to inspire our people to make butyl rubber.

MORRIS: The Germans made a great mistake of never introducing a diene [as a comonomer]. Why do you think they failed to do that?

GREEN: Because they were only interested in GR-S.

MORRIS: I see.

GREEN: They weren't interested in butyl rubber even when it came along.

ASBURY: In 1938, [Fritz] Ter Meer came over from Leverkusen. He was their big synthetic rubber man. He came over and I think Russell talked to him. I was in the meeting, and butyl rubber was mentioned, but he didn't have any interest in BR at all.

MORRIS: Were the Germans offered butyl, were they offered the formula?

GREEN: Well, you read Mr. Howard's book. He talks about it. What does he say? I thought he offered it in one of the meetings.

MORRIS: Certainly, the Germans never used it. However, it is one of the allegations made against Standard for helping the Germans. But the only thing they used polybutylene for was, as you say in your memoirs, an additive like polyethylene. They used it, but only to a very small extent as a non-diene additive.

As you know, they had an interesting polymerization process where they mixed it with liquid ethylene so that the ethylene evaporation brought the reaction down to the required temperature as it flowed on to a plate.

GREEN: They mixed it with ethane (7).

MORRIS: Oh, was it? There was a scraper moving along the plate, removing the polymer.

GREEN: A peculiar apparatus.

MORRIS: They only made a small amount, about one thousand tons per annum.

ASBURY: One theory is that Mr. Howard offered them butyl rubber to try to get them to move on Buna rubber.

MORRIS: That is a point we might come back to. I have a good idea of what the IG research effort was like but I'd like to know about the attitudes of the laboratory scientists. Were they like academic researchers but working in an industrial location, or were they hard-headed about commercial success? I'm talking about the people at the bench.

GREEN: They were very interested in making a success of their work. When I went over there for several months in 1933, Hitler had been in power for a year and the chemists I was in contact with were anti-Hitler. They were pretty frank about it to me.

MORRIS: What about the people that we are speaking of--relatively low-level people? Paul Baumann would be a case in point. Can you name anyone else on that level working on synthetic rubber, who had an anti-Nazi attitude?

GREEN: Hans Beller. He was involved in the oxidation route.

MORRIS: What about the attitudes of the higher-ups? Senior people, people like Ambros.

GREEN: Who was the head of the laboratory there?

ASBURY: Dr. Mathias Pier was the head of the hydrogenation laboratory where I was. He was their top expert on hydrogenation of coal and oil. I got the feeling from discussions with him that he didn't care for the Nazis. But some of his assistants like Dr. [Fritz] Ringer, turned out to be very full Nazis.

[END OF TAPE, SIDE 2]

MORRIS: [to Asbury] You were actually working in Germany for a while?

ASBURY: I was the contact man with IG Farben in Ludwigshafen when we were getting the hydrogenation information, passing it back to Exxon.

MORRIS: What period were you in Germany?

ASBURY: 1931 to 1933.

[BREAK IN INTERVIEW]

ASBURY: We got into the Perbunan process. Butadiene-acrylonitrile oil-resistant rubber which was competitive with Neoprene. We started up the Baton Rouge plant in 1941.

MORRIS: What did people outside the company think America was going to do if it was cut off from supplies of natural rubber? Was the government going to depend on stockpiles alone?

GREEN: The American people couldn't have cared less.

ASBURY: And the government didn't care either.

MORRIS: It was a question that no thought was given to at all?

ASBURY: Frank Howard would go down to Washington time and time again, and talk to them [about the problem], but it didn't do any good.

MORRIS: Was this lack of governmental interest because Standard had a vested interest in getting into synthetic rubber?

GREEN: Could have been.

MORRIS: I suppose it would not have been practicable for Standard to have started up a really big program quite independently.

GREEN: Well, we couldn't get into manufacturing and expect to sell it, because it would have a much higher price than natural rubber. Like the problem with synthetic gasoline.

MORRIS: You could have argued that the country was very likely to be cut off and would run out of natural rubber.

GREEN: No, we couldn't tell whether it would be cut off. We couldn't be sure then. We weren't interested in getting into the general rubber business. Perbunan was different; that was a special product sold at a premium price.

MORRIS: How did you deal with the rubber companies to avoid potential conflict?

GREEN: Well they put up their own Buna N plants--Goodrich, Firestone, and, after a year, Goodyear.

MORRIS: What about Ameripol [originally, an acrylonitrile/ butadiene copolymer]?

GREEN: Goodrich.

MORRIS: Did Standard regard it as an infringement of their patent rights? Was Goodrich being deliberately provocative, trying to make capital out of a critical situation by producing it?

GREEN: I wouldn't be surprised.

MORRIS: The rubber companies thought that Standard was being unnecessarily uncooperative, in not giving them licenses for synthetic rubber. What did Standard think? Did Standard really have the technology to give them?

ASBURY: We didn't have it complete, but we developed our own process for making GR-S. Byron Vanderbilt developed a process in November 1939. He got a lot of help by reading the IG patent application for Perbunan. By the following May we had a pilot plant running at Baton Rouge. We designed a pilot plant while he was doing his lab work. A year later we had a commercial plant running at Baton Rouge, although its output was only five or ten tons a day.

MORRIS: It was better than nothing.

GREEN: But a couple of these other rubber companies were also active. They might have been a little bit behind us, I'm not sure.

ASBURY: You realize that later, under the auspices of the rubber program in Washington, there was a technical committee set up to exchange information on synthetic rubber.

MORRIS: The so-called Exchange Agreement.

ASBURY: Vanderbilt disclosed our laboratory results to them, and I think our formula [for GR-S] was adopted.

MORRIS: You have made explicit an interesting point. Standard was developing both Perbunan and GR-S independently, without any input from IG. Standard had the patent, but not practical hands-on information. Is this correct? That Standard was getting nothing from the Germans in 1937 and 1938?

ASBURY: Dr. Beller did help Vanderbilt read the patent application before the patent was issued. So he got an advanced look at what was going into the U.S. Patent Office. From there he got the key ingredient, modifying the GR-S reaction by the addition of mercaptan. You should talk to him.

MORRIS: That's one person I'm hoping to interview.

GREEN: You should, he just had a 50th wedding anniversary.

ASBURY: I just got a card from him the other day.

MORRIS: You were working on butyl rubber in Baton Rouge, and just got the whole thing going when the management told you that you'd have to double it up.

GREEN: We got the plant to work pretty well at Baton Rouge, under the conditions for which it was designed. Suddenly our management told the government that we could triple plant capacity. [To Asbury] Were you in on that?

ASBURY: No.

GREEN: Good thing.

MORRIS: That obviously came as a great shock to you.

GREEN: I think Howard and Murphree were down in Washington and made that suggestion based on something they had seen down in the lab a day or two before.

MORRIS: I suppose the company felt under pressure to come up with something good.

GREEN: No, that wasn't the reason. The reason they made the proposal was because of the shortage of strategic [stainless--later 3% nickel] steel. Alloy steel, chromium and nickel alloy, which we needed for the low temperature [polymerizer]. It was a problem to get, and if we got some, somebody else wouldn't. Howard thought he would be patriotic and made this proposal.

MORRIS: How does that fit in with the steel?

GREEN: Well, we could cancel one or two of the plants, not build them at all.

MORRIS: Oh, I see. The proposal was not so much to expand production per se, but to produce more with the same plant.

GREEN: Fewer units. We were talking about closing another big plant at Baton Rouge, as big as the Baytown plant. That was three times as big as the little plants. So that was canceled right away.

MORRIS: How did this break in communication come about? Did they just feel on the spur of the moment that it was something they could do?

GREEN: I don't know. I wasn't in on the discussion, you see. [laughter]

MORRIS: Did that create great problems? Is that part of the reason why Baton Rouge never worked fully?

GREEN: That was part of the reason, because as soon as that decision was made we had to try to run the reactors at three times the rate they were designed to run, so that they plugged up much faster, and we didn't have spare reactors to substitute while they were being cleaned out.

MORRIS: Presumably that was not a problem at Sarnia, for example.

GREEN: They didn't try to get this high production when they started out and everything there went fine (8).

MORRIS: Probably you could have gone to a spontaneous over-capacity, if you had not been forced to.

GREEN: Well, that's what happened at Sarnia. As the years went by the plant made more and more although they still had the very same equipment that we had in the first unit at Baton Rouge.

MORRIS: Well, you got bogged down with problems. There were conflicts, as you said in your memoirs. There was a conflict between the Standard Oil Development Company, for which you worked, and the Baton Rouge regulars who were more or less running the show themselves.

GREEN: They put a different crew in Baton Rouge.

ASBURY: Yes.

MORRIS: And you found that the people at Baton Rouge had more or less taken over control of it themselves.

GREEN: When I went down there the plant manager told me, "This is your project. You tell them what to do". In the meantime, the government plant was set aside as a separate organization, so the cost could be kept separate. The people running it were kept separate. The plant manager didn't know anything about chemicals; he couldn't care less. Perhaps I shouldn't say that but, anyway, that's the fact.

So they didn't do what I wanted them to do. But the main trouble was to try to get three times the capacity out of something that wasn't designed for it. The local laboratory people made suggestions--you add this, change this and all that. Every time this was done the plant had to shut down to make the change. Then the operators of the plant had to switch around to other units, so that nobody got less money than he was suppose to get. They got new jobs, and the ones that came back to the plant when it was started up again needed to be retrained. That happened about three times. That's why Baton Rouge was so slow in coming up to production.

MORRIS: I understand your problem. That would be a problem on other polymer plants.

GREEN: On the butyl plants?

MORRIS: Well, other butyl plants and GR-S plants.

GREEN: Changes weren't made in those plants the way they were in this plant.

MORRIS: Was unionism stronger at Baton Rouge than in other parts of Exxon?

GREEN: I wouldn't say that, not at the time.

ASBURY: You have to realize that the Baton Rouge refinery had a lot of new projects coming in, new catalytic cracking units, new rubber units, everything popping up, and as soon as a new unit came in they had to start shifting workmen around. It was a question of seniority; the senior people would get a shot at the new plant. That caused frequent disruptions in our labor force at the butyl rubber plant. New people had to come in and be trained. It's a process that had to be run carefully.

MORRIS: What is the difference between a tubular reactor and an annular reactor?

GREEN: A tubular reactor, if I can remember [Green sketches a diagram], had a lot of tubes in it and there was a pump here, so the material would be pumped up, come back through the tubes, and go up again. An annular reactor was made longer to get more surface area. It still had the pump, but instead of the tubes there was annular circulation.

MORRIS: I see. The water goes around the wall.

GREEN: Not water, the methyl chloride solution of the rubber.

MORRIS: The description of the reactors refers to the arrangement of the water pipes.

GREEN: There's no water in them; they are fluid pipes.

MORRIS: Now I see what you mean.

You also mentioned how Paul Flory had helped you out with the butyl work but you also said he didn't work very long on this wartime project.

GREEN: He was very helpful. I was interested in the theory of polymerization. The butyl reaction is instantaneous. I wanted to get some idea of the effect of concentration of the reactants, temperature, and that sort of thing, on the molecular weight of the polymer, unsaturation in the product and so on.

MORRIS: Molecular weight distribution?

GREEN: I talked to Paul as he was the expert in the field, and he gave me some ideas on how to get data and how to correlate the data. I got Dr. Joe Nelson to make laboratory tests at small conversions so that the reactant concentration didn't change much. On the basis of his data, Ed Marshall and I worked up the correlations which were used to run the big plants.

MORRIS: I see.

GREEN: I don't know what they've done since then, but I know those correlations were used for years. That is what Paul did. Paul worked under Per Frohlich. In the Esso system, usually people worked on what they were told but Paul Flory had his ideas about what he wanted to work on, and I don't think his ideas always matched what his bosses thought.

MORRIS: I think when he went to Goodyear he had a promise that he could spend time on his own problems. What other work did he do at Esso? Do you know anything about the work he did?

GREEN: I don't. He worked in the lab but I'm not sure what else he did.

MORRIS: Did he strike you as being someone who'd win a Nobel Prize?

GREEN: He was a very bright guy, yes. I liked him very much. I was very impressed. But I didn't think of the Nobel Prize, at that stage. That was forty-five years ago!

MORRIS: He was born in 1910, so that would make him thirty-three. By that time he'd already published several absolutely important papers.

GREEN: We used to get together to play bridge.

MORRIS: I suppose you didn't have a lot to do with the laboratory, only calling on them when you needed help with a chemical problem.

ASBURY: No, I didn't have anything to do with it. I never got in contact with them.

MORRIS: What were you doing in this period, say, 1942 and 1943?

ASBURY: I came back from England after the war really got under way and then I got involved, working at Linden, with a lot of coordination projects connected with synthetic rubber, aviation gasoline and things like that. I was working as an assistant to Mr. Murphree. One of my problems was to contact the authorities in Washington, such as Rubber Reserve, and every Saturday morning I would get on the phone and talk to the people in Rubber Reserve about what was happening on the rubber plants. I acted as a liaison with Washington. I was following the research work on a lot of the projects making aviation gasoline and synthetic rubber. I was sort of in an administrative position. Sometimes I'd go to Baton Rouge, and spend time in the butyl rubber plant too. I had some pretty hard nights there too. I was essentially an assistant to Mr. Murphree during that time. In 1945 I went to Europe with the U.S. Strategic Bombing Survey, and we visited a lot of the plants. I was in the oil and rubber section. We operated out of London, and whenever the opportunity arose we flew into Germany and looked at the plants that had been liberated by the army, to see what we could find out about the result of the bombing. We put out the bombing survey report in 1945 about what had happened in Europe.

MORRIS: What particular plants did you visit?

ASBURY: I went back to Ludwigshafen, and I went to Leuna, just before the Russians came in.

MORRIS: Of course, it had been liberated by the Americans.

ASBURY: The Americans had already liberated it when I got there.

MORRIS: They also liberated Schkopau.

ASBURY: I was in Schkopau. Our team visited Chemische Werke Hüls and plants like that. The Germans had kept very careful records of the bombing of their plants day by day, and what had happened to production.

MORRIS: That was very convenient from your standpoint.

ASBURY: They called the bombing that had ended up outside of the plant "agricultural bombing." They recorded the sizes of the bomb fuses, and we passed that information back to Washington--that the larger bombs seemed to be more efficient. I wasn't there all the time. When the war ended I was in Hanover.

MORRIS: What kind of an experience was it to go back to Ludwigshafen or Leuna, which you had seen back in 1933?

ASBURY: Pretty bad. Pretty bad. We saw some of our friends; I talked to [Heinrich] Buetefisch in Leuna, and he told me how serious the bombing had been in Leuna. I went to Leuna to get information on the [German-made] synthetic nitrogen plants that were in Japan. The plan was to use that information in any possible bombing of Japan before we invaded. Before I left the man who had got me this information said, "Now I have to ask you a question. What do I do tomorrow? The Russians are coming here tomorrow. I can stay here and work for the Russians or I can go with the Americans. They'll take us out of here tomorrow night, and they'll load us in a bus or a truck, with one bag each, and they'll take us to the American sector. What should we do?" I don't know what he did; I never heard from him since.

MORRIS: You weren't able to take anyone with you?

ASBURY: No. It was a terrible feeling to realize that the Americans had liberated this region and the damn Russians were coming in the next day.

MORRIS: I'm writing a paper at the moment about the German use of synthetic rubber before and after World War II. I wonder whether it would have shortened the war if the Allies had started early enough to knock out the synthetic rubber plants? Whether knocking both of them out would have made things very difficult for the Germans?

ASBURY: Both oil and rubber you mean?

MORRIS: Both oil and Buna. If they'd knocked them out, say in 1942, would it have made a radical difference to the war, do you think?

ASBURY: At that point I don't think so. The Allies were bombing the hell out of those plants. Bob Carrier and I went down to Washington to look at the bombing pictures to see what had

happened to the plants after they'd been bombed. If you saw a lot of steam coming out you knew that they had got a unit back.

MORRIS: You don't think sustained bombing would have made any difference?

ASBURY: I think we did a lot of bombing. I think we did about as much bombing as we could with our available resources.

MORRIS: Hüls was knocked out for six months in 1943.

ASBURY: But we found from our photographs that the Germans were rebuilding them fast. They had an organization under [Albert] Speer for rebuilding. The first thing you know you see steam coming out of some unit, and you knew they were back in operation. More sustained bombing would have been fine, but I don't know if the Allies could have mustered the personnel to do it.

[END OF TAPE, SIDE 4]

MORRIS: The bombing of Hüls was probably as great as it could have been. There was no sustained attempt to bomb Schkopau until about 1944. I suppose that was due to the distance involved.

ASBURY: Of course they were bombing Leuna fairly regularly.

MORRIS: But only after July 1944.

ASBURY: July 1944?

MORRIS: That's when Carl Spaatz took charge. They first bombed Leuna on 5 July 1944, and Albert Speer wrote in his diary the next day, "Now the Americans are doing it right. The Americans should have been doing this since 1942."

ASBURY: We were urging the air force through our contacts to bomb these plants and we were telling them where the plants were and what they were making. We knew all of that before the war, and the British were doing the same thing. The man who worked for me in London was doing the same thing, trying to pick the right target for them. You know there were a lot of bombs that didn't hit the target.

MORRIS: I know that was a problem.

ASBURY: A lot of the bombs hit the farmland around, and didn't make the target.

MORRIS: Even so, Hüls was out for six months, which was probably the largest single blow to the synthetic rubber project. That was the only time the synthetic rubber project was mentioned to Hitler during the war. He told them that it had completely lost production, and that something would have to be done about it. You didn't work on the FIAT reports, you only worked on the bombing survey, never in the intelligence field?

ASBURY: No, I just worked on the bombing survey.

MORRIS: Were you ever involved in the intelligence work at all?

GREEN: No.

MORRIS: Let's move on a bit. Could we get hold of a copy of Rubber from Oil, the film that was made about the butyl project (9)? The Center would be quite interested in seeing the film.

GREEN: I don't know where it is.

MORRIS: I suspect Paul Smith might know where it is.

GREEN: Paul Smith. You know Paul?

MORRIS: I gather he is our ultimate paymaster; we are run by ACS and he is chairman of the board of directors.

GREEN: You could ask him; he could probably hunt it up. It was a lousy film, but anyway.

MORRIS: What do you think of the actor who played you?

GREEN: Not much. [laughter]

MORRIS: What was wrong with it?

GREEN: I didn't think he looked like me. I wasn't a very important character in the film, not as important as I thought I should be. [laughter] I was the guy who suffered through the Baton Rouge agony. These other guys didn't.

MORRIS: In your memoirs you mentioned several times the question of morale. That it is very difficult to get chemists or chemical engineers to work on something full blast for three or four years, then have the company turn around and tell you it was a very bright idea, but we've now decided that we are not going to use it. Or to work on a project for three or four years, the arc process for example, which was not really practical. Did you find that morale was a big problem?

GREEN: I wouldn't say it was a big problem, but as the years went by, we got pretty tired. We got to the point where we had to work nine hours a day, six days a week, and that gets very tiresome. We didn't think we were treated right in Baton Rouge. We didn't think the top people understood.

MORRIS: Standard wasn't a chemical company. Did that have anything to do with their lack of understanding?

GREEN: At Baton Rouge?

MORRIS: Because it wasn't a chemical company, did they understand your problems less well than, say, the chairman of Du Pont might have understood them?

GREEN: Well Jay [M. J.] Rathbone understood it. He became president of New Jersey later on. He was sympathetic.

MORRIS: Reading about research, and the problems of directing research, I think little attention is given to the inevitable problems that must arise with morale.

GREEN: I think there was a morale problem in the chemical division, where the chemists would work on things that looked promising to them, but the company wouldn't follow up.

MORRIS: Was it difficult to keep key workers?

GREEN: Of course, there is no use in spending a lot of money on some project unless the commercial people were interested. We had a number of projects where they said they were not interested.

MORRIS: With hindsight, do you think their judgment was sound?

GREEN: One was synthetic detergent.

MORRIS: That was eventually licensed, wasn't it?

GREEN: I don't think there were any licenses involved. Chevron got ahead of us on that because our commercial people were not interested.

MORRIS: On that very same line, what about Parapol-S [an isobutylene/styrene copolymer]? You wrote that you felt that the failure there was probably in marketing.

GREEN: The people who got interested in this were the Swedes. They found out how to use it to coat cardboard, to make these triangular packages [Tetrapaks].

MORRIS: What do you do with them?

GREEN: You put liquids in them.

MORRIS: I see.

GREEN: That wasn't a very big outlet.

MORRIS: Marketing is an interesting point. Several studies of innovation have indicated that really successful companies are those that get high marks for both research and marketing. IG Farben, Du Pont, IBM, for example.

GREEN: We were weak on that.

MORRIS: You were weak on marketing. That's interesting.

Another thing about that period. In your memoirs, you hint at the fallout from the wartime recriminations about the Esso-IG agreement, and in that background there was the war crimes trial of IG Farben in Nuremburg. Wasn't that a difficult time for the people who had worked with IG Farben before the war?

GREEN: I never heard anyone in the company ever regret working for the IG.

ASBURY: I was upset with all the bad publicity we were getting in the newspapers, and various committees attacking us (10).

GREEN: That isn't quite the question he asked.

MORRIS: It's a mixture of both. Whether the public barrage made anyone in the company regret doing it.

GREEN: Well we were mad, we were just mad. At the attorney general, at Thurman Arnold, the whole crew, Truman, and [Homer T.] Bone's committee.

ASBURY: We had to go to those committee meetings, wasting our time when we should have been working on the war. I had to testify at one of these committees.

MORRIS: Was that a tiring experience?

ASBURY: Yes, a very exasperating experience.

MORRIS: I believe Du Pont had similar feelings before the war.

ASBURY: We felt that we were being tried without a jury.

MORRIS: There are four accusations that one commonly comes across about Standard and IG. The accusations are like this: that Standard Oil hindered the development of synthetic rubber in America on an order from IG Farben.

GREEN: That was a bald-faced lie. I think the guys that said that, knew it.

MORRIS: As you explained, Standard wasn't in a position to do so because they weren't being given the necessary development information.

GREEN: They couldn't get it.

MORRIS: The second one: the accusation that Standard Oil gave butyl to IG Farben. Even though IG Farben never made any use of any information given.

ASBURY: We offered to give it, but I don't think they ever got the process.

GREEN: Never got it.

MORRIS: The third one is about synthetic oil: that Esso helped to develop synthetic oil processes in Germany.

ASBURY: You are thinking about the Fischer-Tropsch process?

MORRIS: Well, general technical advice, so to speak.

ASBURY: We gave general technical advice to IG.

MORRIS: On the other hand, you probably got more information from them.

ASBURY: We felt that we were getting a lot. We gave them enough to get what we wanted. We learned a lot about catalysts. Their details about catalysts were the most important new things we learned in the oil business. It saved us a lot of time.

MORRIS: One accusation that I know nothing at all about is that Howard personally, rather than the company, arranged for IG to get a large shipment of TEL [tetraethyl lead]. Germany was very short of tetraethyl lead in 1939, and Howard used his influence with the Ethyl Corporation to get tetraethyl lead for Germany. That's an accusation I never found the answer to.

You raised an interesting point that after the war, you were improving butyl all the time while, at the same time, the GR-S people were improving their product all the time.

GREEN: We tried to get butyl into tires. We worked pretty hard at that.

MORRIS: Trying to hit a moving target--competing with a product that was improving all the time. You say [in Green's memoirs], very perceptively, that it was a hopeless struggle because you were talking about a captive market. A rubber manufacturer making GR-S wasn't going to turn around and say that butyl is better.

GREEN: But it was possible that butyl might make better tires.

MORRIS: It would have to be very much better.

GREEN: Yes, it really would.

MORRIS: At one time butyl had a very high cost advantage over GR-S.

GREEN: On paper.

MORRIS: But they have narrowed it down a bit.

GREEN: I understand that butyl is doing pretty well for the company.

ASBURY: Making a lot of bromobutyl.

MORRIS: Let's speculate about GR-S. Suppose synthetics continued to be developed at the prewar pace, without the forcible wartime intervention. Do you think then that butyl might have been preferred to GR-S?

GREEN: I don't really think so.

MORRIS: You think that GR-S would have won out?

GREEN: I don't think Jersey wanted to get into the rubber business, making tires and all that sort of thing.

MORRIS: You both visited Germany in the fifties, 1953 and 1955, and you both had visited Germany in the thirties. What did you find to be the great contrasts both in Germany and the German chemical industry, in those twenty years? Of course, the Nazis were no longer there but, in more subtle ways, did you see many differences?

GREEN: I didn't see any Coca Cola signs in 1933.

MORRIS: What about industry?

GREEN: Well, when I was there, and Bill too, it was in the Depression. It was hard to get good food; you'd go into a restaurant and you'd get rabbit. I had trouble finding good meals in Mannheim.

ASBURY: Before the war there was a really bad depression.

MORRIS: You revisited before the German economic miracle in the mid-fifties.

ASBURY: They were doing all right.

GREEN: They were doing very well.

ASBURY: I was back in the Ruhr in 1955 with Esso, in Düsseldorf and places like that. They were doing pretty well.

GREEN: That's right.

MORRIS: What about industry? My impression is that one of the great changes in West Germany after the war is the way in which the chemical industry completely changed direction from being very much based on coal, directly or indirectly. The chemical industry was pleased about a petroleum duty being imposed in 1928, and yet in 1953 they actually asked the government to remove it. That was a difference.

GREEN: But in this country, back in the 1930s our industry was based on coal. Ammonia was made from coal, not from natural gas.

MORRIS: That's true, but on the other hand, America was the great petrochemical producer before the war. It may not have been very extensive, but it was enormous compared to either Britain or Germany. I think that by 1943 they were producing as much ethylene in America as they were producing acetylene.

GREEN: Yes, I think there was quite a change in the late 1930s.

MORRIS: Because of the work done by Union Carbide and Standard. Anyone else?

GREEN: Esso, Dow, I imagine.

MORRIS: What about Indiana Standard?

GREEN: Well they weren't doing much in chemicals then. Shell in this country, of course.

MORRIS: In your memoirs you talked about the research strategy in chemicals after the war, when Exxon went much more definitely into the chemical field. What particular kind of chemical were they looking for?

GREEN: Well, there was always an argument.

ASBURY: In 1955 we got a license from Professor [Karl] Ziegler to make polypropylene and polyethylene and a lot of the research efforts were devoted to those fields. We built a pilot plant at Baton Rouge to make polypropylene and I guess Baytown built the first big plant.

GREEN: There was a big shift into polyethylene and polypropylene.

MORRIS: Up to that point Esso had been rather reluctant to go into polymers?

GREEN: This was going into plastics. Maybe ten years later than we should have.

MORRIS: What did the other people want to do?

GREEN: We wanted to go into polyethylene. But our commercial people said they would rather sell ethylene, rather than taking the risk of trying to sell the polymer.

MORRIS: And that wasn't so good?

GREEN: It was all right.

ASBURY: Then along came Professor Ziegler and his process was taken over by a lot of people, including Carbide in this country, and this changed the outlook on plastics. It really did, so a lot of our efforts were diverted into polypropylene.

MORRIS: In fact, you were in charge of the negotiations with Ziegler.

ASBURY: Yes, I was.

MORRIS: What was your impression of the setup over there? I think you said that you were surprised at how much they managed to do in such an old-fashioned laboratory.

ASBURY: I wasn't impressed with the work so much as I was with Ziegler, who had been working twenty years on aluminum compounds. His basic research in Heidelberg had got him into this field, then his attorney got him the patent rights, and that's when he came through with other patents and other work. It was a big development.

GREEN: I'd like to get in a minor point. Both Ziegler and [Giulio] Natta had rather meager facilities compared to the big U.S. laboratories, whereas these days the Europeans have completely caught up.

MORRIS: I have an impression that in the technical quality of laboratories the U.S. was pulling away from Europeans.

GREEN: More automated, too. Our laboratories are more automated. I've been in some laboratories in Russia and they looked like ours thirty years ago.

MORRIS: It must have been a great rush when all kinds of chemical companies were trying to get into this field. Just to mention a few, Phillips, Du Pont, Standard Indiana, and so on. Why did Standard of New Jersey decide to go into such a crowded field?

GREEN: It wasn't quite so crowded then.

ASBURY: It wasn't quite so crowded, no. I think that Mr. Murphree was really interested in it, and when he saw our friends in combat, he got the impression that we could get a license. So then I went to work to try and get some licenses. I'm talking about Ziegler right now. Of course, Carbide came through with a new invention on a greatly improved low-pressure polyethylene plant. It used to be a very high-pressure process but it is lower pressure now.

MORRIS: What was it like to negotiate with Ziegler? I believe he was fairly formidable.

ASBURY: He was difficult, but his patent lawyer was even worse. Ziegler was sort of, "Well, I'm the big man here now. Everyone is coming to me for a license and why should I give it?" I made a number of trips to see him, I went to see his lawyer, worked with his lawyer. I had some help. I had a very good assistant helping me on this; he has since died.

GREEN: Who was that?

ASBURY: Pat Wainwright.

MORRIS: You got more or less what you wanted?

ASBURY: We even got more than we wanted. We started out with polyethylene, then before we got through, he sent me a cable in New York that we could have a polypropylene license. Of course that just meant that we had to do a lot of work. We just had laboratory experiments, basic work from the laboratory, and we had to go and develop it.

[END OF TAPE, SIDE 5]

MORRIS: Polypropylene is the next big story. It is the longest patent battle in history.

GREEN: Right.

MORRIS: Which has been going on for thirty years. Apparently it has love affairs, murder, and all sorts of other things involved. I don't quite know how they come into it. Apparently Attilio Bisio thinks it so gripping that he would not only like to write it as a history but also make it into a novel.

ASBURY: Is he still working for Exxon?

MORRIS: Yes, he just published a book on scaling up (11).

ASBURY: Where does he work?

MORRIS: I'm not quite sure. I think he is some sort of research coordinator.

GREEN: I heard that Bisio had already published a book, when he was in Washington.

MORRIS: His book about the synthetic rubber project is due to come out soon (12).

GREEN: So this is something new that he's doing.

MORRIS: He has been working on it for ten years, with someone I don't know at all, Vernon Herbert.

ASBURY: Vernon Herbert used to work for me.

MORRIS: Well, Vernon Herbert's name has figured in all this, but having met Bisio, I gathered that it's mainly his own idea.

GREEN: Well, neither of them were involved in synthetic rubber, as far as I know. Maybe Bisio, but Vernon Herbert wasn't.

MORRIS: But Bisio isn't old enough.

GREEN: Small world isn't it?

MORRIS: You mentioned at the very end of your memoirs that you were afraid that the lack of innovation in Exxon would be a problem in years to come. That was nearly ten years ago. To what extent have your gloomy predictions come true?

GREEN: I haven't seen any startling things come out of Exxon research, have you Bill?

ASBURY: No, I haven't.

MORRIS: Could that be due to the general dearth of exciting things coming out of many chemical companies these days?

GREEN: That could very well be.

MORRIS: I don't really think that Du Pont has come up with anything that's going to set the world on fire.

GREEN: I can't think of any new thing in recent years.

MORRIS: I'm writing a book called Polymer Pioneers, which is going to deal with twelve people (13). [John Wesley] Hyatt for celluloid, [Marcelin] Barthelot, the French chemist who said something early on about polymers. Samuel Pickles, whom you may never heard of, but who first suggested that rubber might be a chain molecule, rather than a ring. [Leo Hendrik] Baekeland, of course, then [Wallace] Carothers and Carl Marvel. Then [Hermann] Staudinger and [Herman] Mark, Flory and Werner Kuhn and, at the end, Ziegler and Natta. In conclusion, I was going to draw attention to all the exciting things that are happening in polymer chemistry today but, actually it has rather fizzled out. The most exciting things of the last five years would be impossible to explain to anyone without a good knowledge of chemistry.

GREEN: I really only know what I read in the press. I get the magazines. I haven't seen much that's new.

MORRIS: Both of you have had a lot to do with innovation in the chemical industry. You lived through a period that saw all kinds of new products, like the synthetic rubbers, low-density polyethylene, and so forth. Do you feel that the momentum has failed to be kept going?

GREEN: Well, I don't worry too much about it. I know that Cliff Garvin has plenty of worries these days about the future of the petroleum business, and for Exxon that's the main thing.

MORRIS: What are these fears? About where they are going to get it from next?

ASBURY: Well, Exxon is buying back stock, buying its own stock. They don't have new projects to spend the money on the way they used to.

MORRIS: A lot of companies are buying stock, to prevent takeovers.

GREEN: They're just copying Exxon, most of them.

ASBURY: The petroleum end of the business is not expanding. In fact it's contracting, and refineries are shutting down. We're shutting down big refineries in Hamburg, and the one in South America, Aruba. That is one of the biggest ones.

MORRIS: That's one of the oldest ones too.

ASBURY: As a result, the oil companies generally don't have the incentive to develop new petroleum processes.

MORRIS: What is the flow of petroleum these days? My impression is that the number of sources of petroleum are shrinking very rapidly. There's a whole block of petroleum "out there" which is entirely speculative. People think it might be there but it hasn't turned into a real, known petroleum source.

GREEN: There's a lot of it in the Middle East, but who's going to control it twenty years from now?

MORRIS: Even the Canadian fields are running down.

GREEN: That's really the big problem of the petroleum industry. Where are we going to get gasoline from twenty years from now? What could we substitute?

MORRIS: You think the problem is going to hit within twenty years?

GREEN: I don't know.

MORRIS: About ten years ago everybody considered the year 2000 as Doomsday, but my impression is that it has been put off a few years, partly due to fall in consumption.

There are two things that we haven't covered. Is there anything particular about the growth of petroleum-based chemicals between 1930 to 1960 that has been overlooked?

GREEN: I would think there would be a tendency to go to coal as a raw material for chemicals, like it was in the twenties and thirties.

MORRIS: Maybe in a hundred years' time the petroleum industry will be seen as some sort of bizarre interlude.

GREEN: I think it will be much sooner than that.

MORRIS: There's the old synfuels question. When we had an oil crisis the government proposed to spend lots of money on synthetic fuel.

ASBURY: Exxon's got a new process that they developed at Baytown for liquefying coal. It was run on a large demonstration plant scale. It's shut down now as there's no reason to use it right now, but it can be started up.

MORRIS: Since you were so heavily involved with hydrogenation in 1930, you must have felt like it was a bit like old times when the fuel crisis started in 1974.

GREEN: Old times.

ASBURY: Here we are again.

GREEN: Déjà vu. If you remember the twenties, what was the estimated life of the oil reserve? Seven years, something like that?

ASBURY: Then along came the East Texas field in 1928, and then Saudi Arabia.

MORRIS: The growth of petrochemicals would seem rather odd, in retrospect.

GREEN: It's going to be a rough field now they're making these petrochemicals in Arabia.

MORRIS: Back in the seventies the late Shah of Iran was fond of saying that the oil producers would have to make sure that the chemical industry got all the oil, not the fuel industry. But with an unregulated economy, as in America and Western Europe, that would be impossible. I think that if petroleum became too expensive for the fuel industry, the chemical industry would also be likely to go back to coal.

GREEN: I'm glad I'm not running Exxon.

MORRIS: You're both chemical engineers, and we touched upon the fact that Germany didn't have many specifically trained chemical engineers in the 1930s. What do you see as being the relative roles of chemical engineers versus chemists in chemical industry? Do you envision a situation where chemists are going to be more restricted in their potential employment in the chemical industry?

GREEN: You have to have both. I think the trend now is in the biological field, which certainly takes chemists and all kinds of other professionals, but to make those things you have to have engineers too.

MORRIS: So you think there might be a sort of growth.

GREEN: There may be a different kind of engineering.

MORRIS: Bioengineers.

GREEN: That's smaller-scale stuff.

MORRIS: But how different would the task of a bioengineer be from a present-day chemical engineer? I can't see that the task of a bioengineer, for example, would be any greater than your problem with butyl.

GREEN: I don't know. I think there are real problems in that field.

MORRIS: One question I wanted to ask about butyl, and I forgot. You said that the reaction was instantaneous and to get a feasible process, you had to carry it out at a very low temperature. It surprises me in a way, that the research done on the catalysts could not have produced a slower reaction which would have been more controllable, run at room temperature, and one that you could have handled better.

GREEN: Well, maybe so, if you could discover it.

MORRIS: Can you use the Ziegler catalyst to make polyisobutylene?

ASBURY: Polyisobutylene, that's aluminum chloride.

MORRIS: To be specific, there's stereochemistry involved. The strategy was never attempted during the war to try to produce a more amenable reaction.

GREEN: Higher temperature, you mean?

ASBURY: Aluminum chloride, didn't we?

GREEN: It would be an entirely different polymer. Everything would be different. You could use boron fluoride. There are other catalysts you could use, but aluminum chloride would be the simplest. Takes so little you don't have to extract it from the product.

MORRIS: I can see the advantage. Is there anything that you feel we haven't touched upon?

GREEN: Do you think you've got what you wanted?

MORRIS: I'm not sure but I'll find it very useful. It's always useful to talk to someone who's worked on synthetic rubber projects. [Turning to Asbury] It would be interesting to speak with Vanderbilt.

GREEN: Vanderbilt was at Linden.

ASBURY: He was at Linden, too, Vanderbilt.

GREEN: The fundamental work on synthetic rubber was done at Linden.

MORRIS: I found it particularly useful talking to you about what happened in IG Farben, because I've never met anyone outside of Germany, who had been in close contact with them.

[END OF TAPE, SIDE 6]

NOTES

1. A. Donald Green, An Engineer Putting Chemistry to Work, typescript, 1977. See BCHOC oral history file #0065.

2. The acetylene is converted to butadiene through the aldol or four-step process. This process was used in Germany before and during World War II. Acetylene is hydrated in the presence of a mercury catalyst to acetaldehyde. The aldehyde is treated with dilute potassium hydroxide to convert it into acetaldol. The latter is hydrogenated to 1,3-butylene glycol and the glycol dehydrated to butadiene.

3. F. A. Howard, Buna Rubber: The Birth of an Industry (New York: Van Nostrand, 1947).

4. Whenever acetylene is heated (as it obviously is in the arc process), it polymerizes to a great variety of products, including benzene, and a complex mixture of hydrocarbons which Berthelot (1862) called cuprene. "A yellow-brown, solid polymerisation product made by heating acetylene in presence of copper," Hackh's Chemical Dictionary, 3rd edition, completely revised and edited by Julius Grant (Philadelphia: The Blakiston Company, 1944).

5. The main by-products of the arc process are ethylene and hydrogen. All of the other by-products are insignificant in quantity. On the Hüls arc process, see Ullmann's Encyclopedia of Industrial Chemistry, Fifth, Completely Revised Edition (Weinheim, Germany: VCH Verlagsgesellschaft, 1985), volume A-1, pp. 116-120.

6. I. G. Farbenindustrie, "Polymerizing Isoölefins," British Patent 401,297, issued 3 November 1933; I. G. Farbenindustrie, "Polymerizing Isobutylene," British Patent 421,118, issued 10 December 1934; I. G. Farbenindustrie, "Polymerization of Isobutylene," British Patent 432,196, issued 15 July 1935.

7. The process that uses liquid ethane, ethylene or any other gas that will vaporize is known as autorefrigeration. This concept is widely practiced.

8. The plant at Sarnia came on stream in 1944.

9. Rubber From Oil [A motion picture on the discovery and development of Butyl Rubber made by Esso publicity department, 1958.]

10. See Joseph Borkin, The Crime and Punishment of I.G. Farben (New York: Free Press, 1978).

11. Attilio Bisio and Robert L. Kabel, Scaleup of Chemical Processes: Conversion from Laboratory Scale Tests to Successful Commercial Size Design (New York: Wiley, 1985).

12. Attilio Bisio and Vernon Herbert, Synthetic Rubber: A Project That Had to Succeed (Westport, Connecticut: Greenwood Press, 1985).

13. P. J. T. Morris, Polymer Pioneers (Philadelphia: Center for the History of Chemistry, 1986).

INDEX