CHEMICAL HERITAGE FOUNDATION

WARREN G. SCHLINGER

Transcript of an Interview
Conducted by

Arnold Thackray

at

Pebble Beach, California

on

24 July 2002

(With Subsequent Corrections and Additions)

CHEMICAL HERITAGE FOUNDATION
Oral History Program
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WARREN G. SCHLINGER

1923 Born in Los Angeles, California on 29 May

Education

1944 B.S., applied chemistry, California Institute of Technology
1946 M.S., chemical engineering, California Institute of Technology
1949 Ph.D., chemical and mechanical engineering, California Institute of Technology

Professional Experience

1949-1953 Instructor and Research Fellow, California Institute of Technology

Texaco, Inc.
1953-1957 Chemical Engineer
1957-1961 Senior Chemical Engineer
1961-1969 Supervisor, Research
1969-1981 Manager
1981-1987 Associate Director, Gasification
1987-present Consultant

Honors

1976 Technical Achievement Award, AIChE, Southern California Section
1981 Chemical Engineering Practice Award, AIChE
1985 KFA Achievement Award, Electric Power Research Institute
1991 National Academy of Engineering

Professional Organizations

Sigma Xi, The Scientific Research Society
American Institute of Chemical Engineers, AIChE
American Chemical Society, ACS

ABSTRACT

Warren G. Schlinger begins the interview by tracing his family heritage. As a boy, Schlinger's family moved around in California to accommodate his father's employment with the United Parcel Service of America, Inc. It was in the sixth grade, Schlinger asserts, that his career began in earnest. His introduction to chemistry came in the form of a Gilbert Chemistry Set owned by a friend. It was not until the eleventh grade that he was formally taught in the subject, and by then he was already collaborating with classmates on experiments. While a young man, Schlinger began to attend public lectures at California Institute of Technology [Caltech] where he eventually was accepted and completed his education, earning a doctorate in mechanical and chemical engineering. After four years of post-doctoral research with Bruce H. Sage, Schlinger moved into the world of industrial research with Texaco, Inc. Schlinger spent the entirety of his career at the research lab in Montebello, California as an innovative and enthusiastic force within the West Coast branch of research and technology at the oil company. Schlinger recollects the history of Texaco, and especially of the Montebello research facility. He shares aspects of his private life—stories of meeting his wife Katharine, the successes of their three children, and the Warren and Katharine Schlinger Foundation that the Schlinger family established and manages. He concludes the interview by reflecting on his career and the evolution of chemical engineering at Caltech.

INTERVIEWER

Arnold Thackray is President of the Chemical Heritage Foundation. He majored in the physical sciences before turning to the history of science, receiving a Ph.D. from Cambridge University in 1966. He has held appointments at Oxford, Cambridge, Harvard, the Institute for Advanced Study, the Center for Advanced Study in the Behavioral Sciences, and the Hebrew University of Jerusalem. In 1983 he received the Dexter Award from the American Chemical Society for outstanding contributions to the history of chemistry. He served on the faculty of the University of Pennsylvania for more than a quarter of a century. There, he was the founding chairman of the Department of History and Sociology of Science, where he is the Joseph Priestley Professor Emeritus.

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INTERVIEWER: Arnold Thackray

LOCATION: Pebble Beach, California

DATE: 24 July 2002

THACKRAY: Warren, please begin by telling me about your parents and your childhood?

SCHLINGER: I came into the world in 1923. My father was from a German family that immigrated to the United States in the mid-1800s. My mother's family lived in New England for quite sometime and moved west with the growth of the country. My mother was born in Iowa but moved to California when she was still a young girl. She married my father in 1921. My mother's name was Esther [Gleason] and my father was William M. Schlinger. I was born in Los Angeles [L.A.], but my family moved around the area several times during my early childhood. I lived in Long Beach, Pasadena, and Glendale. I started grammar school when we lived in Hollywood. In the second or third grade, my family moved back to Glendale, and I graduated from Glendale High School in 1941.

THACKRAY: Why did your family move so often? What took your father to California?

SCHLINGER: In those days you didn't commute from Pasadena to Long Beach. [laughter] You moved! My father was transferred around to different divisions of UPS, the United Parcel Service [of America, Inc.], as it expanded and developed in southern California.

My father was actually born in Los Angeles, California. My great grandfather and his wife and two sons emigrated from northern Germany to New Orleans. They were farmers. I think that the move to America was to avoid being enlisted in the army. Anyway, his wife died two weeks after they arrived in New Orleans. The family subsequently moved to Kansas. Eventually, my grandparents moved to Los Angeles, where my father was born.

My mother's father was also a farmer but in Iowa. My maternal grandmother and grandfather's origins lay with English immigrants to the East Coast. When my mother was born, she was the youngest of three daughters, and my mother's father decided he couldn't run the farm without any sons. [laughter]

THACKRAY: Did your maternal grandfather eventually move to Los Angeles?

SCHLINGER: My maternal grandfather, whose name was Irving Gleason (his wife's name was Fanny Mattoon [Gleason]), came to southern California as a farmer. At various times he lived in Riverside, Corona, and Los Angeles. He went into the citrus business, and was quite successful. He was also one of the earliest people to develop the farming potential of Imperial Valley by diverting Colorado River water into the Valley for irrigation. He was very involved with the water company in Imperial Valley for a while.

THACKRAY: Your father was one of how many sons?

SCHLINGER: My father was the youngest of ten brothers and sisters of widely scattered ages. Several of them came to Los Angeles before he was born though. Some of his older brothers and sisters stayed in Kansas until later in their lives.

THACKRAY: Since your father had a German background, was German spoken in your family?

SCHLINGER: My father used to try to teach me German, before I went to school. My mother didn't speak German, and I didn't speak it. My father, of course, had gone through an English speaking school in Los Angeles, so he only heard German spoken by his mother and father. I still have his family Bible, it's about six inches thick, all in German. [laughter]

THACKRAY: When I think of farming communities in Germany, I think of those communities in a church context. Was that context true in California? Was your family church connected?

SCHLINGER: I don't really know much about that, although they did come from a small town in the Ruhr Valley of Germany. When I tried to look up the records of the family, I found that the church where the records were maintained had been destroyed in World War II [WWII], and the records were all gone. So I can't trace my German family background any further, but I know that there are a whole lot of Schlingers in northern Germany. There are quite a few in the United States, as well; many are descendants of my grandfather. My grandfather stayed in Kansas and his brother went to Minnesota, so there are also many Minnesota Schlingers.

My father was never a farmer; he sold newspapers when he went to school. He worked all the time to help support his family because he was the only one left at home. His mother and father were quite old by that time, and he never had an opportunity to go to college after he graduated from Los Angeles High School.

THACKRAY: What did your paternal grandfather do?

SCHLINGER: I never had the chance to meet my paternal grandfather, nor my paternal grandmother. They died before I was born. However, I have many cousins, aunts, and uncles.

THACKRAY: Do you know how your father got into his occupation?

SCHLINGER: Yes. He sold newspapers while he was in school, and shortly after he graduated from high school, he and another fellow, Russell Peck, formed a small delivery business. They delivered packages, letters, and other things to people in Los Angeles on bicycles and motorcycles, I guess. That was shortly before World War I. My father joined the army during World War I and studied communications. When he was discharged, he went back to the same job again with the Russell Peck Delivery Business.

In 1919 or 1920, a small package delivery service [Merchants Parcel Delivery] that originated in Seattle decided to expand and move into southern California. They acquired the Russell Peck Delivery Business and continued the employment of my father. Then they opened a branch office of what eventually became United Parcel Service. My father continued to work in the southern California area until retiring in 1964.

THACKRAY: How did your mother and father meet?

SCHLINGER: They met through a mutual friend, like many people do. The friend was a fellow named Steve Black. He worked with my father in the delivery business and lived next door to my mother and her family in Los Angeles, so he introduced them. My mother, by that time, had graduated from Stanford [University] and was teaching school in Los Angeles.

My father took night courses in business school. But, he wanted his two children to go to college, which we did.

THACKRAY: In what year were your mother and father married?

SCHLINGER: They were married in 1921 in Los Angeles.

THACKRAY: Did your mother give up teaching school after marriage?

SCHLINGER: Yes. In those days, women became a homemaker when they got married. She had two older sisters who also lived in the area, and they were both married at that time.

THACKRAY: How many children were in your family?

SCHLINGER: My family has just the two boys, my brother and me. I think, all total, I have twenty-six first cousins. [laughter] Most of them are on my father's side, and some were actually older than he was.

Almost all my family lived around the Los Angeles area. A few cousins lived up in the Bay Area, and one stayed in Kansas. One brother flew the coop and moved to the Philippines. He married a Portuguese lady that I never met, but they came back to California after World War II with a son about my age. The rest of my cousins were pretty much local, and we saw quite a bit of each other. In those days, it was common to go over and visit your aunts and uncles on Sunday afternoon. We didn't have as many other distractions.

THACKRAY: What are some of your early memories of your family?

SCHLINGER: I started school in Hollywood, and I moved to the Glendale school system shortly after that. By the time I was in sixth grade, my career really got its start. My classmate Keith Padgett and I were good buddies in school. One day, Keith got a Gilbert Chemistry Set. [laughter] He invited me over to his house, and we did every experiment in the book. I was fascinated. The Christmas after that, I'm quite certain that I got my first Gilbert Chemistry Set, and my interest in chemistry continued. In junior high school, I began to learn a little more. I frequently visited the library and read quite a bit about chemistry. I was really looking forward to getting into high school where I could actually take a course in chemistry, and I was well prepared for the class by the time I got there. In fact, I think I could name all the elements on the periodic table, which I can't even do now! [laughter] Not counting the ones that were beyond uranium.

THACKRAY: Did you have some sort of laboratory set up in your home?

SCHLINGER: Yes. I had something that could be called a laboratory. It really was an attachment to the garage. It wasn't until I took chemistry in high school, in the eleventh grade, that I really got serious about this laboratory. In those days it wasn't very difficult to buy chemicals, so I had all kinds of chemicals. I still have them. They're all boxed up. [laughter]

THACKRAY: Yes, we will have to get to those in due course.

SCHLINGER: I had a couple of other good friends in high school that also had little chemical labs. We'd exchange ideas and perform various chemical experiments, making incendiary devices and so forth, as kids do! By the time I got through chemistry in high school, I pretty much knew that chemistry or chemical engineering was what I wanted to get involved in.

One of the things that probably influenced me as much as anything was a math teacher I had, beginning in the seventh grade. He also taught my science class in the ninth grade. So, I had the same teacher for mathematics, and when I went to high school, he was my teacher there. He and I were just inseparable, and he really inspired me. His name was Leland Lease. He loved photography and took me to Death Valley and Yosemite [National Park, California]. We had great experiences. Probably as much as anyone, I'd have to say that he was the one that inspired me to go to Caltech [California Institute of Technology], although he didn't know much about the school.

Around the time I started Caltech, I also began attending "Evening Demonstration Lectures" there with some of my high-school friends. These were public lectures that were given by prominent faculty—even Robert A. Millikan gave one of the lectures. The lectures were designed to make the public understand what science was about. That was how I became infatuated with Caltech.

Caltech also had an open house each spring. I had gone to Caltech's open house for the two years previous to entering school there. Of course, in those days, you didn't have to apply to college until the spring before you were to enter. Fortunately, we didn't have the standardized tests like they have now. We actually had to go to Caltech and take an exam on the campus. There were three exams in three successive weeks.

THACKRAY: Were the exams in the sciences?

SCHLINGER: The exams covered physics, math, chemistry, English, and history. I didn't do too well in history. [laughter]

THACKRAY: It would have been difficult to take Caltech's entrance exams if one was living in Philadelphia and not California.

SCHLINGER: No. If you wanted to take a test in Philadelphia, Caltech had alumni who would supervise the test. Following the exam, promising candidates were personally interviewed by a member of the faculty, no matter where they lived. Faculty would take a couple weeks trip and go back to the East Coast and interview everybody who had applied, if they had gotten to the

point where Caltech considered accepting them. I don't know, I imagine the acceptance rate was probably one out of four at that time. Now it's closer to one out of twenty-five.

I was not sure I would be accepted. If I hadn't been accepted, I don't know what I would have done. I mean, I would have been devastated, in terrible shock. But it didn't happen that way.

THACKRAY: What did your parents think of the situation?

SCHLINGER: They were pushing me, of course, and were very pleased to see me want to go to college. There wasn't much they could do in those days to affect the outcome, but I made it in and I started at Caltech in October of 1941. The first quarter was undoubtedly the toughest quarter I ever had. [laughter] Half the people that were admitted had gone for a year or more of prep [preparatory] school, but I didn't even have an inkling what calculus was about. My high school math teacher couldn't tell me why d(xy) was x(dy) + y(dx)! [laughter] I would say, "That doesn't make sense to me—not algebraic sense!"

Also, we were using calculus in physics and chemistry. We had to know calculus to do the physics problems. Somehow, the concept finally got through to me, and by the end of the first quarter, I was a little more at home. But that first year was a tough one!

THACKRAY: Please, tell me about your brother [Evert I. Schlinger]?

SCHLINGER: My brother is five years younger than I am and taller than me. He also went to Glendale High School and was quite an athlete. He was named to the All-California Interscholastic Federation, the high-school football team. He wasn't a real good student, but he ended up going to University of California at Davis [UC Davis].

THACKRAY: What did he study?

SCHLINGER: He studied entomology, and he, too, had an interesting experience in entomology when he was just a kid. He was interested in black-widow spiders, much to my mother's chagrin. In those days you used to buy coffee in a two-pound glass jar. I can still see those jars. He would punch a couple holes in the lid, put the spiders in the jars, follow them, feed them, and watch them develop. They just fascinated him.

When he was in high school, Evert started working at the Los Angeles County Museum on weekends. There was a curator there who was also interested in spiders. I don't know if Evert got paid, but he got a lot of experience. So he had a strong background in entomology,

particularly spiders, and today he's a world-recognized expert on spiders and insects. He became quite involved with biological control and eventually got his Ph.D. at UC Davis. Then, Evert was appointed head of the entomology department at University of California at Berkeley [UC Berkeley] for a number of years before he retired.

THACKRAY: It appears that there is a very strong, common scientific/academic trend in your family.

SCHLINGER: I give my mother and father a lot of credit for that because they wanted us to go to college. Evert got very involved in biological control and was one of the first to apply it commercially to the fields in California. Evert and another of his friends, after he had left Davis with his Ph.D., were hired by one of the faculty at [University of California] Riverside. He worked there on various biological control problems. They developed a parasite [*Trioxys complanatus*] that actually destroyed the [spotted] alfalfa aphid [*H. Therioaphis maculata*]. The aphids were devastating the alfalfa fields in California, and the fields were sprayed with parathion, but the aphids became resistant to the chemical. It was a big controversy. My brother and his colleagues came up with a parasite that actually destroyed the aphid eggs that were hatching. The parasites would die off when there weren't enough aphids to survive on anymore. The whole situation was controlled that way.

This solution presented itself when the researchers decided to look at the alfalfa's natural environment in the Middle East. They found the parasite there, brought it over here, and within four or five years all the spraying of alfalfa stopped. He has since done a whole lot more developing. He goes all over the world to find more parasites for development. There are numerous parasites that control many of the problems that we have, particularly with imported trees, plants, fruits, and vegetables that don't have a natural immunity to the conditions that they are imported to.

THACKRAY: Five years is quite an age difference, especially when you are very young.

SCHLINGER: Yes. We have always had different groups of friends—five years is quite a difference at a young age.

THACKRAY: As a young boy or teenager, did you spend most of your free time with a particular group of friends? Did you continue to spend time with the young man with the Chemistry Set?

SCHLINGER: I really lost touch with him. He moved away from the area, so he did not go to high school with me. I had other friends that I met in high school, and we are still close friends,

but none of them followed chemistry. Four of us were admitted to Caltech from Glendale High School that year, and we all commuted back and forth to Caltech from Glendale during our freshman year.

THACKRAY: Was commuting the most obvious way to get to Caltech?

SCHLINGER: Well, it was cheaper. It was maybe two hundred fifty dollars a quarter for room and board. [laughter]

THACKRAY: Did you receive scholarship support, or were your parents paying your tuition?

SCHLINGER: No, I didn't have any scholarships. Tuition was, I think, a hundred twenty-five dollars. It was ridiculous. My father gave me a thousand dollars on the day I was accepted to Caltech. He said, "You've got to make that last." And I did. You could go to college for a whole year on a thousand dollars.

THACKRAY: How affluent was your family when you started college?

SCHLINGER: My father was quite successful in the United Parcel Service, which was a very good company. Eventually, he became vice president for the whole West Coast. We were certainly middle-class people at that time, but we all had struggled during the Depression. The United Parcel itself almost went under, as I remember very well. But my father was never without a job.

[END OF TAPE, SIDE 1]

SCHLINGER: When the War came along, the Pearl Harbor affair, some of my friends went off to the military, but not too many of them—none of the Caltech ones did. We did have a naval program at Caltech that moved in at the end of my sophomore year, the V-12 program. I applied to that, but they wouldn't accept me because I am deaf in one ear. I've been deaf in that ear since I was in seventh grade. So I was able to keep on going to school. The three other students from Glendale joined the V-12 program. We all graduated in 1944.

THACKRAY: Were you in an accelerated program or did you graduate in four years?

SCHLINGER: After the War began, we started going to school year-round. That's why I graduated in only two years and nine months.

THACKRAY: How much of a disruption was the War at Caltech? Did the faculty disappear?

SCHLINGER: The War was very disrupting. The faculty was deeply involved in aiding the government programs and the War effort. They couldn't talk about what they were doing. Many of them were involved in the atomic bomb development, the development of rockets, and JATO [Jet-Assisted Take Off] rockets. JATO came from Aerojet [General Corporation], which was founded by [Theodore] von Karman, who was at Caltech at the time.

The forerunner of Jet Propulsion Laboratory [JPL] was being operated by Caltech people, and, originally, the work was done right on campus. Eventually it moved up to Eaton Canyon, north of Pasadena, and then over to where they are now [Pasadena]. That took a lot of people.

The faculty was still pretty good; they showed up for their lectures. They were awfully busy, and the whole campus was isolated. You could hardly go anywhere because the buildings were all secured. Teaching went on, undergraduate programs continued, but the graduate program was pretty badly disrupted. Of course, most of the people that were going to graduate school were spending most of their time on some type of War project.

That's what I did after I graduated in 1944. I worked with [Ernest] Swift on developing equipment for remotely detecting war gases in the field. Today that wouldn't be much of a problem, but in those days [laughter] it was a major challenge.

THACKRAY: When you say "remotely," what do you mean?

SCHLINGER: The instruments were designed to be deployed in no-man's-land where they would be continuously sampling the air and trying to detect components of known chemical agents.

THACKRAY: And sending radio signals?

SCHLINGER: I am not certain how the communication worked; that was another project. We made some units that were tested by the army in the field but they were never deployed overseas.

THACKRAY: Going back into your undergraduate experience, did you live at home all the time?

SCHLINGER: No. I lived at home the first year. The second year I lived on campus in housing that later was taken over by the [United States] Navy. My third and final year, I lived in off-campus housing.

My freshman inorganic chemistry teacher was Linus [C.] Pauling. [laughter] We had lectures by people like Robert Millikan and Carl [D.] Anderson in our physics courses. These professors were Nobel laureates, yet they were talking to freshmen; they would actually take time to do this. Well, Pauling wasn't a Nobel laureate yet.

THACKRAY: Did they teach didactically?

SCHLINGER: No. They would only give lectures. The teaching assistants did the teaching, but they would talk to you face-to-face. In biology, of course, we had Thomas Hunt Morgan. He gave lectures. It just was such an inspiration. Just unbelievable.

THACKRAY: But tough because of the caliber?

SCHLINGER: Caltech was designed to make you learn how to solve problems, not to memorize solutions that somebody else already developed. You had to apply all your faculties. It was a great experience. The second year, I lived in student housing, so I became more involved in some student activities. I did quite well with everything, except humanities. You had to have 25 percent of your courses in humanities in those days. [laughter] I was lucky if I got Cs in humanities. Anyway, at the end of my sophomore year I was awarded a scholarship just on the basis of my grades—I didn't even apply. I think it was a hundred fifty dollars a quarter or something, [laughter] but it helped in those days. So that made life a lot easier. Then I started working with Ernest Swift in analytical chemistry laboratory.

THACKRAY: You started working with Swift as an undergraduate?

SCHLINGER: As an undergraduate, yes. He was one of our professors. Of course, he already had an assistant, but I really loved his course. I did very well in it. He hired me to work in the lab after school, making up the unknowns and the standard solutions, which I did until I graduated. After I graduated, he immediately hired me to work on his NDRC [National Defense Research Committee] program. I only took one week off before I started working to backpack in the Sierras.

THACKRAY: I take it that you must have had good manual dexterity in the lab?

SCHLINGER: Yes, I did. I was a pretty good glass blower by that time. I was making a lot of apparatuses for my own laboratory. Ground glass joints were just beginning to appear. You know, rubber stoppers were a couple of holes with tubes coming out! [laughter] It's amazing what we could do.

THACKRAY: What was your extracurricular life like?

SCHLINGER: I guess the thing that I did the most was ski. We had a ski club at Caltech, and I got quite involved with that. I've been skiing for most of my life until this year, as a matter of fact.

THACKRAY: Skiing does not seem like an obvious thing to do in Los Angeles!

SCHLINGER: This is the first year I haven't gone skiing since 1940. For sixty-two years that was the main extra activity I had. At that point and even earlier, during high school, I really loved to go backpacking in the High Sierras [Nevada mountain range]. There were many opportunities and people that backpacked in the Caltech community. We'd go up even for weekends and camp out. There were a lot of rock climbers. I was never a rock climber, but I loved backpacking and fishing.

When I was a senior in high school, I had to write a paper about what I wanted to do after I finished school. I still have that paper. It may sound ridiculous, but I said, "What I want to do is have a research laboratory isolated up in the High Sierras. I don't care if I can't even get out all winter long. I just want to do my research up there." That's what I wanted to do: research. Needless to say, I received a lot of questions from my teacher in high school about that paper. [laughter]

THACKRAY: That was a nice vision.

SCHLINGER: I thought that would be an ideal life. I was always focused on chemistry and not really involved with engineering. I didn't know what chemical engineers really did at that point. Only gradually did everything come together, and chemical engineering became my goal.

THACKRAY: When you were a junior and senior, and beginning to get involved in chemistry, what were other people in your class doing?

SCHLINGER: We were divided into six sections with twenty students in each section. When the Navy came in, my classmates weren't interested in chemistry as much. They were interested in being electrical engineers, mechanical engineers, naval engineers, communications people, and everything else related to the Navy. My section really narrowed down because of this, so most of the people that I knew from chemistry were much older than I was. They were at Caltech as graduate students, trying to earn credit toward their degrees.

Chemical engineering in graduate school pretty well ceased when the War started. I mean, students just weren't interested in it. Chemical engineering was only taught in the fifth year, so if you took the fifth year, you got a master's degree in chemical engineering. There weren't many chemical engineering degrees that were awarded at Caltech in the wartime period. There were groups that graduated in 1941 and 1942, but in 1943 and 1944 there weren't any graduates in chemical engineering. Actually, the chemical engineering faculty was completely involved in the War effort. There were only two members in the chemical engineer faculty. [laughter]

THACKRAY: Who were they?

SCHLINGER: William [N.] Lacey and Bruce [H.] Sage.

THACKRAY: It seems that you were extremely immersed in research as an undergraduate. Was your research also helping the war effort?

SCHLINGER: When I stayed at Caltech after graduation and went into Ernest Swift's NDRC program, that was strictly a full-time job.

THACKRAY: That was the patriotic and appropriate thing to do.

SCHLINGER: That's right. It was either that or get drafted into the [United States] Army. I decided that the NDRC would be better. That was in 1944. The War in Europe ended by the summer of 1945. The War in the Pacific went on for a little longer. By that time, I was working on rocket propellants.

THACKRAY: Were you still in Swift's laboratory?

SCHLINGER: I was with Swift but working on a different NDRC project. He and the team began working on the physical properties of solid propellants. The idea was to develop propellant configurations that delivered a constant thrust as they burned. We wanted to design a propellant that had a constant surface area exposed that would not disintegrate during the burn and still maintained physical strength to get a constant thrust.

THACKRAY: Were you still working on the Caltech campus?

SCHLINGER: I was pretty much on campus. We were doing a lot of the physical testing of the propellants there. Most of the combustion experiments were done up in the Eaton Canyon lab, which was run by Bruce Sage and William Lacey. In my senior year, as part of the applied chemistry curriculum, I took a few courses in chemical engineering design taught by Dr. Lacey, so I began to understand a little bit about what chemical engineering was.

THACKRAY: Did you like those courses?

SCHLINGER: Yes. I knew I liked chemical engineering. It just intrigued me. The first opportunity I had to go back to school was in October of 1945. That was the first class of postwar master's students. I got my master's degree in June of 1946. During that time, I met Katie [Katharine Stewart], Bruce Sage's secretary during the War and for several years thereafter. [laughter]

THACKRAY: How was your master's work funded?

SCHLINGER: Savings and part-time work.

THACKRAY: Did you meet Katie before you started on your master's?

SCHLINGER: No. We didn't really get to know each other until I was completing my master's thesis. After I got my master's degree, I had offers from Chevron [Corporation] and DuPont [E. I. DuPont de Nemours and Co., Inc.]. I was considering leaving school, but then decided to spend another year and earn a professional engineering degree. I had a part-time job with Sage and Lacey on the API [American Petroleum Institute] project—the PVT [pressure-volume-temperature] properties of hydrocarbons. And I received a scholarship for my second year of

graduate school from Chevron, which I got through Caltech. That scholarship enabled me to continue. By that time there was no living on campus. I had to live off-campus.

THACKRAY: In that 1944 to 1945 era of doing "practical things," you decided that you would get your master's in chemical engineering when the opportunity came?

SCHLINGER: Yes, initially, I wanted to get my master's degree. That was my goal.

THACKRAY: How did your relationship with Sage and William Lacey help you to decide upon a career in chemical engineering?

SCHLINGER: I didn't really know them very well. I knew Lacey, but I did not know Sage because he had not taught any of the undergraduate classes. I convinced Lacey that I was a good candidate for graduate work. The whole problem was that they'd never had a Ph.D. program before, and they hadn't had a master's program for about three years—there weren't enough instructors. [laughter] A grassroots thing. I guess I'd saved enough money during my year-and-a-half of work there that I could make it through the master's program—living on that, I guess. I rented a room down the street; I think it was thirty-five dollars a month. [laughter] They really were interesting times. Of course, I still went home on weekends. I don't remember having any financial help from Caltech the first year of graduate school.

THACKRAY: Was your younger brother still living at home?

SCHLINGER: Yes, he was still in high school. He didn't graduate from high school until February 1947.

THACKRAY: How many students were there in that master's group?

SCHLINGER: There weren't very many. There might have been four, maybe six. I'd have to look it up in the Caltech catalog, but the size of the group grew the following year.

THACKRAY: What were the courses and requirements for a master's in chemical engineering?

SCHLINGER: Sage and Lacey were strongly against teaching unit operations by making students run a piece of equipment and get data on it. They were very focused on

thermodynamics. That's when I first got exposed to Sage; he taught a very important thermodynamics course. Lacey taught courses in chemical engineering design, and we still had to take classes outside the department. One of the things that I also just really gobbled up were the applied math courses. Chemical engineers, in those days, were not very well versed in applied mathematics. That course helped me to learn how to apply concepts to problems in chemical engineering and thermodynamics. We still had courses in chemistry to take. I can't remember what courses they were, but we did not have unit operations. We did have a course where we had to learn how to make equipment.

THACKRAY: On what scale?

SCHLINGER: By hand. Learn how to weld, learn how to use the machine lathe. That was Bruce Sage's area. Because of the unorthodox quality of the chemical engineering program at Caltech, the department was not recognized by the AIChE [American Institute of Chemical Engineers] in those early years. Just before I got my Ph.D., Caltech was finally accredited by the AIChE, even though they didn't have a unit operations class.

THACKRAY: That's very interesting because there's MIT [Massachusetts Institute of Technology] with its strength in unit operations and in stressing thermodynamics and applied math—you were ahead of the game.

SCHLINGER: As it turned out, that's right. We used MIT textbooks, and we had unit operations as a course, but we had to solve problems. We had a hard time selling that.

THACKRAY: It's always difficult to sell the future, I think. [laughter]

SCHLINGER: That's right. There were a lot of chemical engineering activities, especially processing. Caltech was very good about taking us on industry tours. We visited an operating plant that U. S. Borax [Inc.] owned to see how they recovered their borax and all the chemicals they made from dry lake brine.

THACKRAY: Where else did you visit?

SCHLINGER: There were a lot of tire manufacturing facilities in southern California, and we also had a lot of refineries. We still do. It was great to have the chance to go see chemical engineering in action. That was a very important experience. I'm trying to think what other

courses we had. We did have classes in electrical engineering and mechanical engineering. I was a minor in mechanical engineering when I finally went on.

THACKRAY: Did you enjoy the variety of chemical, electrical, and mechanical engineering?

SCHLINGER: It was good. Any chemical engineer who doesn't have a sound understanding of thermodynamics is hopelessly lost. And thermodynamics was not new, but it was not recognized for the potential it had.

THACKRAY: It hadn't yet become the organizing principle.

SCHLINGER: It hadn't; that's right. Of course, we didn't have computers in those very early days. So that was the background. All during my graduate experience there, I worked on the PVT properties of hydrocarbons, API projects determining the thermodynamic properties of materials. API supported Project 44 at Caltech for a number of years. I guess it began back in the 1930s. It didn't terminate probably until 1960.

Nearly all the equipment in the laboratory was used to work on Project 44. In fact, one of my research projects for my Ph.D. was an ONR [Office of Naval Research] sponsored project to determine the thermodynamic properties of NO_2 [nitrogen dioxide] which is interesting because of the reversible dimerization of the molecule.

[END OF TAPE, SIDE 2]

THACKRAY: I'd like to ask Mrs. Schlinger a few questions. "Katie," can you tell us about yourself?

KATHARINE SCHLINGER: I was born in Alhambra, California, which is very close to Los Angeles and Pasadena. I'm one of two siblings. I have a sister who is two years older than I am. I lived most of my life in Alhambra. My sister did not have very good health, so we had to move around to quite a few places. My father, who was a Cornell [University] graduate in electrical engineering, had a very serious case of typhoid fever. He finally had to give up his job with the [Southern California] Edison Company and was forced into whatever work he could find where it would be healthful for him and for my sister. Of course, when the Depression came along, he was willing to do anything to support the family.

We had a farm with chickens at one time; we also raised peaches. My sister and I would sit out at the curb and sell the peaches. We'd have a great time. My mother was a concert

pianist, and so we studied music with her. I was told I had a fairly good singing voice and started taking voice lessons. I did quite a bit of singing and finally became the soprano soloist in our church. We had a Catholic choir director who liked to do the large requiems and wonderful music; it was a magnificent music program.

Then the War came along, and we decided that school would have to be put off. I went to junior college and hoped to eventually go on beyond that. When the War came, I began working at Caltech to help support the war effort, as many people did. I had a wonderful job with a nice staff of probably twenty people, working on war projects. I worked with a group of typists and editors, some very interesting people. One was a child storywriter, and one was an editor for McGraw-Hill [Companies]. Very well educated people came to work for us because of the War, and luckily I had them on my staff.

When the War was over, I started teaching school. I assisted two professors in chemical engineering. There were some graduate students whom I became well acquainted with—kept their grades, and all of that. There were two of them who were particularly friendly with me, and one of them, Warren, asked me to type his master's thesis. I did that for a lot of the boys. I said to him, "All right, that's fine." So Warren and I spent the evening together, and I typed his master's thesis. As a nice, little gift for that, he took me to dinner at a restaurant called Eaton's [Restaurant] in Pasadena. The only reason I mention that is because, eventually, we seemed to hit it off quite well, and we later married. After our wedding, I didn't know where we were going to spend our wedding night. We had a large wedding and then arrived at the same restaurant that he and I had gone to on our very first date, which also had an adjoining motel. [laughter]

THACKRAY: Did you give up working when you married?

K. SCHLINGER: Eventually, yes. We debated then whether he should set his sights higher than the professional degree and go for the doctorate. I thought he might regret the fact if he didn't. So, we more or less put off having children and lived in an apartment as long as we could. We both still worked, he on his doctorate program, and I as secretary to the two heads of the chemical engineering department [which I enjoyed anyway]. We had a good time. Then, we had a son, and I decided it was time to retire. Warren got his doctor's degree in the meantime. It all worked out fine. [laughter]

THACKRAY: Is all that true? [laughter]

SCHLINGER: Yes. That's better than I can tell it! [laughter]

K. SCHLINGER: I was singing—I still did a lot of vocal work. That's how we came to Carmel. I became a soloist for the Bach Festival and brought all three of our children with a nanny. We had a wonderful time and fell in love with the area, so we looked at property, and found a nice spot to settle down. Later on, I retired from singing.

THACKRAY: What was the first year you first sang in the Festival?

K. SCHLINGER: Nineteen hundred fifty-six. I sang with the Festival for a long time, maybe ten or twelve years. I came when Sandor Salgo was in his first year as director. It was great fun. We still enjoy the Festival and are going to it this week. [laughter] Not as participants but as supporters and audience members, which they need also.

THACKRAY: Warren, let us return to your side of the story. You were completing your master's degree and enjoying it, and then you decided to stay at Caltech?

SCHLINGER: That's right, and I had a chance to see this beautiful lady every now and then! By the time I finished the master's degree, we were beginning to think about getting engaged. We eventually decided we could get married and survive. As I said, we were married in June of 1947, a year after I got my master's degree. We decided that it would be a good idea for me to continue on in Caltech's Ph.D. program. I was getting scholarship money from Chevron, and Katie had a pretty good job working for Sage and Lacey.

THACKRAY: Who else was completing their Ph.D. in chemical engineering?

SCHLINGER: Two chemical engineers who had received their master's degree before the War came back to school the same time I did and started on their Ph.D. program while I was in the master's program. The first two were Bill Corcoran who you've probably heard of and Glen Billman, who went to work for Chevron after he got his Ph.D. He now lives in the Bay Area.

In the second class, which was my class, there were only two of us, me and Dave [David M.] Mason. Dave became chairman of chemical engineering and dean of engineering at Stanford for a long time. Dave and I were the third and fourth Ph.D. chemical engineers at Caltech. After us, the classes got a little larger. I'm trying to think of all the names in the right chronology. Cornelius [Neil] Pings, who became an academic administrator, was behind us, and Scott Lynn who became a professor at UC Berkeley. A number of other people have done quite well, but it was a very small group. Everybody knew each other very well.

The master's program increased to where there were eight people for the next couple of years. When I was there, the program was limited for a while, faculty-wise as well as space-

wise. Chemical engineering at Caltech was in an area that was part of the steam boiler house. You had to go through the boiler room to gain entry to the lab. There were two boilers for the whole campus steam plant in an adjoining building which contained laboratory equipment for the PVT work and the offices.

Linus Pauling was the division chairman by this time, and that included chemistry and chemical engineering. We didn't pay much attention to his position; we saw very little of him.

THACKRAY: Caltech had such a basic science orientation to it. As an engineer, even if you were doing thermodynamics, it was hard to compete with basic science, especially in the context of World War II.

SCHLINGER: I think what we were doing, in our little world, wasn't competing with atomic energy. As far as nuclear energy goes, to this day, I don't know who was doing what and where, but I know a lot of people that were certainly involved in it. Rocket propulsion was pretty much thermodynamics. That was the main thing that the chemical engineering people were involved in. It was the forerunner of JPL [Jet Propulsion Laboratory].

Thermodynamics and chemical engineering are closely related to aeronautics. Even when I used to go to Caltech for their open house program, back in high school, Caltech had a demonstration of rocket propulsion. The demonstration was rudimentary, but they were thinking about what could be done with rockets, if you get one out into space somehow. That was something that was in the mill.

Of course, JPL was instrumental in getting the first satellite into orbit. When it was launched, it used all the knowledge that we could put together at that time. They were basically developing rockets for munitions as well as for added propulsion in airplanes.

THACKRAY: What did you need to do to complete your Ph.D. at Caltech? Were you taking further course work?

SCHLINGER: Yes, indeed. I continued my work in applied mathematics, and then I had a minor in mechanical engineering. I took a number of courses in mechanical engineering. I also studied applied mechanics, structural engineering design, and things like that. About a third of my time was spent in the classroom. I also spent a good deal of time doing my research. In those days, you had to design and build the equipment that you used for your research program yourself. Although, we did have a highly skilled machine shop available. I had a couple people that could help me do that. I had to piece equipment together and order the parts. That was a major part of the effort.

My thesis was composed of three parts. One was determining the thermodynamic properties and isobaric heat capacity of 1-butene and 1-pentene. At this point I got involved with Chevron because they had supported the cost of building an outdated calorimeter that was used for the study. The equipment had been sitting idle all during the War and had to be rebuilt and modified. Plus we had thermocouples, galvanometers, and resistance thermometers to measure temperatures.

Technological advances have made things a lot easier. Today, you just go out and buy a piece of equipment from some vendor to do what you want it to do. In those days, everything in the lab was made by people in the laboratory and the machine shop that we had there. Occasionally, we'd have to go into a campus machine shop that was left over from the two hundred-inch Palomar [Observatory] telescope days. The machine shop was available for things that you couldn't do on your own. Every department had their own machine shop. Chemistry had theirs; chemical engineering had theirs. It was an interesting time.

THACKRAY: Pentene and butene research were important parts of your thesis. What were the other parts?

SCHLINGER: One was the thermodynamic properties of NO_2. I had publications on it and on the pentene and butene work. The third part was the study of a turbulent combustion flame. I had a predecessor who had done work on that, which I took over. He had a tubular chamber—about 6 inches in diameter, 20 feet long, with a 1-inch axial inlet of natural gas. Combustion occurred at the interface of the gas jet entering the annular air stream. We tried to determine the distribution of velocity, temperature, and molecular components downstream as a function of position. We made the sad mistake of making the equipment horizontal rather than vertical. So we had a lot of thermal gravitational effects that distorted everything and it wasn't a terribly successful experiment. But then again, we had to build all the equipment for sampling and measuring the velocity and temperature in the flame.

THACKRAY: You worked on an interesting mix of very practical research, math, and thermodynamics. Did you like all parts of this mix?

SCHLINGER: I loved it. I always liked to build things. That part was easy for me.

THACKRAY: That must have made you an attractive student because usually people fall on one side or the other.

SCHLINGER: A lot of people had real problems building their own equipment. They didn't do too well. Several people didn't complete the Ph.D. program, but they ended up with the two-

year degree of professional engineer. There were some who switched back to chemistry. Do you know Paul Farrington from UCLA [University of California, Los Angeles]? He was in our group of fifth year students who got their original master's degree, but went back to chemistry. Another one who was in that class was Hugh Baird. Hugh Baird became president of C. F. Braun Corporation in Alhambra. It's since folded. He's still around.

THACKRAY: It sounds as if life was pretty good.

SCHLINGER: I think all the people in that class were quite successful. Katie and I were married in 1947. I didn't get my Ph.D. until 1949, so we had two years of survival in between. At that time, I thought that I wanted to be involved in teaching. After I graduated, I was offered a position as a research fellow at Caltech, which is a step below assistant professor, so I taught for four years.

THACKRAY: Had somebody else taken that route ahead of you?

SCHLINGER: No. In the fifth year master's program, there was a fellow, who had gotten a chemical engineering degree back in 1940 or something like that, working as an instructor in the lab. Dave Mason, after his Ph.D., went to work for JPL. I stayed on at Caltech partly because of Katharine. She wanted to continue working with Sage, and it would have been difficult if I'd gone someplace else.

Anyway, I taught for four years, until 1953. At that time, in an agreement with Sage and Lacey, I went out and got some experience. They thought that I would be a much better teacher if I knew what I was teaching my students to do, and I agreed with that. That's when I went to Texaco [Inc.] at Montebello Research Laboratory.

THACKRAY: Would you talk about your professional life during the years of 1949 to 1953?

SCHLINGER: Although I still had several research programs going on, my main assignment was teaching the application of thermodynamics to fluid mechanics. Sage taught the thermodynamics course. I was also teaching the first year laboratory course for the master's students. This was the course where they had to learn how to make equipment. That was a natural for me.

One of the most interesting things that I did then was to start using computers to develop equations of state, actually calculating the PVT properties of specific compounds. At that point in time, the Benedict-Webb-Rubin equation of state developed at MIT was the best available equation; the constants in the equation were determined empirically. We developed the first

program that would take a batch of PVT data and calculate the constants for a Benedict-Webb-Rubin equation of state using least square criteria of variation thanks to the computer. At the time, Caltech had only one computer, an IBM 640. It needed its own full-time technician and had several hundred vacuum tubes. The computer had a memory that we thought was very impressive, even though it was about the equivalent of an IBM [punch] card. [laughter] We were able to write programs and make some improvements of our own that doubled the memory in the computer by modifying the use of the punched cards. [laughter] It would take several hours to calculate the constants in the Benedict-Webb-Rubin equation. Once one had the constants, one could calculate the thermodynamic properties from the equation. The equation had one exponential term which contained a constant. That was rather difficult to optimize. The computer didn't do that too well.

THACKRAY: When you say "we," who would that be?

SCHLINGER: I was working with one of the graduate students, Harry Brough. We adapted that computer to quite a few chemical engineering problems. You had to wire all your program boards and do everything by hand. At that time I was a research fellow. I also did some work on designing equipment for use in studies of diffusion of hydrocarbons in the air. I think the computer processed the diffusion data, too.

THACKRAY: When was the first time you left California?

SCHLINGER: I'd been vacationing outside of California for quite a number of years, but I never had worked outside of the state. In fact, I still never have, except when I went on business trips. I'd been over most of the western part of the country. After Katie and I were first married, we took camping vacations in British Columbia and Alberta, Canada. So we'd seen a lot of the western part of the country. When I was teaching, I was involved in a program sponsored by the government—Project VISTA—and it involved many people on the Caltech campus. This was during the Korean War. I was involved in the ballistics program to calculate the trajectories of missiles and things. I had to travel occasionally to Washington [DC].

THACKRAY: Did you travel by plane?

SCHLINGER: No, by train. You'd go one weekend, stay there a week, and come back the next weekend. You could get on a train Friday after work in Pasadena about nine o'clock at night, and could arrive in New York or Washington D.C. in time to go to work Monday morning. It was a three-night and two-day trip.

THACKRAY: You, your family, and Katie's family had grown up in the West. How did you react to the East?

SCHLINGER: My first visit to the East was to give a paper at a Boston ACS [American Chemical Society] meeting on the Benedict-Webb-Rubin equation. Ironically enough, there was a fellow from Caltech, Jack Sherman was his name, who worked for Texaco. He was the research technical department's computer expert, and he gave me a rough time on that paper. [laughter] I found it ironic that I ended up going to Texaco and working for them.

No, that's not right; I forgot about this: when I graduated from high school, my father sent my mother and me back to Detroit to pick up a new car in 1941. We took the train to Chicago and on to Detroit. We visited relatives in the Thousand Islands and Rochester before driving back to California. [laughter] It was quite an experience. We came back through South Dakota and North Dakota, having gone across Lake Michigan to Minneapolis on a ferry, up through the Black Hills, saw the [Mount] Rushmore [National] Memorial being carved out of the rocks, and then Yellowstone [National Park], and then through Nevada, through Reno to Los Angeles. That was my first visit to the East Coast. I remember the [Thomas A.] Edison museum [Edison Institute Archives] at the library [The Henry Ford] outside of Detroit [in Dearborn, Michigan]. [Thomas A.] Edison was a man that always fascinated me. I'd love to read his autobiography.

My mother and I visited some of her relatives in the Thousand Islands, in the St. Lawrence River. We drove across the border, over into Ontario. There was a house out on an island. The only house on the island. No refrigeration, no electricity. Interesting. I remember distinctly that in June, it was still perfectly light at ten o'clock at night. [laughter] Quite amazing. See, you're making me recall things. Anyway, I did see that part of the country. Then, I guess, the next time I went, it was to the ACS meeting in Boston, representing Caltech.

THACKRAY: Had you met people on the MIT chemical engineering faculty before your trip to the ACS meeting?

SCHLINGER: No, not very many. A couple of them had visited Caltech after I was a graduate student. When I was on the faculty, I remember [Thomas K.] Sherwood came out once, but I think this was just a casual visit. The only MIT faculty I had ever really met until I started with Texaco were those that came out to Pasadena to visit Caltech. Perhaps I met a few at an ACS meeting, but I don't recall.

THACKRAY: By this time were you going to several ACS meetings? Did you go to AIChE meetings?

SCHLINGER: No, I didn't really get very involved in AIChE. I was a student member of the ACS, and then I dropped my membership for a while, but I rejoined again about the time I got my degree because I wanted to get their publications. All of my work was being published in the *Industrial Engineering and Chemistry*, not by the AIChE. So I paid my dues to ACS, in fact, I received my fifty-year membership four or five years ago.

I didn't join the AIChE until I was with Texaco in 1958. I'm still not a fifty-year member of AIChE. Though after that, I was quite active in the AIChE. In fact, I was on the board of a local section for several years. I didn't go to many of the local ACS meetings after I left Caltech. However, I was very active in the local AIChE meetings during the time I was at Montebello. I encouraged my staff to belong, and Allen Robin, one of my people who worked at Montebello, was chairman of the section.

AIChE meetings provided an excellent platform to promote your technology. I gave several papers and presentations at AIChE meetings after I was with Texaco. I was involved in the local section and knew the people, particularly the people in the plant construction business.

I've always maintained contacts with a lot of my Caltech friends. Of course I've kept up with Sage and Lacey. Bruce Sage was a consultant for Texaco. That's why he knew about Montebello Research Laboratory and that they needed somebody. That's why I went there. He was a consultant even after I was running the laboratory. We had a lot of things in common. I lost track of Caltech for a number of years in the 1960s.

THACKRAY: In the context of an academic career, was the idea of going into industry attractive?

SCHLINGER: Yes, that was my original concept. I wanted to get some first hand information and learn how things were done in industry. I had a pretty good idea what went on academically. This was about the time that we started talking about admitting women to Caltech. It was talked about when I was there, but it didn't happen for another ten years.

THACKRAY: It was an all-male world.

SCHLINGER: There were no women undergraduates and only a few women graduate students, but not in chemical engineering.

THACKRAY: How did your thinking about industry develop?

SCHLINGER: In my mind I was at Texaco temporarily. Nobody else knew that except the fellow who ran the lab at Texaco, [Dubois] Eastman. He was quite a remarkable engineer, very inventive. I learned as much from him as from many of my professors at Caltech. I worked with him almost every day. He graduated from Berkeley and went to work for Texaco in the late 1920s and spent a number of years developing fluid catalytic cracking. He was Texaco's main contribution to a joint committee working on catalytic cracking before World War II broke out.

There were several different versions of catalytic cracking, but the fluidized bed version supported by Texaco involved Mr. Eastman. He was really instrumental in getting the Texaco version perfected. After the War was underway, he was appointed to be Texaco's representative on the government program to develop and commercialize production and separation of butadiene for the manufacture of synthetic rubber. He was instrumental in designing that first butadiene separation plant in Port Neches, Texas.

After the War, [Percival C.] Dobie Keith, who founded and headed the Hydrocarbon Research Institute [HRI], came to Texaco with a proposal to convert natural gas into synthesis gas to be used with the German Fischer-Tropsch synthesis technology to make synthetic crude out of surplus natural gas. He convinced Texaco management that this was a good idea. Texaco and HRI agreed to build a demonstration plant in Brownsville, Texas, which would have been a first to use fluidized bed Fischer-Tropsch synthesis and partial combustion of natural gas with oxygen to make syngas [synthesis gas].

When the chips were down, nobody knew how to do the partial oxidation. Dobie Keith had a good concept. He proposed to use a bed full of hot ceramic rings and pass the natural gas and oxygen through the bed, in order for it to come out converted to carbon monoxide [CO] and hydrogen [H_2]. Well, what somebody seemed to forget was that if one really applied thermodynamics to this process, he would find that the carbon was a pretty stable phase component in such a system. [laughter] You came out with carbon monoxide and carbon [CO_2] dioxide. Eastman eventually got the idea of getting rid of all the packing. He wanted to burn natural gas and oxygen, which thermodynamically, if done correctly, you could run at around 2,500 degrees Fahrenheit without making carbon as long as you could get through that phase where carbon is a stable component. That happens when you get down around 2000 degrees.

You had to get the reactants hot and then somehow quench the gas through the lower temperatures. They decided that they needed a laboratory to demonstrate what Texaco thought they could do for this program. Eastman was to run the laboratory. He had *carte blanche* to put the laboratory wherever we wanted to put it, if he had a good reason for it. He wanted to come back to California and leave Texas. He said, "The natural gas in Texas has sulfur in it and we don't want to go through the expense of having to take the sulfur out of the gas before we burn it. The [gas] field out in Montebello had sulfur-free gas. There was a gas plant there at that time. The plant was compressing gas, removing the LPG [liquefied petroleum gas], and putting dry gas into the distribution system." They tried to talk him into building the pilot plant at the Texaco refinery in Wilmington [California], and he said, "No, the gas was better at Montebello." So he got the Texaco producing department to dedicate a little part of land that

they owned where they had a natural gas plant. They were using the plant to separate the natural gas from the LPG, and putting it into the distribution system. There were eight or ten compressors, running around the clock, and we bled out a little compressed gas for our use.

THACKRAY: When was this?

SCHLINGER: It was about 1947. They were having problems getting a gas-oxygen burner in the gasifier that would not make carbon. That's when they came to Caltech and got Bruce Sage to consult for them. He had some pretty good ideas and came up with a design concept for the burner, which is still used today. The patents don't tell you how to make the burner exactly. That is what's used today. Everybody wanted to develop a burner that had a bunch of little holes in it, like we have on a stove. This burner is just a singular, annular diffusion flame. We really got it working. Of course, we had to develop refractories that would hold up under these temperatures. It wasn't too bad with natural gas, but when we went to oil there was a problem. The plant was enlarged, scaled up, and put down in Brownsville. When I went to work at Montebello in 1953 the plant was just starting up. The plant had the biggest oxygen plant in the world. Of course, it wasn't very big by today's standards.

THACKRAY: What was the name of the company that ran the oxygen plant?

SCHLINGER: I think it was Air Products [and Chemicals, Inc.]. At the time no one had successfully compressed pure oxygen to between 500 and 600 psi without severe problems. So this plant pumped liquid oxygen up to the required pressure and then vaporized the liquid. Thermodynamically, this wasn't very efficient, but gas turbo-compressors were not available.

THACKRAY: Once you decided that you would go into industry, did you interview at a lot of places?

SCHLINGER: I was offered a job at DuPont in Wilmington. I was offered a job at Chevron and a job at Texaco at Montebello.

THACKRAY: Did you visit many of these companies?

SCHLINGER: I did talk to the two other people. Katie and I had just started our family, our second child [Norman W. Schlinger] was on the way, and Mike [Michael S. Schlinger] was already two years old. So moving to Wilmington or Chevron for two or more years didn't look very attractive when I could just drive to Montebello. That was, I think, fortunate. I don't know

what would have happened if I had selected one of the others, but it turned out very well. I really got going with Texaco at Montebello.

THACKRAY: What were you hired as, and who was at Montebello in 1953?

SCHLINGER: At that point, it was a small group. There were three chemical engineers in addition to Mr. Eastman, and I was number four. There were also two analytical chemists. We had a laboratory manager, Roland Beck. We had enough operating people to run two pilot units around the clock, twenty-four hours a day, seven days a week. In addition we had a maintenance crew. I think the total number of employees was about forty to fifty people.

THACKRAY: When you say two analytical chemists, four chemical engineers—were these Ph.D.-level people?

SCHLINGER: No. There were only two of us with Ph.D.'s. The year before Texaco had hired a Ph.D. from MIT named Charles Marion. I was the second Ph.D. We had Ph.D.'s back in Beacon at the research laboratory in New York, and some down in Port Arthur, but none at Montebello. Charles Marion majored in combustion with [Hoyt C.] Hottel at MIT. He was quite an addition. He was working specifically on the burner design.

THACKRAY: So you were pretty highly qualified?

SCHLINGER: I believe I was.

THACKRAY: What salvation were you to bring?

SCHLINGER: When they brought me in, my first assignment had dribbled down from the vice president of the R&T [Research and Technology] department. He had been on the government committee to review what the United States should do to prepare for the coming oil shortage. We were going to run out of oil. This was in the late 1940s. It was recognized that we didn't have enough indigenous oil for more than ten or twenty years. The recommendation that came from this study committee was, "We've got to go to oil shale." That was my assignment, to figure out how to economically get oil out of oil shale.

THACKRAY: A small task! [laughter]

SCHLINGER: That was my first assignment. I wasn't involved in the combustion and operating problems at Brownsville.

THACKRAY: You said that the vice president for R&T gave you this assignment. Where was he?

SCHLINGER: He was in New York at the main research laboratories in Beacon, New York. He shuttled between the Chrysler Building and the offices up at Beacon.

THACKRAY: How many chemists and chemical engineers were in Beacon?

SCHLINGER: Beacon had mostly chemists and mechanical engineers. They probably had several hundred technical and non-technical people there. It was Texaco's main R&T lab.

All the engine testing for oil and gasoline additives were at Beacon. They did all the lubricants and additives development. Then when they needed to prove something out, they'd go down to Port Arthur. Finally, they would scale it up into the pilot plant, and eventually it might go into commercial production.

THACKRAY: I don't know enough about Texaco history. Why were the main offices in New York, if the very name says "Texas?"

SCHLINGER: The move to New York happened well before my time. I believe that the management of the company felt back in the early 1920s that if you're going to be a worldwide company, you had to have a presence in New York. They moved in, I think, as one of the initial, primary tenants of the Chrysler Building when it was completed in the late 1920s. I have been told by a lot of people that Texas was very unhappy to see Texaco move to New York, but they still had their major refinery in Port Arthur. In those days it was officially "The Texas Company."

When it was decided that a first-class research and technical department was needed in the early 1930s, management wanted those departments separate and isolated from the administrative operations. So they went up the Hudson River to Beacon and bought an old milling plant. They started from scratch and built several laboratory facilities. Lubricants were major in those days. Texaco was respected as the leading company in developing greases. It was all done up there. It was like a university campus. The first time I went there, it was shortly after I started to work for Texaco.

THACKRAY: So Texaco focused on long-range research?

SCHLINGER: Beacon was the long-range research laboratory. They were doing catalyst development up there on Fischer-Tropsch synthesis as well as lubricant, oil, and gasoline additives and greases.

[END OF TAPE, SIDE 3]

THACKRAY: Tell me about Texaco in California.

SCHLINGER: In the late 1920s Texaco decided they wanted to market its product in all forty-eight states. I think they were the first company to do this. To get a handle on products on the West Coast, they purchased an oil company that had a small refinery and was producing oil in Fillmore.

THACKRAY: Where is that?

SCHLINGER: Fillmore is about halfway between Ventura and Los Angeles. It's up in the first row of mountains north of the San Fernando Valley. There's still oil production in that area. There were people working for us that came into that company when I first went to Texaco. I don't know whether the small existing refinery Texaco purchased in Wilmington, in southern Los Angeles county, was part of the Fillmore deal or not. By World War II, Texaco had built a large refinery in Wilmington, refining crude oil from southern California and the San Joaquin Valley.

THACKRAY: As I understand it, the center of gravity for production was in Texas and for research was in New York?

SCHLINGER: Yes, and Mr. Eastman was in California. He was a highly respected man in this company, and that lab would never be there if it wasn't for that individual. Many of the things that we have successfully accomplished were envisioned by him. The development of gasification took a major surge when he asked, "Why don't we start making ammonia with our gasification technology, instead of just trying to make synthetic crude?" Because I was assigned to the shale, I worked diligently on that for several years.

THACKRAY: What did you do? That was a pretty big assignment for one person, wasn't it?

SCHLINGER: There were two major approaches to processing oil shale. You either mine the shale as you do with coal, or you try to process it *in situ*. We elected to pursue the mining alternative. I visited the [United States] Bureau of Mines in Rifle, Colorado, went through the mines, and inspected the atmospheric pressure moving bed retorts they were operating. Texaco had large holdings of oil shale they had bought back in the 1920s. I believe they still own the reserves.

Anyway, you define the quality of the oil shale by how many gallons of oil you can get out of a ton of shale. Anything more than 20 gallons per ton is considered pretty good shale. A lab test known as a Fischer Assay is used to evaluate oil shale samples. The shale is heated in a special retort to see how much oil can be recovered under specific conditions. At Montebello, we got shipments of oil shale and we were working with it.

I had the idea that we should be able to retort the shale under pressure with hydrogen. We had equipment to generate hydrogen and CO from natural gas at 300 to 400 psi. We just needed to catalytically shift the gas to make 95 percent hydrogen after we scrubbed the CO_2 from the product. We filled a six-inch pipe with crushed oil shale and circulated the hot H_2. We found that we could recover oil equal to 130 percent of the Fischer Assay. Nobody had realized this was possible. We got some patents on this idea. This was pretty hot stuff, and actually, Texaco thought this was going to really be a winner. We named the process hydrotorting.

THACKRAY: This was when?

SCHLINGER: This was probably in late 1955. I had gotten so involved in this; it became the main reason why I didn't go back to Caltech. We bought land up in Salt Lake City. We were going to open a shale oil laboratory and a large pilot plant.

THACKRAY: Was this all based on the hypothesis that the United States would run out of oil?

SCHLINGER: We knew we had to compete with the present price of oil, but many believed that oil would soon be more costly to find and produce. No one realized how much oil there was in the Middle East. We knew there was oil there, but nobody realized it was as extensive as it turned out. When Texaco bought that property, we felt we could compete with ten-dollar-a-barrel oil. We were making serious evaluations of a much larger-scale plant that we would locate up in the shale country. However, every time we would make an improvement and get the cost of producing shale oil down, oil prices would drop. [laughter]

Then, there was the problem of what we were going to do with all the tailings of the operation when the shale oil precursors were recovered from the ash. The ash was a fine, cement-like product and disposal was always a problem. Why don't we just put it back in the mine? It became more obvious that disposal was a major ecological problem, so the cost of the plant kept rising. We eventually abandoned any active research on hydrotorting.

In the meantime, because we had hydrogen available in quantities that were large enough to do some large scale pilot plant testing, we were asked to do studies and provide a process design for the first hydrotreater to be built in a Texaco refinery to treat the middle distillate and gasoline and reduce sulfur content by catalytic hydrogenation to form H_2S [hydrogen sulfide]. The first unit was installed at the refinery in Los Angeles because virgin naphthas from California crude typically have too much sulfur to be used directly in catalytic reformers using platinum containing catalysts.

THACKRAY: Was there a concern of catalyst poisoning?

SCHLINGER: Yes, sulfur deactivates the platinum catalysts, so you need to get the sulfur out of the reformer feed. We even did it with diesel fuels and kerosenes. We were doing a lot of work on that phase of it. Our laboratory was looked at as a place where companies could get a process design to build a commercial scale unit, so we were much sought after. I was in charge of that part of the program.

THACKRAY: Were plants built for this type of production?

SCHLINGER: Yes, several plants were built. As far as I know, most of them are still operating. They may have changed or improved catalysts, but it was the cobalt-molybdenum catalysts that were used for desulfurization. In the pilot plant studies, we could use sulfur-free hydrogen.

THACKRAY: Was this in the 1960s?

SCHLINGER: No, it really began in 1954 and continued into the earlier 1960s, but we didn't give up on our hydrotorting process. We said, "If we can extract oil out of oil shale, what'll happen if we feed residual crude oil into this system instead of oil shale?" We used a counter-flow scheme of hydrogen going up through a bed of pea gravel and residual oil and coming down from the top. We had resid passing down through the gravel at first, and then we had it eventually flow down over a bunch of partial ¾ discs, free-falling, as hydrogen, at 1500 psi, would go up through it. We found we could take residual crude bottoms, which are normally

sold as fuel oil, and run the resid through this system and recover 50 percent of the product as distillate. We called this Texfining.

We had a large scale Texfiner at Montebello, and we could run 100 barrels per day [bpd] resid through the system. We used the 100 bpd data to design a full scale five-thousand-barrel-a-day commercial plant, which was built at the Texaco refinery in Los Angeles. The unit was started up in 1964. They used our technology to build a hydrogen generation plant as well.

In 1961 I was appointed supervisor of the research laboratory. We had refined our technology of making hydrogen. We could use residual crude, or we could use fuel oil or any kind of pumpable liquid hydrocarbon with oxygen and convert it to synthesis gas [H_2+CO]. The Texfining operation was a consumer of hydrogen. We consumed on the order of 2000 cubic feet of hydrogen per barrel of liquid product to catalytically hydrogenate and desulfurize the hot overhead stream from the "stripper" passed down through the catalyst without cooling. That hydrogenated olefins made a much better product.

We were competing at that time with the fixed-bed processes that Union Oil [Company of California] and Chevron had developed using expensive noble metal catalysts, but getting much more efficient conversion. They did have to use distillate feed rather than residual fuel. Union, I guess, had the best fixed-bed technology, but this was back when we were still developing new processes for refining crude. By now, our gasification technology was well along, and we had a number of commercial partial oxidation plants up and running on natural gas and oxygen, making ammonia. We had those plants all throughout the United States, up in Canada, and one in Holland. For places that didn't have natural gas, we were also working to provide plants designed to run on residual oil.

THACKRAY: Was this technology developed in Montebello?

SCHLINGER: Yes, all that technology was developed by Montebello.

THACKRAY: I want to go back in the time. How different was the world of Montebello from the world of Caltech?

SCHLINGER: It wasn't as different as I expected. We were always investigating and evaluating new technology and ideas. We had provided process design information for more than sixty commercial plants by the time I retired. In most cases the required technology was under a licensing agreement with Texaco. The licensing fees supported the laboratory. In the 1950s and 1960s, as long as the licensing arm of the company, which was known as Texaco Development Corporation, was bringing in more money licensing the technology than it took to run the laboratory and making a net profit, they didn't care what we did.

THACKRAY: Were you licensing your technology to other oil companies?

SCHLINGER: We were mainly licensing it to chemical companies. Once we got it going on oil, we licensed it to several plants in Japan. The first company in Europe that we gave a license to was in France. In 1962 we raised the pressure, and we could operate up to 100 atmospheres. I think 80 atmospheres was as high as we ever built a commercial plant; we built the first eighty-atmosphere plant at BASF [Corporation] in Germany—that was a real interesting project, working with the Germans. They looked at things in a very detailed, regimented way, whereas we always kept the big picture in mind We spent a lot of time over there. I spent a lot of time in that plant, which was designed to make ammonia from heavy residual fuel oil.

THACKRAY: When was this?

SCHLINGER: That plant design begun in 1964.

THACKRAY: As early as that?

SCHLINGER: That's when we started the design. They came over and we made the estimates. That plant went on stream in about 1967.

THACKRAY: Back in Montebello, was the operation growing?

SCHLINGER: No. We didn't really grow very much. The company took the attitude that they didn't want to spend a lot of money on stuff that they were just going to license. They could make more money finding and selling oil, and they were probably right. In the meantime, as long as we didn't ask for ridiculous amounts of money and if we kept supporting ourselves, they kept us alive. We had the backing of the Texaco Development Corporation and had key representation on the necessary financial committees, so we survived as independent, almost like a start-up company. [laughter]

When our proposal moved from the eighty-atmosphere operation to the one hundred-atmosphere, and then finally to one hundred sixty-atmosphere, one of the strange things that you find as this pressure goes up is that another component suddenly appears: formic acid [HCOOH]. It was some time before we recognized that HCOOH was the culprit. We had a lot of corrosion problems when we raised the operating pressure. Then by the time we thought the oil was going to peter out, we tackled coal.

At Montebello, Texaco tackled coal before I ever came to the lab. The concept was that they could take a slurry of pulverized coal and water, pump it through a heater, vaporize all the water, feed the coal and steam mixture into a gasifier with oxygen, and make hydrogen and CO. That part worked pretty well. They never could keep the vaporizer heaters from fouling up the coal. We tried to keep a higher velocity, but erosion was too severe.

THACKRAY: What date did you begin that?

SCHLINGER: I wasn't there yet. Texaco had built a demonstration plant in Morgantown, West Virginia. They built the gasification plant but they didn't build the air separation part. They tried to run it on air first, but it didn't work very well. It was not very successful. They never did build an oxygen plant. They never thought that we did well enough on air to justify the expense of building the oxygen plant. The Bureau of Mines supported that program. Anyway, the demo plant was shut down in 1953.

By the time we decided to go back to coal [about 1970], we had made some process developments on oil gasification that would significantly improve coal gasification operation. It had been demonstrated at both Montebello and the Texaco refinery that we no longer required steam in the gasification feed to moderate the temperature and that hot water could be used instead.

One day we decided that if we could eliminate the steam with residual oil, why couldn't we do the same with coal and water? Pump the coal and water slurry. We did that, and it worked. Unfortunately, we had a lot of problems with learning how to handle the slag from the coal. We had a slagging gasifier. It was operating at temperatures high enough to melt all the ash in the coal, so we had to quench it properly.

That was pretty good, and we licensed that technology to Ruhr Chemie in Germany. We spent a lot of time over there, because Ruhr Chemie already had an oil gasification plant. They put in a fairly large demo plant, which used tons-a-day of coal. We had a lot of operating problems with it, but they were using it to make methanol—that was their main product at the time. And we also licensed a plant to Tennessee Eastman [Company], which is still running, by the way.

THACKRAY: Yes, I've been to that plant.

SCHLINGER: They kicked us out after the exchange agreement expired, so we don't really know what they're doing anymore. Apparently, they knew what they wanted to do. They wanted to have a gas mixture with a high concentration of CO in their hydrogen, and if you used oil, you had to make more CO someplace and get the desired CO/H_2 ratio. And so they liked this coal.

THACKRAY: That plant started up when?

SCHLINGER: The mid-1970s. The Ruhr Chemie plant started up a little before that.

THACKRAY: I want to go back in time again. You were moving up in the management of the operation, and your titles were changing—you became supervisor in 1961. What did that mean to you?

SCHLINGER: I was over all the research, but we had a business manager there in charge of personnel problems. I was made supervisor of research when Mr. Eastman died. He was manager of research. The fellow who was there already as business manager wasn't really involved in research. He was just running the laboratory, making sure all the money came out right, and hiring people. He was made manager of the laboratory, and I was made director of research.

THACKRAY: In 1961 you were, effectively, managing the research?

SCHLINGER: I was the top research person, yes. Mr. Eastman, of course, had died in 1961. He was only fifty-five; it was a terrible loss.

THACKRAY: Inside of eight years, you'd gone from going out to get some experience to running the California research operation of Texaco.

SCHLINGER: Right. In the meantime, I was shipped down to Port Arthur for an assignment. I decided I wanted to go back to Caltech rather than work in Port Arthur. I was just used to too many things in the civilized world, and they didn't have them down there. [laughter]

THACKRAY: When was this?

SCHLINGER: This was in 1957. I spent six months in Port Arthur, Texas.

THACKRAY: Did your family travel with you?

SCHLINGER: I was there about six weeks when the company found a place for me. I came back to California, and my family and I drove down to Texas. They didn't like it. By that time, we had a baby girl [Sarah Lynne Chrisman], and if it was my choice to stay at Port Arthur or go back to Caltech, Caltech would have won.

THACKRAY: Why did you go to Port Arthur?

SCHLINGER: To get some experience [laughter]—they wanted me. You know, Mr. Eastman told me, "You're on a fast track, but you're going to have to spend time at Port Arthur."

THACKRAY: You had to "punch the ticket."

SCHLINGER: I didn't think I needed to do that, but I went for six months.

THACKRAY: How did you get back? How did you "un-punch" the ticket? [laughter]

SCHLINGER: I got Mr. Eastman to say he needed me back in Montebello. [laughter] But I killed my chances of moving on up in the research department, which would have meant going to New York or Houston. I could probably have gone to the Texaco Development Corporation, but that wasn't what I wanted to do.

I immensely enjoyed what I was doing. We had all these opportunities out in Montebello, I was seeing the world and had all kinds of challenges. I was giving talks and papers and getting patents and I was quite happy with myself. I was paid quite reasonably at the time, I thought. I just didn't think that was the life I wanted for my family. We were down in Texas when segregation was a big issue. Also, air conditioning was a rarity. We had air conditioning in the office buildings at work, but all we had where we lived was an attic fan. [laughter]

THACKRAY: By not being a good corporate man and staying in Port Arthur, you were making a set of choices. Why did you do that, and what are your reflections on how that situation turned out?

SCHLINGER: Well, Katie and I talked this over and we decided, adding up all the positives and all the negatives, that staying in southern California would be fine because I knew I could probably go back to Caltech if I wanted to. At least I thought I could. Then, unfortunately, a

year or two years later I was offered an assistant professorship at Caltech and I had to remake the decision about what I wanted to do.

THACKRAY: If you had stayed in Port Arthur or gone back to Caltech—what is it that you would have had or missed compared with what you did?

SCHLINGER: Well, I don't know what I missed; I don't know where I would have gone. I don't think I would have really enjoyed the type of thing that the general manager of research at Texaco has to do. He has to worry about people and dollars, and to be sure he pleases the president of the company. It's a challenge, but I just didn't think I wanted to do that. People at Texaco whom I talked to about it, of course, didn't agree with me. They tried to get me to stay at Port Arthur. Then I said, "No, I just don't want to." The people were great. I mean, we made the best of friends, and we're still friends.

THACKRAY: What about your decision not go back to Caltech?

SCHLINGER: It was about 1959 when I got the offer to come back to Caltech. I kind of expected to get that, and I was happy to get it. I still have the letter. This was about the time things were really beginning to blossom on what I was doing at the company. I said to Caltech, "It looks like there's going to be real satisfaction ahead," so I turned the position down. I don't know what would have happened if I hadn't turned it down, but I did.

THACKRAY: That offer, in part, was also an indication that what you were doing was attracting attention.

SCHLINGER: My work was very much attracting attention. I was recognized by all kinds of people in the company. I knew people all over the place, and we always talked about what was going on in Montebello. We were proud of what we were doing.

THACKRAY: From the company point of view, it was the positive commercial implication?

SCHLINGER: Yes. I didn't feel that if I was involved in research, even in those other laboratories, the freedom and the satisfaction one could get out of what they did would be anywhere near equal to that at Montebello. It was just a major opportunity. Very few people, I think, ever have a chance to be involved in something like this. Early in the 1960s and the mid-1960s, I hired another Ph.D. from Caltech, Neal Richter. He was one of my earlier students when I was teaching. He's about seven or eight years younger than I am, and he was an

assistant professor at Caltech. He was on the faculty there for about ten years after he graduated.

I'm not sure when he got his Ph.D., but he knew he wasn't moving as fast as he wanted to move at Caltech. I talked him into coming down to Montebello. He's still there, and he is one of two Texaco Fellows today. He's seventy-one, and he's still with it! [laughter] They still pay him a full salary. He just goes around and advises people on their research and evaluates what they're doing. It was an even better opportunity than what I ended up doing. [laughter]

THACKRAY: What were the positive and negative aspects of being in the role of manager at Montebello?

SCHLINGER: It did take time—I was really spending an awful lot of time there—and my production of patentable ideas began running down hill. They wanted to know why, and I said, "I just don't have enough time to think about those anymore." We had a Texaco board of directors meeting in Los Angeles and one of the things they wanted to do was visit the laboratory. We were expected to have everything painted up brand new and nothing scattered around. Everything needed to be in ship-shape, and I was a little pokey getting it done. [laughter] They had to send somebody out to help me.

That's the kind of thing I didn't like to do. I didn't want to show a false picture to anybody. You know, we don't work in a spic-and-span laboratory. We don't have everything fully painted every day. I wanted them to see the laboratory the way it was. That would not do. That would not be good. I knew the chairman of the board very well, and I knew he wouldn't chastise me the least bit for not having it all spic-and-span. The top brass down in Los Angeles—this was their show, and they wanted this to look like it was in mint condition. It was that way for about a week. Anyway, I'm very glad I didn't get into that. That's a false thing. The board knows that's what you do when they come around and see it. The board of directors knows that this is not the way you operate, but that's not what my bosses in L.A. thought. John McKinley was chairman then. In fact, he was my boss when I went to Port Arthur for six months. Anyway, I don't regret that I made that decision. I have no way of knowing what would have happened if I hadn't made that decision, I don't think I could have been happier.

THACKRAY: Did you cease to be manager in 1981?

SCHLINGER: That was to free me up because I was expected to do a lot of contact with potential licensees and go out and make talks at meetings. I really couldn't do everything. I was the spokesman for the gasification technology of the company.

THACKRAY: Montebello was still small, was it not? Or had it grown?

SCHLINGER: By this time it had grown. In the early 1970s, a high level decision was made that "We don't need Montebello research anymore. We're going to close it down." I was left high and dry, but I had a lot of acquaintances at the Electric Power Research Institute [EPRI]. I don't know if you've ever been there or not. They had a coal gasification division that was very active at this time. I kind of sounded them out. They really wanted to buy Montebello; they wanted the whole laboratory. They thought the technology was a real winner, so they backed us 100 percent.

Earlier, I had been contacted by them, and I went to their meetings. They worked with [United States] DOE [Department of Energy] and were heavily involved in developing the solvent refined coal technology. DOE had a demo plant near Olympia, Washington, at an army base. They put a lot of money into that operation, but they couldn't figure out how to get the hydrogen to run a commercial plant. They had a residual fraction of solvent-refined coal, which was full of ash and was a pumpable liquid above 800 degrees Fahrenheit, but they really didn't know what to do with that. I suggested to them that we could make hydrogen out of it. I guess they thought I was out of my mind, but we were able to demonstrate the technology—we'd never be able to do it today with the EPA [Environmental Protection Agency] regulations—and we were able to synthesize the product.

They sent us some of the liquid. They were heating it and had some way of quenching the liquid in water. It was full of carcinogenic compounds. They sent us a couple of barrels of this residue; we mixed it with additional coal, made a pumpable mixture containing 20 to 30 percent ash, and fed it into the gasifier. It really worked very well. Everybody thought, "You saved the SRC program." This was the missing link. EPRI was really supporting our technology, but DOE never did build a bigger plant. EPRI was also very interested in our coal gasification technology.

In 1968, I met a fellow from Pratt & Whitney at a United Nations conference in Geneva [Switzerland]. He and I came up with a scheme for what is now combined cycle coal gasification. We thought it was a fairly novel idea. I'd never seen it written down. We were proposing Texaco technology to gasify the coal, remove the H_2S from the gas, and burn the CO-hydrogen mixture with steam in a Pratt & Whitney gas turbine, generate power, and then use the exhaust to generate additional steam to generate more power. We worked on a study showing such a scheme could approach 50 percent thermal efficiency.

We were both very interested in that, but nobody at that point had any experience firing gas turbines with 300 BTU or 275 BTUs per cubic foot gas. So Texaco Development Corporation and Pratt & Whitney's counterpart agreed to bring and install at Montebello one stationary combustor from a gas turbine. We actually showed that we could thoroughly burn and combust gas in that combustion chamber with very low NO_X emissions. So that set off the possibility that you could indeed burn syngas in a gas turbine, and do a good job. It has such a low-heating value, it doesn't get terribly hot, so you don't make a lot of NO_X.

Well, that was really the key thing. EPRI decided they really wanted to promote this, so they signed a multi-million-dollar contract for the pilot work at Montebello and that was enough for Texaco to decide not to shut the plant down. Then Texaco's long-range planning people, some of whom had come from the research department and talked the Texaco management and the board into supporting a joint program to build a one hundred-megawatt demonstration plant to prove the concept that power generation using combined cycle coal gasification could indeed run practically emission-free on coal. They were going to go solicit help from the Synthetic Fuels Corporation.

Texaco put together two hundred twenty million dollars from several sources, and Bechtel built the plant at Coolwater in the Mojave Desert near Barstow. Southern California Edison provided the site and purchased the power. They already had a small generating plant at Coolwater. That plant went on-stream in 1982. It was designed for a six-year demo program and built with a waste-heat boiler at the gasifier exit.

[END OF TAPE, SIDE 4]

THACKRAY: You mentioned earlier, Warren, that you had moved away from Caltech, but then you later mentioned that you had re-established contact.

SCHLINGER: When I turned down Caltech's offer, I was <u>just</u> involved with Texaco at the time. I just didn't get back on campus very often. Bruce Sage died, for one thing. I used to go back and consult with him. I lost that contact. Then later, I guess it was in the late 1960s, I was asked to be on the board of the alumni association, which I accepted. That got me re-involved in Caltech. My involvement has increased over the years.

THACKRAY: Is that board for general alumni or only for chemical engineering?

SCHLINGER: No, we don't have separate groups. We don't have many alumni. We also have what we call "The Caltech Associates ." These people are not necessarily alumni. They're people who are helping to support Caltech financially, and there are about eighteen hundred members. Most of them are in southern California, but there are chapters in eastern and northern California. We sponsor trips. The Grand Canyon trip I told you about is one of them.

THACKRAY: You retired in 1987, when you were pretty close to sixty-five. Was that what precipitated the retirement?

SCHLINGER: That was one of those periods when Texaco was trying to cut down on the number of employees, so they offered me half salary for a year, if I retired six months early. I said, "Fine." They cut down on your pension because the pension is based on your last five years' salary. I gave up six months of a much better salary than I had to. So I retired six months before my normal retirement, when I would probably have had to retire. Neal Richter, liked working at Texaco so much that he didn't want to retire, and they said, "All right." He had a good time.

THACKRAY: Did you keep up any type of active chemical engineering involvement when you retired?

SCHLINGER: None except for my meetings with faculty I would go to see. I go to occasional lectures and support chemical engineering at UC Berkeley, UC Santa Barbara, Stanford, as well as Caltech. So I go to meetings and seminars there from time to time. I read the published literature, which I have a hard time finding time to do it. That's the way I've kept up.

I did some consulting at Texaco on using CO_2 for secondary or tertiary recovery of crude oil. I had some people in the producing department I worked with. They were able to come up with pretty good numbers about how much oil is really available. There's no question about it, it would be great—particularly, some of these old fields in Texas where they just opened the well up and produced as fast as they could, and they drained all the gas off, and in many cases, just flared it. CO_2 is quite miscible with oil when you get the pressure up and it lowers the oil viscosity significantly. The CO_2 saturated oil moves through the formation much faster. I really think it's got a big potential.

THACKRAY: Its time has not yet come.

SCHLINGER: Look at it this way; somebody will need to spend one to two billion dollars to make it work. You'd have to build a thousand-megawatt power plant, a thousand dollars a kilowatt.

THACKRAY: You saw the Caltech chemical engineering department in its very early days. What strikes you about the difference between that department then and now?

SCHLINGER: Chemical engineering is changing. It no longer is just process design. It is process design, but it's designing much different processes. I think the move has been very beneficial because conventional chemical engineering was just kind of "dying on the vine." Back in my time, probably 50 percent of those who chose not to stay in academia went to work

in refining, including refinery construction. Another 25 percent went to the petrochemical business. Very few, if any, went into bioengineering or things like that.

THACKRAY: What have been your main occupations and preoccupations since retirement?

SCHLINGER: Well, of course, this house has taken quite a bit of additional time. You see, I do the brickwork outside. My wife and I have enjoyed traveling a little bit more. When I used to go on business trips Katie would go with me, but we couldn't go to places where I didn't have to go for work. As I said, I try to keep up by going to the AIChE and ACS meetings out here on the West Coast. I still go to meetings that EPRI and the Gasification [Technologies] Council organize every year on gasification. Katie and I did create a foundation [The Warren and Katharine Schlinger Foundation], which we manage—there's a lot of time involved in that.

THACKRAY: How do you manage the foundation?

SCHLINGER: I do all the accounting except I get an expert to prepare the tax returns. We have our three children on the board of directors, and I'm shoving some of it on to them now. It takes time, determining to whom we want to give how much.

THACKRAY: What do you hope the foundation may achieve?

SCHLINGER: We mainly support education and the performing arts. One of our primary goals is to support chemical engineering, so we created endowed professorships at Caltech, UC Berkeley, and UC Santa Barbara. We also support a lot of educational programs and scholarships. Our kids each have allotments where they can do what they want to do.

THACKRAY: When you say education, do you mean science education?

SCHLINGER: Mainly technical education. We also support churches and disadvantaged people. We made fifty different donations last year. You must write a letter with every one, and be sure you get all the documentation you need. It just takes time. I tell everybody, "It just takes me longer to do everything these days, when you get to be my age!" [laughter] It takes me longer to get dressed; it takes me longer to put something into the computer; it takes longer to lay a block on the wall outside; and it takes me longer to weed and fertilize the garden.

THACKRAY: Would you say something about your three children?

SCHLINGER: They've done very well. I'm very proud of them. Our oldest son, Mike, tried to be an engineer. He thought he'd like to be an aeronautical engineer. This was back in the time when the space program was full of all kinds of opportunities. He changed his mind. He graduated from USC [University of Southern California] with a degree in business administration. First, he had a hang glider business that didn't do too well. Then he got involved with a fellow who repaired mechanical equipment. The two of them had a business called KMI—I don't know what the "I" was for. Maybe it was "incorporated." Anyway, they did contract repairs for all kinds of equipment. He did a lot of jobs for government organizations as well as individual companies.

He sold his part of the business and bought a small vitamin compounding plant in Vista, about halfway between Los Angeles and San Diego. I remember that after four or five years, their sales were a million dollars a year. Then they moved to a new location, started expanding, bought several buildings, and now sales are a million dollars a month. He has about fifteen to twenty people working there. They buy bulk vitamins and compound them for wholesale distribution. Mike now lives down in Yorba Linda, California.

Our daughter, who lives in Santa Barbara, went to Stanford, graduated with a mathematics and music major, and got a business degree at Cal Berkeley graduate school. Then, she went to work in Silicon Valley. She met the man who's now her husband there. He was an EE [electrical engineer] from Washington University. He has some novel concepts about databases and high-speed data transmission. He and our daughter put together a business plan and tried to market it. At about that time we bought our first house here, 1981 or 1982. Interest rates were terribly high. They had a hard time getting financing. They eventually got financing, and instead of 50 percent of the company, they only owned 15 percent.

It really boomed. They developed a high-speed transmission system using telephone lines or microwaves. But at the time, the transmission speed at which you could transmit the data was quite limited. It was limited by the fact that people didn't know how to synchronize the receiving end with the sending end. I don't understand it. I don't know how they do it today. But anyway, he came up with a scheme that increased the speed of transmission by about a factor of ten and everybody wanted it. After about five or six years, IBM came out with their OS/2 system, which depended upon the system my daughter and her husband had developed. IBM thought they could buy them out, but they didn't sell. Their business was growing by leaps and bounds, and they did not want to sell it. But a couple years later, they cashed in and retired. [laughter] They live in Santa Barbara now.

Norm [Norman W. Schlinger] went to Berkeley and has had several disappointing experiences. He came out of school at the beginning of the computer age, so he was very computer oriented. He was also a business major. He got a job with Western Pacific Railroad and kind of brought the computer to them. They didn't know much about it. He taught them how to keep track of their railroad cars, where they were, and how they could use them more efficiently. He moved up rapidly and got to the point where he was vice president of the

company in ten years. Then Western Pacific sold out to Union Pacific [Railroad], and they said his job was going to Omaha. Well, he didn't want to go.

THACKRAY: Almost as bad as Port Arthur! [laughter]

SCHLINGER: Right! So he went to Southern Pacific [Railroad] and did essentially the same job there. He was manager of a division of marketing, and he did very well there. He moved up to an assistant vice president. And guess what happened? Santa Fe [Railroad] bought them out. Then his job moved to Chicago! [laughter] So he decided he'd go to Merrill Lynch [& Co., Inc.]. He stayed with Merrill Lynch a couple of years. He learned quite a bit about the stock market, but he wasn't happy with the opportunities available. He's been remodeling, building, and selling houses ever since. He's done all right. He has a home on Lake Tahoe now, as well as in Alamo and Lafayette.

Katie and I are very proud of all three of our children.

THACKRAY: Warren, you have led a remarkable life. Thank you for sharing it with me. Would you like to share anything else?

SCHLINGER: In looking back on my life, there was a mixture of making the right decisions at the right time, kind of unknowingly, and being in the right place at the right time. I had good fortune.

I realize now, though, that one of my problems was dyslexia. Nobody ever talked about it or heard about it when I was younger. My ability to read at high speeds is not very good, even now. I know some people at Caltech who, if you give them a page, they can read right down and they can almost repeat it verbatim. I can't do that.

THACKRAY: Well, instead, you made major contributions to the development of chemical technology.

SCHLINGER: Certainly an interesting version of chemical technology anyway. I have had a lot of other people who worked very hard with me. They were a nice group of people.

THACKRAY: Well, the United States has been an excellent place to be in the twentieth century. The western United States has been a very good place to be; chemical engineering has been a very good place to be as well.

SCHLINGER: All those things are very fortunate decisions, some of which I had control over and some I didn't. I certainly enjoyed my chances to visit and get to know people in other parts of the world. I liked to see how other people did things.

THACKRAY: Warren, thank you.

[END OF TAPE, SIDE 5]

[END OF INTERVIEW]

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