GEORGE W. HOUSNER
(1910- 2008)

INTERVIEWED BY
RACHEL PRUD'HOMME

July 2, 3 and 11, 1984

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

Subject area

Engineering, earthquake engineering

Abstract

Interview in 1984 with George W. Housner, Carl F. Braun Professor of Engineering emeritus. BS, University of Michigan in civil engineering, 1933. MS Caltech, 1934. Interest in earthquake engineering after 1933 Long Beach earthquake; 1934-39, designed schools, bridges, and dams in Los Angeles; returned to Caltech for PhD (1941) with R. R. Martel. Worked for Corps of Engineers in Los Angeles, protecting aircraft industry from possible wartime attack. Adviser to the air force in North Africa and Italy during the war. Joined Caltech faculty 1945 as asst. prof. of applied mechanics; buildup of Engineering and Applied Science Division under chairman Fred Lindvall. Comments on differences between seismologists and earthquake engineers. Recalls origins of earthquake engineering at Caltech under Martel. Chairs engineering committee on 1964 Alaska quake. With Paul Jennings, consults on earthquake design for buildings in downtown Los Angeles. Founding of Earthquake Engineering Research Institute [EERI]. Comments on liquefaction in 1964 Niigata earthquake. Recalls Theodor von Kármán's part in designing pumps for Colorado River Aqueduct. Recalls his own involvement in Feather River Project in 1950s as president of EERI, and Ralph Nader's misrepresentation of its earthquake safety. Comments on engineering improvements in aftermath of 1971 San

Fernando earthquake. Visits China in 1978 as member of delegation on earthquake engineering. Comments on superiority of Japanese earthquake preparedness. Founding of International Association for Earthquake Engineering and Caltech Earthquake Research Affiliates. Establishment with NSF funding of a Committee on Natural Hazards, including wind damage. Sen. Alan Cranston's part in getting NSF money in 1974 for earthquake research. Comments on his work at Palomar Observatory and Union Bank Building. Comments on demolition of Caltech's Throop Hall following San Fernando quake, on future of engineering education, and on his stint as chairman of the faculty. Comments on Ed Simmons, inventor of a strain gauge, Simmons's legal battle with Caltech, and Caltech's patent policy.

Administrative information

Access

The interview is unrestricted.

Copyright

Preferred citation

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George W. Housner controls the frequency of a rotating shaker atop a simple five-story building model (1978).

California Institute of Technology

Oral History Project

Interview with George W. Housner

by Rachel Prud'homme

Pasadena, California

Caltech Archives, 1989

Errata

pp. 29 and 31: "Grand Coolee Dam"—Correct spelling is Coulee.

p. 49: "Hiro Kanamori"—Correct spelling is Hiroo Kanamori [Caltech professor of geophysics].

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CALIFORNIA INSTITUTE OF TECHNOLOGY

ORAL HISTORY PROJECT

Interview with George W. Housner by Rachel Prud'homme

Pasadena, California

Session 1	July 2, 1984
Session 2	July 3, 1984
Session 3	July 11, 1984

Begin Tape 1, Side 1

Prud'homme: Where were you born?

Housner: I was born in Saginaw, Michigan.

Prud'homme: And did you live there all during your childhood?

Housner: I lived there until I graduated from college. I grew up in Saginaw, attended Saginaw High School, went to the University of Michigan (Ann Arbor) and graduated there. Then I came out here to go to graduate school.

Prud'homme: Were any members of your family scientists or interested in science?

Housner: No, not really. My father is reported to have been inclined that way, but he died when I was a year old so I never knew him. Otherwise, not. My family were all hard working, honest-type people, and I'm not sure they all approved of my going to college. [Laughter] In fact, I was the first of my generation of fifteen cousins to go to college. All those younger than me did go. I started the trend.

Prud'homme: And you went to the local high school.

Housner: Yes, I went to Saginaw High School.

Prud'homme: Did you have any special teachers there?

Housner: No, not really. In retrospect, it wasn't really a very good high school.

Prud'homme: What made you decide to go to college?

Housner: I don't know. I was always interested in engineering and science, and I just always had it in mind from youth onward that I would go. My mother didn't object, so off I went.

Prud'homme: Who did you study under there? You took an engineering degree?

Housner: Yes. Well, you don't really study under anybody when an undergraduate.

Prud'homme: Well, let me phrase my question differently. Were there any people who influenced you?

Housner: Yes, probably the professor who influenced me most at U. of M. was Professor Stephen Timoshenko. He is very famous in engineering circles. Then--I think it was in the late 1930s--he went to Stanford and finished his career there. In retrospect, looking back on the 1920s and '30s in Saginaw, Michigan, it just seems like it was a real backwater town of 50,000 people.

Prud'homme: And it was the depression time.

Housner: Yes, the depression. I remember when I graduated in 1933, of the whole civil engineering class only one student had a job lined up, and that was with his father who had a construction business.

Prud'homme: Is that one of the reasons that decided you to go on for your master's?

Housner: Well, obviously in Michigan at that time there was nothing in the way of a job.

Prud'homme: Why did you pick Caltech?

Housner: I talked to some of my professors at Michigan. . .and probably I should explain first that I grew up with my mother's parents--when my father died, my mother moved back with her parents--and when they passed away in the early 30's, my mother was worn down from acting as a nurse. The doctor told her she ought to get away and rest up a bit. She decided she'd like to go to California for a while, so I thought I'd go out there to school instead of Michigan. And one of my professors recommended Caltech, so that's why I came here, though I didn't really know much about Caltech at the time.

Prud'homme: What was it like when you got here, in contrast to the University of Michigan?

Housner: Well, the University of Michigan was very big; you felt always sort of lost. Whereas here, especially in the 1930s, it was a small place and you could get to know everybody. Although, like most students, I wasn't as aware of people as I should have been. I didn't really broaden my view very much.

Prud'homme: Were the students different?

Housner: Well, yes, I think the students were.

Prud'homme: In what sense?

Housner: I think now the students are more serious than they were then.

Prud'homme: Who were the leading professors at Caltech then? Who were the people who impressed you as a young graduate student?

Housner: There was Dr. Millikan, who was preeminent. I recall Professor Thomas asking me to go to lunch at the Athenaeum. We sat at a big table that otherwise had all professors at it, and Dr. Millikan sat at the head of the table, guiding the conversation.

Prud'homme: What was he like?

Housner: He was a very pleasant man; everybody got along well with him. To a student, he was sort of overwhelming.

Prud'homme: That's one of the advantages of a smaller institution.

Housner: Yes, you knew everybody.

Prud'homme: Was the Institute primarily an engineering school then?

Housner: Well, let me put it this way: until 1920, when it became Caltech, it was really an engineering school, but then Dr. Millikan started the departments of physics and geology, biology and chemistry, so in the 1930s engineering was not the major part of it.

Prud'homme: Was physics the major part of it?

Housner: Well, it's a little hard to say. At that time, there were probably more students in engineering than in any of the others. But I think it was less than half. The engineering was still going on, carrying on from the pre-Millikan days I think, now, looking back at it. The staff didn't move into the modern times as I think they should have.

Prud'homme: What do you mean?

Housner: Well, before Millikan came, it was a small engineering school, and it was teaching and not research, and so on. And it wasn't easy for the staff to change their views. Some of them did, but some of them said, well, engineers shouldn't do any research, shouldn't really go on for a Ph.D.

Prud'homme: So there developed a kind of schism between the pure scientists and the. . . .

Housner: I think Dr. Millikan didn't want to stir up a hornets' nest--just let them alone. And it wasn't really until after the war, when he appointed Professor [Fred] Lindvall to be chairman, that he really pushed the division into modern times.

Prud'homme: It sounds as though he was a wise administrator.

Housner: He was very good, yes. He ran everything. If you wanted a little money for research, you went to see him. If you wanted a job, you went to see him. He ran everything. He knew where all the money was.

Prud'homme: After you got your master's, you worked for five years as an engineer in Los Angeles. What did you do?

Housner: I was involved in designing structures. I still see things I designed--school buildings, bridges, dams. I suppose I was moved to get a job and go to work just to prove to myself that I could. I enjoyed it; it was interesting. But then I came back in 1939.

Prud'homme: Why did you decide to come back?

Housner: I don't know. I guess it was just a feeling. I probably always had the feeling I wanted to do it. But first I had to prove that I could do a job outside.

Prud'homme: Did you become interested in earthquake resistant building at that point? Or was that much later?

Housner: Well, when I came here, it was just after the Long Beach quake, so there was a lot of interest in it. And Professor Martel was much interested in earthquakes. That's R. R. Martel. His son, Hardy Martel is now professor in electrical engineering. When I worked, of course, the earthquake design of buildings was a big item; it was a new subject. So when I came back, I was interested in doing research on the earthquake problem.

Prud'homme: Did you work under R. R. Martel then?

Housner: Yes.

Prud'homme: Did you do your dissertation with him?

Housner: Yes. I did it on the earthquake behavior of buildings.

Prud'homme: What kind of a person was he?

Housner: He had a big influence on me. He was the type, I guess, that you now call laid-back. He was not the type to create a lot of things and so on, but he was a very wise man. Many of his students--a great many--were very influenced by him. When he retired, a number of us got together and decided we would have a little ceremony, with letters from all his former students put into a book. I suppose Hardy still has it. We put in a little biography of him and the letters. It was interesting that all the letters we got--you know, we asked them to write back on their business letterheads and tell us what they'd been doing over the years, and so on--all the letters were upbeat. They were all very successful and so on, except two that I remember: one was a former student who had been stricken by some terrible illness and was in an iron lung; the other one was a former student from Japan who'd gone back and had an eminent position, and then the company went broke and he was unable to find another job. So his letter was a sad one, too. But everybody else had done very well.

Prud'homme: What were the changes for you, after having worked, in coming back? Did you find that you felt at home in an academic institution again?

Housner: Oh, yes. I liked it very much.

Prud'homme: And did you find that the Institute had changed?

Housner: No, I don't think so. The same people were here. I guess there were a couple of new buildings. In '34, there weren't too many buildings. This building, Thomas Laboratory, wasn't here. I think in '34 the only buildings were Throop Hall, which was the central building; and what's now the mathematics building was the electrical engineering laboratory; the physics building; and chemistry--Crellin; and that was it.

Prud'homme: What did you want to do with your Ph.D. after you got it?

Housner: Join the university here.

Prud'homme: Had you done any teaching at that point?

Housner: Yes, as a graduate student, that was one of Dr. Millikan's innovations. In order to encourage students to come here, he made liberal use of them as teaching assistants. We taught regular classes. I taught undergraduate classes in what's called "Strength of Materials" and "Dynamics." And that was a very worthwhile experience. Of course, all of us in those days went through that; now students don't have that opportunity anymore. They do some of it in physics, where they have big classes, and in chemistry, but not in engineering anymore.

Prud'homme: That's too bad. I often think that you don't really understand your subject until you can explain it to somebody else satisfactorily.

Housner: That's right. That's how you really learn it.

Prud'homme: But you got your Ph.D. in 1941. And what was the feeling on campus about the hostilities in Europe?

Housner: There was the feeling that we would soon be in it.

Prud'homme: And indeed we were.

Housner: Yes, that's right. And after I got my degree, I went to work for the Corps of Engineers in Los Angeles.

Prud'homme: As a civilian?

Housner: Yes, as a civilian. What we did then was prepare for the war.

Prud'homme: And you did that because of the war coming? Or would you have done that anyway?

Housner: No, it was just because of the war. The times were clearly unsettled then, and it was not a good time to apply to a university to go on.

Prud'homme: What did you do for the Corps of Engineers?

Housner: The big item was protecting the aircraft industry against attacks by hostile aircraft. We put chicken wire over the whole facility with painted chicken feathers to camouflage it; we put protective walls inside to protect the critical machinery against bomb blasts. It was interesting work.

Prud'homme: So you were involved in stresses and strains of buildings.

Housner: Yes, that's right. Blast effects, and that sort of thing.

In the newspaper we see complaints from some of the Japanese who say they shouldn't have been herded off into the camps. But I remember at that time we were much concerned about an attack from the Japanese fleet on Los Angeles, thinking that they might make a diversionary attack, and we were completely unprotected.

Prud'homme: It's a fairly logical assumption.

Housner: Yes, they could have come in and disrupted everything. They couldn't have hung on for very long, but they could have lasted maybe a year. So I can understand why it was decided to move them out. There wasn't any time to stop and question who should or shouldn't go.

Prud'homme: I was in school during the war I remember and that the Army Corps of Engineers had a wonderful reputation. Do you remember?

Housner: Yes. Of course, they were also responsible for flood control; they built many dams in the 1930s. When you graduated from the military academy, you could opt for what you wanted to do--go into the Corps of Engineers or the artillery, or ordnance. At least that's the way it used to be. I'm told that in peacetime, all the smartest ones always opted for the Corps of Engineers, because there was something interesting to do.

Prud'homme: And then you were in North Africa and in Italy.

Housner: Yes.

Prud'homme: But that wasn't with the Corps of Engineers?

Housner: No. The National Research Council set up a number of groups funded by the government for military research at universities. One of them had been directed to organize personnel for what we called "operations analysis sections" for the air corps. And John Burchard of MIT, a a friend of Martel's, was in charge of that group of NRC and was asking for recommendations of people who would do that. I thought I would like to do that, so off I went.

Prud'home: Did you join the Army?

Housner: No, I was a civilian. I spent some months with the National Research Council group at Princeton University. Then a team was organized to go to the Ninth Bomber Command, which was in North Africa. So off I went with that.

Prud'homme: That was quite a change.

Housner: Yes it was, indeed. I remember we departed this country from Boca Raton, Florida. It's still vivid in my memory. We got on a little bus one evening and they said, "Now we'll all go to the airplane," and we all sat there in this little bus--you know, with maybe six people on a side--and just as it was ready to go, I guess it was the camp chaplain who stood on the back and intoned, "God bless you men!" And off we went! [Laughter] Then we flew down to the field that the Americans had set up in British Guiana. I often wonder whether it was the same place where that man and his cult all died [Jonestown]. The airfield was back in the jungle; it was carved out of a big area. That was my first experience with a tropical rain forest. I walked in about ten feet, and it was so eerie, I came right out again.

Prud'homme: Did you get a chance to go into the rain forest?

Housner: Only that ten feet. It was just too dense and scary; I didn't want to be in there.

Then we flew down to Brazil, to--I've forgotten the name of the place--where Brazil juts out, the nearest point to Africa. And then from there we flew in a Boeing flying boat to Africa.

Prud'homme: It was a long flight.

Housner: Oh, yes. Those flying boats were very slow. It took something like twenty-four hours to get across. We landed in Fisherman's Lake, Liberia. Then we flew from there to Accra--I don't know what country that's in now.

Prud'homme: Ghana.

Housner: And then from Accra we flew to Maiduguri to Kano, and from Kano to El Fasher, and then over to Khartoum. We'd fly and land and spend a night and fly on. That was really the outworks of the world there.

Prud'homme: You went right across the middle of it.

Housner: It's really a big desert. And then we flew from Khartoum up to Cairo, and then from Cairo to Benghazi. The Ninth Bomber Command was located at Benghazi--not in the city; that had been evacuated and was empty of people. We were on the outskirts and lived in tents. Again, it was an interesting experience.

Prud'homme: What did you do for them?

Housner: Well, we studied ways of improving the operations. I can give you some examples of our most successful attempts. When we got there--there were six of us--we studied what they were doing, and we found that the way they were training the machine gunners on the bombers was all wrong. They were told to aim as if they were on a fixed platform, you know, like shooting at birds flying by. Actually, when you're on a bomber, you have to take into account the speed of the bomber because that's affecting the trajectory. So our group prepared a booklet that explained all of this. Then the War Department published the book--at that time, there was no separate Air Force, the Air Force was part of the Army. And that became the standard for educating gunners.

Prud'homme: Your teaching experience must have been very valuable.

Housner: Well, they were all teachers in the group. . . Another example. This is very desert-like country; only a few miles along the coast is habitable. Where the airfields were set up it was desert-like, and terrible clouds of dust were stirred up when the planes took off. The dust was getting into the engines and wearing them out. And the question was, what to do? Then our group noticed that there were remnants of what used to be a salt manufacturing place nearby, where they had let the sea water in and let it evaporate to get salt. And still remaining at the bottom of this was an amount of extremely salty water. We tested it and found it was hygroscopic, and if you laid it down on the runways, it settled the dust. I remember when we proposed to do this--spread this on the airfield--the transportation people who were responsible for maintaining the airfield were much opposed and said it wouldn't work, and if it were used, it would ruin the trucks, the tank trucks, and so on. The commanding general overruled them and said, "You will use it." And it worked very well. And when I saw the report of this that the transportation people wrote, they extolled their foresightedness in doing this successful project, never mentioning our group, or that they were opposed to it to begin with. [Laughter]

Prud'homme: Typical. Then you went on to Italy from Benghazi.

Housner: I'll tell you first about another interesting project. Our bomber command laid on the celebrated low-level raid on the Ploesti oil fields in Rumania. I remember I was asked by the general to estimate the number of losses. When I did that, I came up with a figure that showed about one-third of the planes would be lost, and that was what happened. So in a sense it was a successful study--an unpleasant success.

Prud'homme: So even though you were civilians you were involved in military operations.

Housner: We were in an odd position in that we were civilians but we wore uniforms and were with headquarters and so on. It was kind of an ambiguous position. In some ways it was a detriment to us, but in other ways it was a help, because we didn't have to do anything that we didn't want to. Whereas, if you'd been in the military, you'd have to do whatever somebody told you to do.

Well, then when the invasion of Sicily and Italy was laid on, it was planned to set up a new air force--not a bomber command but an air force, the Fifteenth Air Force--and the bomber command was merged into it. It was a much larger operation, and when the invasion got up past Naples, we moved in. That was in December [1943]. We actually just moved into the headquarters building of the Italian Air Force at Bari and took over the Italian airfields near Foggia. So from then on I spent the rest of the war in Bari.

Well, this was a little too long a tour of duty--about two-and-a-half years. We all sort of felt the responsibility, we couldn't get away from the idea that we might be overlooking something--people were getting killed, and it would be a terrible thing to live with. And it kind of got us down after a while.

Then, when the war came to an end in Europe, everything moved very quickly. Within a couple of weeks, suddenly we were on a plane back to the States. They didn't waste any time.

Prud'homme: Did you come right back here to Caltech?

Housner: No, I went to Washington, because this was in May of '45 and I was scheduled to go off to the Pacific theater. But that war came to an end before they had our group organized to go out, so I spent my time in Washington writing a history of what we had done for the bomber command and the Fifteenth Air Force. And then I came back here.

Prud'homme: You ended up getting a Distinguished Service Award.

Housner: That's right.

Prud'homme: You returned to Caltech in '45 as assistant professor in applied mechanics.

Housner: That's right.

Prud'homme: And this had always been your intention?

Housner: Yes, it had been my hope that I could get on the staff here. And I think that because Professor Lindvall was the new chairman, I got on.

Prud'homme: Can you describe him to me?

Housner: I think somebody has already interviewed him. He was the new blood, and directing the division of engineering.

Prud'homme: How was he new? Or what kind of an impact did he have on the division?

Housner: He was here at a very crucial time when the division was being built up. He was instrumental in getting money from the Ford Foundation at a stage when it was giving money to various schools to upgrade. He was responsible, really, for setting the tone and the direction of the engineering school that we presently have. Everybody agreed that he was very good at that.

Prud'homme: Had he been picked out by Millikan?

Housner: Yes. Of course, he was here on the staff in electrical engineering, and--I'm supposing that this is how it happened--Millikan must have decided something ought to be done, and he probably told him, "Well, you ought to do it."

Prud'homme: So the direction in which the engineering department went was initiated largely by Millikan.

Housner: Initiated in the sense that he put Lindvall in. I think '45 was the year Millikan retired, so this was his last effort. He probably thought, "Well, I ought to do something for Engineering and get it off the dime, get it moving." That was indeed a very critical step, to get Lindvall.

Prud'homme: How were the students different after the war? Did you notice a difference in them?

Housner: Well, I guess for about five years, maybe longer, we got a lot of students back who had been in the military. They were three to six years older than normal, so they were quite different, yes. So until that group kind of worked its way through, there was quite a difference. Afterwards it was more or less back to normal, except, it was clear that students were coming with a better education, were much better prepared than they were in the old days before the war.

Prud'homme: Was the Institute offering more or were the students demanding more?

Housner: No. I mean that they were much better prepared, I think more serious, even after the army types got through. It's just a different world than it was, say, in the 1930s.

Begin Tape 1, Side 2

Prud'homme (on Benghazi): . . . The dust would have gotten into the plane engines and would have made a terrible maintenance problem. . .

Housner: . . .even for those of us working there. In summer every day about ten o'clock a strong inland breeze came up from the ocean and picked up all sorts of dust. Terrible! We'd be sitting working at the table inside, and within an hour it was covered with this yellow dust. You couldn't see your papers on the table. Some of the fellows tried putting gas masks on, but in 100° temperatures, those were intolerable, too. That's why my big recollection of Benghazi was of terrible dust.

Prud'homme: When you came back to the Institute, what were the leading departments here then? This would be just post-Millikan.

Housner: Well, at the Institute the leading department has always been physics, during and after Millikan. They are the prima donnas of the Institute.

Prud'homme: Did the engineers feel looked down upon by the scientists?

Housner: Well, I don't know. It was clear that they didn't understand anything about engineering. I don't know what they would have looked down on us for, except that engineering was different. . . . Perhaps some believe that a physicist feels that anybody who doesn't do physics is kind of a second-class citizen.

Prud'homme: You were technologists and they were academics.

Housner: Physics is the thing. If you do anything else but physics, it's déclassé.

Prud'homme: Yet the engineering department has to help the physicists teach physics! What were your impressions of DuBridge when he first came?

Housner: He had been director of the Radiation Laboratory at MIT. And some of the things his lab did ended up in our Air Force programs. So I knew sort of what he was up to and what he'd been doing during the war. I think we all, right from the beginning, thought very highly of Dr. DuBridge. He was a very good man to succeed Millikan. Of course, Millikan and he had the right touch, a good rapport with the community; people outside of the school thought very highly of both of them. They both had a good speaking manner. Both of them had a big influence in that sense, especially on people who could give money.

Prud'homme: The prestige of the Institute certainly grew by leaps and bounds during that time.

Housner: Yes. Of course, at that time, that was the time when more money had become available, money from the federal government, the National Science Foundation. So there was a big change at all universities. Before the war, there was very little research money coming in from outside. After the war, there was a lot, and this made a big difference in science and engineering.

Prud'homme: Did he get any money for you?

Housner: Well, we got some, yes; in the early years, we got some research money from the Office of Naval Research--that was the forerunner of the National Science Foundation. Some of the early research that we did on earthquake ground motions was through that funding.

Prud'homme: You went back to teaching and research.

Housner: Right. Also wrote some textbooks.

Prud'homme: Could you tell me about that?

Housner: With Professor [Donald E.] Hudson I wrote two books on mechanics; and with Professor Thad Vreeland, I wrote a book on stresses and strains. Every once in a while I run into somebody who says, "Oh, I studied your book," or "I taught from your book, and it's good." Just the other day, a Professor Chu who was visiting the applied mathematics department was introduced to me, and he said, "Oh, yes, I taught with your dynamics book back to 1960; very good." And Professor [Heki] Shibata of Tokyo University said to me, "Oh, I studied mechanics from your book. And that's how I learned English." [Laughter] He didn't learn it very well.

Prud'homme: I presume there was a need for these texts. Or you felt the need for them.

Housner: Yes. It was, again, that most of the textbooks were still in the old style, and it was time to take a different look at the subject. After that, quite a number of books came out along the same lines and that was the general way things went after that.

Prud'homme: Can you give me a bit of the background on the difference in the work done here in seismology and in earthquake engineering research?

Housner: Seismologists primarily study the earth's interior by recording earthquake waves which take various paths through the interior of the earth. Their instruments are very sensitive. If I can explain that with an anecdote: For our purposes--we want to measure the very strong shaking that does the damage--but in this case the seismologists' instruments would be off-scale. We had a lot of instruments--I say "we," I mean the community here in southern California--installed in buildings prior to the 1971 earthquake and it was sort of an eye opener to the engineers to see what these motions of the ground and of the buildings were. And we had a meeting up in San Francisco to show these records and explain them to the engineers. Afterwards, one of the engineers approached Professor Perry Byerly, who was a famous seismologist and professor of seismology at Cal Berkeley--actually, he had just become professor emeritus--and said, "Perry, these are the kind of records we engineers always wanted. Why haven't you gotten them for us before?" "Oh," he said, "if I had specialized in strong motions, I'd now be assistant professor emeritus." [Laughter] And there's a lot of truth to what he said. . . One way of distinguishing is that seismologists are interested from the ground surface down, and engineers are interested from the ground surface up. The dividing line is maybe a hundred feet down. But we're interested in very strong shaking and the nature of strong shaking--where it might occur, and so on.

Prud'homme: There had been a seismology lab here, though, for many years.

Housner: Yes. The original lab was set up by the Carnegie Institute. Then, I've forgotten just when . . . .

Prud'homme: It was '36.

Housner: . . . It became officially attached to Caltech. I think before that it was, in effect, working like a Caltech unit, but then it became a part of Caltech.

Prud'homme: Now earthquake engineering research, dealing with the ground up . . .

Housner: Well, that was started by Professor Martel, who got much interested. He had gone to Japan to attend a world engineering conference in the late 1920s and saw what had happened to Tokyo in their earthquake and that some of the Japanese were interested in earthquake engineering.

Prud'homme: This would be after the '23 Tokyo quake.

Housner: Yes. I think the congress was in 1928.

Prud'homme: The big earthquakes in Tokyo and Santa Barbara, and then Long Beach were precursors in a sense to finding out what potential hazards there were in earthquakes. And then there's a jump to the '64 quake in Alaska.

Housner: Well, there were other quakes, but they didn't happen to hit big cities. An earthquake gets famous for killing people, not for its real size.

Prud'homme: So your job is to keep people from getting killed, basically.

Housner: Right. There was a very important earthquake in 1940 at El Centro, California, which for many years held the record for the strongest recorded shaking.

Prud'homme: How many points on the Richter scale?

Housner: It was 7.1 on the Richter scale. So in earthquake engineering circles, worldwide, the El Centro earthquake is well-known. We've had Japanese visitors who tell me, "Oh, I'm going down to El Centro and see what it's like there."

Then there was a damaging earthquake in 1935 at Helena, Montana. There was a rather big earthquake in 1952 up by Tehachapi. There was a big earthquake in '49 up near Tacoma, Washington, and the one in Alaska in '64. Although the Alaskan quake didn't kill many, it was such a large earthquake, by far the largest in modern times in this country, that it was very important. The Academy of Sciences put out a big report--that string of black volumes there [pointing]; and the fattest one is the one on engineering. I was chairman of that engineering committee and Paul Jennings was also a member. We put a lot of effort into that; it's a monumental report.

Prud'homme: So you're recording and studying ground motion.

Housner: We also record and study the motion of buildings during an earthquake. The objective is--given, let's say, the ground shaking--to be able to calculate what a building will do with sufficient accuracy so you can design it properly.

Prud'homme: Do you deal with soil condition, or is that the seismologist's responsibility?

Housner: No, that's in engineering. Really, I should not have said from the ground surface but from the rock surface. For instance, here, we're sitting on nine hundred feet of alluvium, so the seismologist's interests would only start nine hundred feet down. But our interests would be in the behavior of the ground as well as the behavior of buildings. Ground behavior is a matter of soil mechanics. Professor [Ronald F.] Scott here is our expert on soil mechanics.

From our research on ground motions and the mathematical analysis of the vibrations of structures, we develop procedures for designing buildings, not with a building code but from a more rational approach, actually. In fact, the Atlantic Richfield twin towers--Professor [Paul] Jennings and I were consultants on the earthquake design of those, as well as of the Union Bank building, the Security Pacific Bank building, and what used to be called the Crocker National Bank building . . .

Prud'homme: Can you say a more rational approach as opposed to a building code?

Housner: Well, the building code merely says that you should design to resist a certain force pushing on the building. But in reality, the building is vibrated. To do it right, you need to know how it will be strained. So what we did for these buildings--say, the ARCO Towers--we identified those faults in the general region that might generate strong shaking at the site. This included faults like the San Andreas, which is about thirty-five miles from the site and could generate a magnitude 8-plus earthquake. Then there are closer, smaller, faults which would generate smaller earthquakes. So, on the basis of earthquakes we had recorded, we were able to develop methods of generating earthquake ground motions that corresponded to these earthquakes at different distances. And we computed for each of them how the building would vibrate and what the forces and stresses would be, and then the engineers designed accordingly. So in a sense, those buildings had experienced some four or five earthquakes before they were built.

Prud'homme: What was the state of the art of earthquake engineering before, when you started?

Housner: Well, for example, when we were doing this work on these high-rise buildings, they were the first ever done. And after the San Fernando earthquake, we took records obtained in some of these buildings and computed from the recorded basement motions the corresponding roof motions. These were then compared with the recorded roof motions and we got very good agreement. The Building Department of Los Angeles then said, "Well, good, from now on, all buildings over sixteen stories high must be designed on the basis of a dynamic analysis, taking into account realistic ground shaking." So it made a big change in the way things were done.

Prud'homme: Does the Institute object when you do work outside of the academic?

Housner: No. The rule is that one day a week you're permitted to do something outside--not cumulative, though.

Prud'homme: Oh, you can't save up and work on a . . .

Housner: No, you can't save up.

Prud'homme: That makes it quite difficult if you're working on a large project.

Housner: Well, yes. Actually, they don't check on you. There's a certain tolerance. Sometimes you have to be involved two days a week. I think it's been worthwhile for us in engineering, because that's where you begin to see the problems of real life. So you get a lot of ideas, and see what ought to be researched.

Prud'homme: Do you think that Caltech has pretty much become the leader in this field?

Housner: Well, it was the leader for many years. Now some of the other schools have also built up their efforts.

Prud'homme: Which ones are those?

Housner: Well, notably the University of California at Berkeley has been very active, and the University of Illinois has been active.

Prud'homme: Are they working on the New Madrid fault?

Housner: No, not particularly that. But earthquake engineering is an extremely interesting subject, so it has just attracted a lot of people now. It's interesting, and there are research funds available. We're not claiming that right now Caltech is the leader, but I think it's certainly one of the leaders.

Prud'homme: People have also come to realize that earthquakes are here and will come back.

Housner: Yes, that's right.

Prud'homme: You were on an "Advisory Committee of Engineering and Seismology" since 1947, along with Professor Martel. And it was set up by the Coast and Geodetic Survey. Can you tell me about that?

Housner: Well, that only lasted a certain number of years.

Prud'homme: But wasn't it a precursor to the Earthquake Engineering Research Institute?

Housner: Yes, it was. In the early days those of us interested in earthquakes--we were a very small number--were highly critical of the Coast and Geodetic Survey because they weren't really doing enough. The leader of the group that installed and maintained the strong motion instruments here on the west coast, Franklin Ulrich, got the idea that if there were an advisory committee to his operation, then its recommendations might carry more weight in Washington. So that was why it was set up. As it turned out, it didn't carry more weight, and in sort of desperation, frustration, we formed the Earthquake Engineering Research Institute.

Prud'homme: And what was its function?

Housner: Originally, its function was to do research, to develop the instruments and get them installed, and that sort of thing. And in the very early days, we actually did some of that. I think we developed the first modern shaking machine that you put on buildings to shake them.

Prud'homme: You actually shake the building?

Housner: That's right. We have a machine on top of Millikan now and shake that. But we obviously are under restraint for we can't shake it hard enough to feel. That's part of the student lab work; they shake the building and measure what it does, and so on. Before the library staff moved into the building, we shook it real hard once. And we had the top going back and forth about that much [gestures 1/8 inch]. Professor Jennings noticed in the library--this was before the San Fernando earthquake--that the shelves were not braced properly. So he wrote a memo to Building and Grounds, the physical plant people, saying "These bookshelves are not right; you have to strengthen them so that they won't come down during an earthquake." Well, they didn't do anything. So he wrote another memo. They still didn't do anything. And when the earthquake came, down they went. Oh, it was a real mess.

Prud'homme: And then they did it.

Housner: Yes. Now, if you look up, you can see that they're braced. In fact, all the bookshelves on campus are supposed to be fastened to the walls so they don't fall on the occupants of the room.

Prud'homme: Computers must have had an extraordinary effect on your research.

Housner: Oh, yes, they did, enormous. Without the development of the digital computer, we wouldn't be anywhere near where we are. It's an enormous calculating job to take an earthquake accelerogram and compute the response of a building. One standard kind of calculation we make from an earthquake record is to compute what we called the response spectrum. I first did that for my thesis. And the very first time we calculated it--we did it by pencil and paper, which involved drawing the accelerogram and multiplying and integrating--it took about a day for one point on the spectrum. That was at the very beginning of my thesis research. Then we developed a small mechanical analog computer, and that speeded it up from one day to about fifteen minutes. Well, that was a big advance, about thirty times. But then later we developed an electrical way of doing it and we'd get a point in maybe fifteen seconds. Now, fifteen seconds on the digital computer, and we get five hundred points. An enormous difference.

Prud'homme: The ability to develop equations . . .

Housner: . . . And to calculate the results. Yes, an enormous change. That's been a very big change in the field. Actually, that's what I'm describing here, dictating what I've just written. We're having a big world conference on earthquake engineering in San Francisco the last week of July. Every four years the society puts this on, and we in the United States are doing it this year. At the opening ceremony, I'm to give a speech on the history of earthquake engineering. So I was just putting it together now.

Prud'homme: We would love to have a copy of your speech for the Archives, incidentally. And any papers you care to give. You have developed machines to measure ground shaking, and have spread them over a far greater area than before. And you now work with the seismologists who also record data.

Housner: Right. Actually, after the San Fernando earthquake, the seismologists saw that our records could also throw light on the fault mechanism, the slip of the fault. So they got interested in our records.

Prud'homme: Because you can actually measure the slip of the fault.

Housner: Well, it's not so much that. But when the fault slips, it may slip like the San Andreas fault, which slips this way [gestures], it may slip over a depth of six, seven miles. Over that fault area, it's jumping and sending out stress waves. And our instruments are close; they're giving information on this process of slipping. And that was of great interest to the seismologists. So they are much interested now in our records from that point of view.

Prud'homme: So you're working more and more together on this, as opposed to being two separate strains of academic interest.

Housner: Yes. Of course, it depends on the person. There are some seismologists who work closely with engineers, let's put it that way.

Prud'homme: And then there are those who don't.

Housner: Yes. Well, here at Caltech we particularly work with Clarence Allen and Hiroo Kanamori and Kerry Sieh. For seismologists, the distinction is whether he's interested primarily in seismology or primarily in earthquakes. That makes a difference. And the three I mentioned are interested in earthquakes.

Prud'homme: In '64, there was the great Alaska quake. And then there was the Niigata?

Housner: Yes, there was a Niigata quake shortly afterwards.

Prud'homme: And which had one billion dollars worth of damages.

Housner: That was in '64 dollars.

Prud'homme: Yes. Can you describe the quakes?

Housner: Alaska was the big earthquake, with a magnitude of 8.4. We figure that the fault slipped over a length of about 450 miles. If you had the same kind of an earthquake in California, that would go from below Los Angeles to beyond San Francisco, but, of course, we don't have the same kind of earthquakes. It was a monstrous big earthquake. If there had been large cities in the region, it would have been a great disaster. Because of its size it was extremely interesting, and it's really unfortunate that there weren't any instruments to record the ground shaking. The nearest instrument was in Seattle, Washington. So that was most unfortunate. It was an earthquake well worth studying for the ground behavior and its landslides. One was of a size previously never conceived of. Such a tremendous slide. The ground at Anchorage extends to the ocean, when there was a bluff of about a hundred feet. And during the earthquake, the bluff slipped down. Then, as the earthquake continued, additional ground slipped, slipped, slipped, and the landslide extended about a half-mile back from the bluff and extended along the coast for a couple of miles. It was on the outskirts of the city, fortunately, but there were thirty-five houses destroyed.

Prud'homme: This must have had a tremendous influence on your work in terms of state and federal support.

Housner: Oh, yes. That was the event that got the attention of the government.

Prud'homme: And the money.

Housner: Yes, the money, right. Before that, the National Science Foundation didn't have any special earthquake program. But after that, they did set up a program in earthquake engineering; this is a special program with special funding.

Prud'homme: After the Alaska quake, President Johnson tried to set up an earthquake research program, is that not true, that would call for extensive surveys of faults, and so on?

Housner: Well, yes. He was apparently interested in getting something going.

Prud'homme: Did he?

Housner: No. Unfortunately, his term came to an end too soon. So the earthquake didn't have a lasting influence in that sense. It was really the 1971 earthquake that finally got Congress to move.

The magnitude-7 Niigata earthquake wasn't such a large earthquake as Alaska, but again, it had a remarkable soil behavior. Like most Japanese cities, it's on an outwash plain of a river. It's so mountainous, and about the only place they can build is on an outward. And the top 100 or 150 feet of ground was sand that had been washed down and deposited, and there was high ground water. When the shaking came, there was a tendency for the sand grains to reorient into closer packing. When that happens, because the spaces are full of water, for a while all the weight on the surface is supported by the water--until it oozes out. During that time the sandy soil has little strength and the damage to their buildings was mainly due to that. You may have seen the picture where the apartment house is laying over on its side. Tremendous damage was sustained in Niigata due to settlement and cracking and tilting . . . Well, this phenomenon we call liquefaction--for a while, the material is kind of like a liquid, what used to be called "quicksand"--really came to the attention of engineers for the first time as a possible, serious thing. So now it's watched very carefully when putting up buildings or power plants or things of that sort.

Prud'homme: Do we have areas here that would be subject to that?

Housner: Well, we see the evidence, during and immediately after the earthquake. When this has gone on down below, usually it bursts through to the surface, and some water and sand comes up and leaves a little deposit, a little hill of sand. And that's a sign of liquefaction at depth. We have seen that in places in most earthquakes, but here it seems to be mainly in places like river bottoms and things of that sort, so in California, I don't think it's such a serious problem. But it raises the question more about other parts of the country . . . You know, if we get a repetition of the New Madrid earthquake or the Charleston, would some of their soils liquify? So that's a problem for nuclear power plants and important facilities of that sort.

At the time of the Niigata earthquake, I was a member of the board of directors, of the International Institute of Seismology and Earthquake Engineering in Tokyo. It was a school set up cooperatively by UNESCO and the Japanese government, and I was the UNESCO representative on the board of directors to help it get started. Every year we had a meeting over there, and in '64, when I heard about the earthquake, I went to visit Niigata. Of course, that isn't my specialty, but when I came back, I told Professor Scott that he would have to go over and see it--he should organize a group and get funding from NSF to go over. So they went over, and I noticed when they came back they were just in sort of a state of shock, about what could happen.

GEORGE W. HOUSNER

Session 2

July 3, 1984

Begin Tape 2, Side 1

Prud'homme: You wanted to talk about Theodor von Kármán.

Housner: I just wanted to mention that I was much influenced by him. I took some courses with him, and also had some contact with him on some of the research I was doing.

Prud'homme: He gave himself a certain amount of importance as a civil engineer on various projects.

Housner: Yes. I've been reading a Science article. That is an unfortunate piece, because they based a considerable part of it on that book that this man wrote about Kármán, supposedly Kármán's biography, and the author didn't know what he was doing.

Prud'homme: How was it inaccurate?

Housner: Well, I think what he did is kind of listen to talk and then try to put it together. And I don't think Kármán ever looked at it. He talked about the Grand Coolee Dam and said it was cracked and that Kármán had to tell them how to fix it. But that was all wrong; the dam wasn't cracked. The cracks showed up on the pipes where they were pumping water up from the reservoir to the Grand Coolee. It was a vibration problem caused by irregularities in the pumping pressure.

Prud'homme: Did you work on that?

Housner: Yes, I was a consultant. I went up and told them how to cure it.

Prud'homme: Did von Karman work on that?

Housner: No.

Prud'homme: Did he work on the Tacoma Narrows Bridge?

Housner: Yes, that he did.

Prud'homme: And the Metropolitan Water District?

Housner: Yes. He worked there, but again, the book doesn't have this story straight.

Prud'homme: Could you tell me the straight story?

Housner: We're collecting the data now. And what really happened was that in the 1910s, it became clear to Los Angeles that they wouldn't have enough water. So they set up the project to bring water in from the Owens Valley. In the 1920s, Pasadena saw that it wasn't going to have enough water either. And they undertook to build the Morris Dam in San Gabriel Canyon to derive water but saw that they needed a broader supply, that the population was increasing in the area and there had to be extra water brought in. At that time, Professor Franklin Thomas and Professor Robert Daugherty of Caltech were on the Pasadena board of directors, and Samuel Morris was the head of the Pasadena Water and Power Department. Daugherty was also mayor of Pasadena for a while. So they played important roles. The word I get is that they decided there ought to be a cooperative deal. So they went to Los Angeles, and Los Angeles said, "No, you can't have any of our Owens Valley water, unless we annex you." So they drew up a plan and got state approval to form a metropolitan water district. And Franklin Thomas was on the board of directors of that. And that's how the Colorado River Aqueduct got planned and built. And since there was to be a lot of pumping of water through the aqueduct--this was still before the project was completed, around 1930--apparently the question came up, were the pumps any good? At that date, you merely ordered a pump--the manufacturer said, "I make this kind of a pump, and that's it." So the board of directors had their chief engineer contact Professor Daugherty, who had written a book on pumps. He was interested and got a young assistant professor, Robert Knapp, to start working on it. And Knapp and George Wislicanus, who was a graduate student at that time, set up a little lab. The essence of whether they could do the job or not was whether they would be able to make the necessary measurements with the requisite accuracy. Apparently they worked for a couple of years and were able to show that they could indeed do it. And at that stage a contract was signed between Caltech and MWD to make these measurements and see how they could improve the pumps. Then Kármán came into the picture. Von Kármán and Daugherty and Knapp were sort of the three principals. This lab was then moved over into the basement of Guggenheim.

Prud'homme: This is the pump lab?

Housner: The pump lab. Before that, I don't think it had an official name; it was just a lab in what used to be the old ME shop building, which is now torn down. Then the project went on there. They were able to make the measurements and show how to improve the pump. When I asked Professor Converse if he remembered, he said that they were able to save $50,000 a year on pumping costs. Of course, that was in 1933 dollars so that would be maybe $700,000 a year now. They did a good job.

Then the Grand Coolee project got underway. I should say this, that one of the reasons for concern was that the Metropolitan Aqueduct pumps were very large for the time. And the Grand Coolee project had even bigger pumps, bigger than anybody had used before. So they also came to the pump lab and asked them to do the same thing for their pumps, which they did. Then, after the war, well, the pump lab kept going until--I'm not sure, I don't have the dates in my head, but it must have been around 1950 or the early 50s. And then the Feather River project got underway, and they would be pumping even more than the Grand Coolee. And Professor Acosta tells me that he and James Daily--who, when he got his Ph.D. degree from Caltech in 1945 and then worked in the pump lab--they went up and talked to the Department of Water Resources people in Sacramento, thinking they would be doing the same kind of thing for their pumps. But they said, no, all they wanted was verification that they satisfied the specifications, somebody to take the pump and measure and say yes, it satisfies, and we didn't want to do that, so the pump lab died out.

I should mention that during the war, and after the war, what used to be the pump lab got involved in things like launching torpedoes--the kind that you drop from airplanes, and which impact the water surface. They also studied cavitation produced by high speed objects moving in water. The lab had a large circulating water tunnel for their research.

Prud'homme: Who was running the pump lab then?

Housner: Well, I think when Daily left, it gradually got frittered away. I think as long as Knapp was around, they were interested in the experiments--shooting the missiles into the water and so on, making measurements. Some of the people after that were still interested in cavitation measurements. I remember Al Ellis; he's now a professor at UC San Diego. I don't know exactly, but I guess they didn't have anybody who wanted to really take hold of it, and they didn't see where they were getting any money, and it just kind of died off.

Prud'homme: Can you describe von Kármán for me?

Housner: He was kind of an odd duck personally.

Prud'homme: In what sense?

Housner: First of all, his English was terrible. Then he got hard of hearing. I remember he wore this kind of an ear thing that whistled terribly and sometimes you'd go to the seminar and it would start whistling. [Laughter] So someone had to go and turn him off. At one seminar, he was sitting there listening, and apparently he didn't like what the fellow was saying, and he turned it off--like that--so the speaker could see. [Laughter]

Prud'homme: He could be real insensitive. Doesn't sound as though he was afraid of much.

Housner: No, but intellectually he was a very stimulating man--his way of thinking, what he did. He had many disciples.

Prud'homme: And do you count yourself among them?

Housner: I think so, yes. I wasn't as close as those who were interested in aeronautics, like Frank Marble and Duncan Ranney and [Hans] Liepmann, and others that are now all over the country. He was a witty man. He and Professor Zwicky were friends, and Zwicky, you know, was a rough character who frightened the students. He didn't hesitate to speak up, and he made people angry a lot. Wherever he went people got angry at him. And at one stage, in the aero lab, they were measuring roughness of surfaces as it has to do with air flow over the wings. And there was this scheme they had for measuring, a machine for measuring microscopic roughnesses. And von Kármán was showing Zwicky this thing, and "Very interesting," Zwicky said. "And what's your unit of roughness?" And Kármán answered, "A Zwicky, but it's too big, so we use milli-Zwickys." [Laughter]

Prud'homme: You've done a tremendous amount of work with state and federal governments. How do you work with the government of the state of California? How have you worked with them to help plan for earthquakes?

Housner: What happened there is that when the big Feather River project was planned--I think it must have been in the middle or late 50s--and I first realized there was going to be an earthquake problem, I was president of the Earthquake Engineering Research Institute at the time. And I felt that they're going to build this system of dams and acqueducts, and there will be all sorts of dams and facilities and pumping plants, real close to the San Andreas fault. In fact, the project crosses the fault three times.

Prud'homme: Could you describe the project just a little?

Housner: It's for bringing water from the Feather River. North of Sacramento, where the Feather River comes out of the Sierras, a large dam has been built, the Oroville Dam, which provides the main reservoir for the system. From Oroville Dam the water comes down the river, the American River, and on through Sacramento and out to the delta region of the bay. Then, at the southern end of the delta region, there is a pumping plant which takes water out of the delta and starts it south in the acqueduct. The water is pumped out and comes down the aqueduct--it's sort of an artificial river--along the western edge of the valley to near Bakersfield. Then about half of it gets pumped up over the mountains into Los Angeles, and the rest skirts around east of the mountains and goes down to San Bernardino. Eventually, it will go down to San Diego, but at present it just goes to San Bernardino. Well, this is an enormous system, really. At the time it was built, I think it cost about $3 billion. But I think to do it now would be $10 billion. It was a big project--some twenty big dams, several big pumping plants, and the aqueduct. So it's an enormous project. And in the early days when we saw this, we felt we had to tell them; and I wrote to Harvey Banks, who was the director of water resources, pointing out that they were facing big earthquake problems.

Prud'homme: And you did this as president?

Housner: Well, yes, I did it as president. I wrote the letter, and then in due course, I remember I got a telephone call from Larry James, chief geologist up there, who said that some of them would like to come down and talk to us. So I, Don Hudson, and Sam Morris met with them here at Caltech--three of them: Larry James, Bob Jansen, and Don Thayer. And we explained the problem and how they would have to face up to the risk--and so on. And they seemed impressed by that. But they couldn't sell it to the boss. They went ahead and built Oroville Dam. Then Banks retired and a new head was appointed, Alfred Golzé, who had been at the Bureau of Reclamation. Apparently, these three fellows we'd talked to had gone to Golzé and said, "We think we ought to do something." So they came back here--this was, of course, a number of years later--and said, "We'd like to have you on an advisory committee on earthquakes."

Prud'homme: But most of the construction had already proceeded.

Housner: No, no. That was only the dam. They had designed the dam and were building it, and were just getting ready to start designing the rest of the system--it took maybe six years to build the dam and fill the reservoir. I remember talking with Larry James, who decided who the advisory committee members should be. Hugo Benioff, a seismologist here at Caltech, was chairman; I was on; Whitman--Nathan Whitman, a Caltech graduate and practising engineer in the local area; and Harry Seed of UC Berkeley. When we met Golzé, he said, "Well, we want advice on what to do with the earthquake problem." So we prepared a recommendation based on my research and told them what the strong shaking would likely be and what they should do. And they adopted that procedure. That was the first time such modern procedures had been used on dams and pumping plants. So we set a precedent; now all over the world they do that, the way we recommended it.

Prud'homme: So this was really one of your first involvements with the California project.

Housner: Yes, right.

Prud'homme: Did you get involved in the budgeting problems or the adminsitration of these projects?

Housner: No, just on the technical things.

It's kind of ironic . . . This project is sort of a leader in earthquake safety; it's being held up as a model all over the world. Yet, after the project was essentially completed, Ralph Nader's group came out with a report denouncing the whole project, saying particularly that it hadn't been designed for earthquakes and is not safe! It turns out, apparently, that's standard practice, and when Nader's been asked why he does this, he says, "Well, that's the way to make an impact."

Prud'homme: So he doesn't check up.

Housner: No, he doesn't want to check, you see. He wants to make the impact. I'm really annoyed at that.

Prud'homme: You've done so many things--extracurricular things. You were on the board of directors of the International Institute of Seismology and Earthquake Engineering in Tokyo, which was started by UNESCO . . .

Housner: That was just to get it started, really. I was on for five years and got it started.

Prud'homme: . . . And then you were a member of the AEC advisory panel on safety against ground shock.

Housner: Yes, that was at the Nevada test site in the early days of underground nuclear tests.

Prud'homme: And AID consultant at the University of Roorkee, India.

Housner: That's rather interesting. Professor Jai Krishna, professor of civil engineering at the University of Roorkee, had arranged to spend a good part of the 1958 year in the U.S. He wrote and asked if he could come and spend it with us to learn more about earthquakes. I said okay, so he did. He worked with Professor Hudson and me. While he was here, Dr. Khosla, who was chancellor of Roorkee at that time, came through and stopped off to visit Krishna. We showed him around and told him what we were doing. And he said, "Oh, very good. I want you two to come to Roorkee and help us get underway." And sure enough, in due course, he arranged through AID, which was helping India at that time, that we should come. We had mixed feelings; but then Hudson went--I think he went in October--and then I went over in, I guess it was February or March, somewhere in there, for about six weeks. We helped Krishna organize an earthquake conference, which was the first time India had done that, and helped him get started with a lab. It was a very primitive one. Then when we returned, a couple of their people came over to do graduate work here.

I forgot to say that while we were at Roorkee, Dr. Khosla was a member of the Planning Committee of India. He asked us to go down to Delhi with him to meet with some of the members of the Planning Committee to explain the earthquake problem and why we thought India should do something. Of course, what he wanted was some funding to get going at the university, and that did come through in time. The fellows--Krishna and Chandrasekaran and Shrivastara--who were here were able people, so they've got a very vigorous group there that is recommending how to design their dams and all that sort of thing. It's been a very fruitful thing for India; before that, they just didn't do anything.

Prud'homme: You were chairman of the Geologic Hazards Advisory Committee for the organization of the California State Resources Agency in the late 60s.

Housner: Right. That was sort of to size up the hazards and tell people about them. We met a number of times and prepared a report. Of course, it's hard to tell what these things accomplish. I think you have to sort of take the view that some will fizzle out and accomplish nothing, and some will take hold and accomplish something.

Prud'homme: The report was called "Earthquake and Geologic Hazards in California." And you were chairman of the Panel on Aseismic Design and Testing of Nuclear Facilities for the International Atomic Energy Agency.

Housner: Yes, again that was in the early days. They were interested, and the committee drew up a report, essentially explaining the nature of the problem and what they ought to do.

Prud'homme: I'm interested in the response.

Housner: I suppose these reports, like the ones on geologic hazards and the atomic energy one circulate around and people see them; and maybe they don't do anything immediately but in the long run, something comes out of it.

Prud'homme: And of course, you had the San Fernando Earthquake in February, 1971. And then it all suddenly came to fruition, because there you were, with the backlog of information.

Housner: Yes, and there we were, with an earthquake in our backyard. We prepared a report at Caltech. A number of us were on the Los Angeles County Earthquake Commission; Harold Brown, president of Caltech, was the chairman, and we had Charlie Richter, myself, and Don Hudson. . . .

Prud'homme: What changes in engineering came out as a result of that earthquake? You said before that the old structures are still unsafe, in spite of the 1933 building codes and so on.

Housner: Even at that date, it wasn't enough to move people to do anything about the old buildings. But the thing simmered on the back burner. All the other cities looked to Los Angeles. Los Angeles was the only city big enough to have a good building department with competent people, and so they always looked to LA for leadership. Well, we recommended to the city council that they should do something about hazardous old buildings. And it was kind of like a hot potato; they always had some reason for not taking action--more studies, and this and that. And it kept on that way but it didn't die, which you might have expected. And finally, ten years after the earthquake, they passed an ordinance to get rid of the old hazardous buildings. Of course, they don't try to get rid of them all at once. At that time, they estimated there were about eight thousand. Well, if you try to tear them all down at once, that would be worse than an earthquake, economically. So what they're doing is to identify the most hazardous, and each year notify maybe fifty people that their buildings must be strengthened or torn down. Of course, they don't want to notify too many at once, because they don't want five hundred or a thousand irate building owners coming at them. So the Building Department people were somewhat nervous; they didn't know if they could get away with it. If there were a big outcry, they would have to back off. But so far, there hasn't been; they've been doing this and the owners have been cooperating. One building owner did bring suit a year or so ago and asked for an injunction against it, and the judge said, "No, you can't have an injunction against this." So that has sort of settled it now.

Prud'homme: What can you do about the hidden hazards--the water mains, the gas lines?

Housner: Well, those are all problems. The governor of California has some advisory committees, which I presume are still in effect--this was before Deukmejian's time--to look at various aspects. On the water supply for southern California, there was a committee. These were people who were involved with water supply systems. They came over to talk to us about the general problem. Several often were Caltech alumni. And they were to size up the situation should the big earthquake occur on the San Andreas fault: what would happen to the water supply to the homes. A big amount of our water comes from outside--the majority of our water comes from the other side of the San Andreas fault. And then the question of what happens to the distribution system has to be considered? So they're looking at these things. I, myself, think it isn't a too hazardous a situation. There'll be some damage and interruption with the distribution, but not anything in the nature of a crisis.

You were asking about what else came out of the San Fernando earthquake. I did mention before, didn't I, that the method of design we had used for those big high-rise buildings in LA before the earthquake was verified by the records that were obtained in the earthquake showing that given the ground motion you could calculate what the building would do. And then the Building Department in LA said, "Well, that's good enough for us. We can now force through the requirement that all buildings over sixteen stories be designed on a dynamic basis." So that was a big help.

Prud'homme: That's a very big step. So any new building that goes up. . .

Housner: Well, over sixteen stories; under sixteen stories, they can use a simplified method.

For many years, people interested in earthquakes have pushed the idea that more instruments should be out there to record what's happening. And it was very difficult in the early days to get any money or anything done. We saw one problem was that there weren't any instruments commercially available. So Hudson and I here at Caltech got hold of one of the instrument companies--Teledyne, a local company making geophysical instruments--and convinced them they should build a strong motion earthquake recorder, which they did. After that, you could recommend to people, "You ought to have one, you can buy one right here." We advised the company on what kind of an instrument it ought to be and the kind of cost it should have, and so on.

Then, one of the Caltech graduates became chief of the Los Angeles Building Department.

Begin Tape 2, Side 2

Prud'homme: You were talking about the head of the Building Commission in Los Angeles.

Housner: Yes, John Monning. When he died, his widow gave money to us to help set up our earthquake engineering library. He was a Caltech graduate. He was a very able man, and it was clear that he had the confidence of the city council, the mayor, everybody. He saw our recommendation for more instruments, especially in buildings, was very important. So he talked to the councilmen and got their approval, and they put in the code that all buildings over ten stories high should have three recording instruments in them--at the roofs, at mid-height, and in the basements.

Prud'homme: Teledyne must have been happy with you at that point.

Housner: Well, yes. Of course, it's not Teledyne anymore. Now it's Kinemetrics, it's this little company in Pasadena. Actually, a couple of years ago, they asked me to come over to their plant, and they gave me an instrument with a gold plate--the three-thousandth one that they had made. So we put it up in the Seismo Lab. Kinemetrics has sold instruments all over the world.

But with Monning getting it into the code, then many buildings got these instruments, and when the earthquake came, we were able to get all sorts of records. We got more records on that earthquake than out of all the earthquakes in the world before that.

Prud'homme: And with your new computer technology that we were discussing before. . .

Housner: Yes, that made it possible to do something with the records. And it was because these instruments were there and we got the records that we were able to show that it was possible to compute what buildings do.

Prud'homme: Your implication is that Los Angeles, in earthquake matters, is the leading city in the world, over and above San Francisco.

Housner: For earthquakes, yes. San Francisco, you see, is a small city of less than one million people, so they don't have the competence in the building department. I'm sure that the Los Angeles building department is one of the most competent in the country, and, as far as earthquakes go, <u>the</u> most competent. Usually what happens is that Los Angeles puts something in their code on earthquakes, and then a few years later, it goes into the uniform building code. Monning tried to get this instrument thing into the uniform building code right away. It's the function of what is called the "International Conference of Building Officials." All the small towns like Pasadena get together, and they make a code that's agreeable to everybody. I went to the meeting. But when Monning made his proposal, they voted him down. But I think that now, while it doesn't require it in the uniform building code, it recommends it. And quite a number of cities have done something.

Prud'homme: What about the Japanese and Chinese? You went to China in '78 as a member of the Earthquake Engineering and Hazards Reduction Delegation to the Peoples' Republic of China.

Housner: Yes. Well, when President Nixon went over he and Chairman Mao agreed there should be some scientific cooperation, and earthquakes was the first area they chose because that's so noncontroversial. So a committee of seismologists went--in 1974. Then the first group of engineers from earthquake engineering went over in '78. That was just after Chairman Mao's death, and they were just getting out of the terrible repressive measures that had been in effect. It's not clear how much of that was due to the Chairman and how much to his wife--I think it was mostly due to his wife. They had closed down all the scientific and technical schools on the grounds that they were of no use; they just lost a generation of engineers. So when we were there in '78, we visited Tsinghua University, which is the big engineering school in Beijing. From what they had going there, it looked as if they had closed up the labs in 1945 and had just opened them again in 1978. Just nothing there.

Prud'homme: They're really concerned with prediction now, aren't they?

Housner: Well, that was again under Chairman Mao's wife. Chairman Mao announced that they would do earthquake prediction. They set up a special governmental organization, so they told us in 1978 that they had ten thousand people working on prediction. In each state they had a unit, and this unit was supposed to collect all the information and make predictions. Every once in a while they gave out publicity about how wonderful they were doing. It was all hot air. We talked to the reputable seismologists who were not in that operation, and they just said, "We don't know how to predict earthquakes."

Prud'homme: And the Japanese? Aren't they very concerned, what with their very highly industrialized population?

Housner: Yes, they are very busy. They were somewhat slow off the mark in earthquake engineering. It was only after we had developed the instruments here, and the methods of analysis, and so on, that they really got going. Now they have an enormous program for research on earthquake engineering and earthquake preparedness. I was over there last summer; I was dumbfounded to see what they could do. The Ministry of Construction has new laboratories in what they call Tsukuba Science City. Ten or fifteen years ago the government decided to move its research laboratories out of Tokyo. And they built a new city for them about fifty miles north of Tokyo. It doesn't look like a Japanese city; it's international architecture. But they told me last summer that fifty-two government labs have been moved there. The city has over a hundred thousand population. I visited the new labs for the Ministry of Construction. It was just staggering, and I asked, "How much did these cost?" They said, "About $300 million." In another place, which I didn't see, although I've seen a brochure, they built the world's biggest shaking table. We in this country were the first in this country to build the shaking table for earthquakes. The Japanese finished theirs last year. It is a table about fifty feet square on which they can put a thousand tons and shake it like an earthquake, with the intensity of a big earthquake. A thousand tons, that's a lot. And I asked one of the people what it cost. And he told me somewhat over $200 million. That's for the table and all the ancillary equipment. And he said, "We think it's going to cost a million dollars a month to operate it." And that's only a small part of it. They are now much concerned about a repetition of the 1923 earthquake--not quite in the same place, but adjacent. And they told me that they've been spending about a billion dollars a year getting ready for this earthquake with all sorts of instruments and computers and strengthening buildings and bridges, and big programs in public education.

Prud'homme: That's marvelous. See what you started.

Housner: Yes. I really felt kind of depressed, though, to see what they were doing and what we are <u>not</u> doing.

Prud'homme: Can you tell me about the Caltech Earthquake Research Affiliates? How did that start? Who are they?

Hounser: After the 1952 Tehachapi earthquake, our seismologists, Professors [Beno] Gutenberg, Benioff, and Richter, got the idea that maybe they could get some research funds from local agencies and got Dr. DuBridge to write a letter. A number of organizations agreed and gave money. Then, at some later stage--was it before or after the '71 earthquake?

Prud'homme: 1967?

Housner: Yes, that was it. Well, one of the people in Development, Ted Combs, a Caltech graduate, said, "Gee, you ought to be able to get more money for earthquake research, especially if you include the engineering end of it." We agreed that would be fine, and the seismologists agreed, so that started a cooperative duo between the seismologists and earthquake engineers. The Earthquake Research Affiliates group was organized and it's still continuing. They don't give a lot of money, but it's nice money because there are no strings.

Prud'homme: The members give you a fee every year, and you can use it . . .

Housner: Right. We split it 50/50, and it's money that can be used without anybody asking what you're doing. You don't have to get approval either. It's like having a nice big sugar bowl full of money in your kitchen. [Laughter]

Prud'homme: Where do they get members? What's in it for them?

Housner: They get copies of our reports . . . . And we talk with them. But really, the most substantive thing they get is that once a year we have a special meeting. On alternate years, it's a conference here at Caltech, at which we talk about research and interesting problems, and so on. And on alternate years it's a field trip, going out to look at faults, or when there's been a recent earthquake, we go there. People much enjoy it. The field trip is a bus trip. The last one we took, this spring, we met in San Jose and the next morning went to Coalinga to see the remains of their earthquake. And then we came down the San Andreas fault and looked at interesting things down the way. Very interesting. And Clarence Allen and Kerry Sieh do the hosting on that as we drive along, explaining what we are looking at; and when we stop they have their spiels ready. When we have the conferences, it's the earthquake engineers who arrange the them and do the work. So it's been, I think, a useful thing, because what these people learn and the enthusiasm that's generated I think have an effect.

Prud'homme: Tell me about the World Earthquake Engineering conferences. How did they start?

Housner: Well, I told you yesterday about the Advisory Committee for Engineering Seismology, set up to advise the Coast and Geodetic Survey, and that we got so angry at them for not listening that we formed the Earthquake Engineering Research Institute. For many years, it was a very small operation--fifteen, twenty people, and for many years I was president because nobody else wanted the job. I remember in 1952, I tried to arrange a conference on earthquake engineering. I sounded out various people and decided that there wasn't enough interest to warrant a conference on earthquake engineering itself. So we had one on earthquake engineering and blast--because of the war, blast was still a hot topic. We had it then in July of '52 at UCLA. There was much more interest than we had expected; many more people came--not to give papers, but audience. And then we thought, well, we ought to really have a conference just on earthquakes. And since 1956 was the fiftieth anniversary of the San Francisco earthquake, it was agreed to have it in '56 in San Francisco. We tried to invite people from different countries who were at all interested. Of course we didn't know everybody, but we did make contact with some of the Japanese and some New Zealanders. Some we never did make contact with. When we had the conference, it was clear that there was a lot of interest, and the Japanese offered to host another conference in 1960. And when they were preparing for it, they said there ought to be a society or an association that we can belong to. So we worked out the details of what this ought to be, and at that next conference in 1960 we organized the International Association for Earthquake Engineering. And each year this has gotten bigger and bigger. Now, the way this works is that it's really a federation of national societies. A country with sufficient interest to form a national society can become members of the International Association--I believe the only requirement is that it has to have ten people in a formal organization. And now, I think there are thirty-five countries that are members. So it's a big operation.

Prud'homme: You have a specialized library that you showed me here on earthquake engineering. Who uses it?

Housner: Well, there's the staff here, and graduate students use it. People like engineers in the vicinity come in and use it; people from outside write in and ask for copies of things, so they use it. So it's sort of anybody who's interested in earthquake engineering may make use of it. Since the subject is so recent, there are very few libraries of this sort around. And we probably have the most complete in the world because we started early. It was started when I began collecting books myself. And I began outgrowing my space, so we set it up in the secretary's office for someone to keep an eye on the couple of shelves of books. And people began borrowing them. Well, we got more books; and then back about 1968, we requested funds for setting up the library from the National Science Foundation . . . . Many of the books in there started in my personal library, so I take a very personal interest.

Prud'homme: In 1971, there was a conference on wind engineering research. Can you tell me about that?

Housner: What happened there was, it struck me that for earthquakes we had a lot of activity going on in research and study. But wind disasters were occurring, and there wasn't anything comparable being done. There had never been any conference on wind. So I got from NSF a grant to hold a wind conference, and contacted all the people around who would be interested, and we met here. Papers were presented, and so on, and a resolution was made that they try to set up a society and hold conferences comparable to what we did in earthquakes. And they did that. So now, every four years, they have a conference on wind hazard engineering. But they're having trouble setting up, getting their society organized and active.

Prud'homme: It's not that active?

Housner: Well, they didn't have somebody in a father image who could get them together. So there's been a lot of sort of infighting. But wind is an important problem and it still isn't being given the attention it should have.

Prud'homme: You received a big grant in '74 from the National Science Foundation.

Housner: Let me tell you this first. I saw that earthquakes were happening in various parts of the world and even in this country, and no reports were coming out. And the same with the wind. So I got the National Science Foundation to fund what we called "The Committee on Natural Hazards," which is organized as part of the National Research Council. It's still operating. Its function is to inspect natural disasters and make reports. And over the years, it has done this. I was chairman first, and then Paul Jennings was chairman. So various reports come out on earthquakes. We don't do them all ourselves; sometimes the earthquake occurs in a country where we know people who are competent, and we say, "If you will prepare the report, we'll publish it. We'll get some money to help you," and so on. A lot of reports have come out; so that's been sort of a follow-up from the EERI and the Wind Society and so on.

Now, you were asking about . . .

Prud'homme: . . . I was asking about almost a half a million dollars from the National Science Foundation in '74 for a new research program.

Housner: Yes. That's, of course, the result of the 1971 earthquake. [Laughter] Well, to explain all that, I should say this, that we had thought that the NSF ought to be putting more money into earthquake engineering research. But, of course, it's very difficult to pry money loose when it's already allocated to somebody else. And while they did have a little to put into earthquake engineering, it wasn't much. Then--I think it was just a little before the '71 earthquake, maybe in '70--I got a call from one of the assistants in Senator Alan Cranston's office who said that Senator Cranston was interested in leading a bill through Congress on natural disasters and wanted advice. She asked about winds and it turned out there were a couple of federal agencies doing research on that; she asked about floods and, well, there was the Corps of Engineers doing that, and she said, "Well, we don't want to try a bill with those people in the picture because you'd be stepping on toes," and the earthquake was the only thing left. We were just finishing this report [reaches for it], "Earthquake Engineering Research," published in 1969. (That came out because I'd approached the Academy of Engineering and said we would like to put out a publication in which we looked at the earthquake problem and what's to be done about it in research. They got funding through NSF--this was a National Research Council project. And so we wrote this report on what the problem was, what you ought to do, and so on.) Fortunately I had a copy and sent it to this assistant of Senator Cranston. Ann Wray her name was. In due course, she got back to me and said, "Well, that's just what we want. And we'll try to put through a bill on it." Of course, you can't keep anything secret there, and the Geological Survey got hold of it and said, "Well, you have to also put in seismology." So Cranston's office drew up a bill which had two parts: one for funding research in seismology and one for funding research in earthquake engineering. The scheme they use is that when the Senate draws up a bill the House does, too, and vice-versa. Well, Cranston got his bill approved by the Senate, and then they had the corresponding House committee work one up, and it went to the House. And who should get up and denounce it on the grounds that they didn't need to do anything about earthquakes in California but the Representative from Palmdale, sitting right on the fault. [Laughter] And that killed it--they didn't get enough votes. So then they had to put it away and start again. Well, in between came the San Fernando Earthquake. And Senator Cranston came out--I guess he wanted a little publicity--and he called and said he'd like Clarence Allen and me to meet him at such and such a place and show him around. So we did. Of course, by "coincidence," wherever we went, there were TV people, waiting for us. So Senator Cranston made hay on that. Then he went back and got the bill through both houses, got it approved and implemented. So that's where the big grant came from, because the bill directed the National Science Foundation to put a certain amount of money into earthquake engineering research. I think it was at that time something like $6 million. So that was our payoff. But it's been a very important thing because it funds earthquake engineering research at many universities and it's had a reinvigorating effect on civil engineering, because it suddenly brought them all into the twentieth century.

Prud'homme: Can you describe some of your colleagues to me? You've mentioned Clarence Allen a great deal, and Kerry Sieh.

Housner: Those are in seismology. And Hiro Kanamori. They intermix with us very well; earthquake engineering people and those three get along very well together.

When Hugo Benioff retired, Clarence Allen came on the advisory committee for the Department of Water Resources as chairman. He's still on the committee and I'm chairman now, so we've worked together over the years. And Kanamori and Jennings have done research and published papers together. It's been very good cooperation.

Prud'homme: Are there any women in your field?

Housner: Very few, very few. There is one at Stanford, Ann Kiremidjian.

Prud'homme: Are there many women engineering students?

Housner: Civil engineering is not a popular field for women. In fact, at Caltech, you know we admit about thirty women every year as freshmen, and my guess is that the biggest number go into biology and mathematics. Maybe a half a dozen--six to ten maybe--enter all of engineering. We get an occasional woman among those few who shows an interest in civil engineering topics. You see, we don't sign students up for it particularly; so we might average about one a year.

Prud'homme: Why is that?

Housner: I don't know. Some years there may be two or three, and then you go for a couple of years with nobody. In the graduate school, for instance in earthquake engineering, I think we get on the average of between one or a half-one every year. I mean, some years you may admit one and others none. So it's not a big item. I don't know if they do any better in seismology. They have Kate Hutton and another one whose name I don't know. They've had a few. When I was president of the Seismological Society, I got letters from some women activists about whether we were doing anything--it's a society of about a thousand members, and I think there were three women members. But fortunately, at the time they were beating on me, I was able to say that we had just awarded the Society medal to a woman seismologist. But they didn't say fine; they said, "You ought to do that more often." [Laughter]

GEORGE W. HOUSNER

Session 3

July 11, 1984

Begin Tape 3, Side 1

Prud'homme: Just a slight interjection. We were just talking about your writing and your student's writing. Do you find students now write poorly? There's sort of a general academic myth. I don't know whether there's any truth in it or not.

Housner: No, I think they do better than they used to. When I think back thirty years ago, they had more troubles. I think somewhere along the line, their education is better. Of course, our students are clearly way above the average in that regard. It doesn't really apply to us.

Prud'homme: I want to talk about some of your special projects.

Housner: I've been working on Palomar Observatory. A number of cases of special earthquake problems come up at the school, and we advise on them. And at the Palomar Observatory, the question of earthquake safety came up recently. When it was designed back in the early thirties, not much was known about earthquakes, and they didn't give too much thought to it then. Actually, earthquake design was considered; Professor Martel was the advisor on that, so they did it according to their knowledge at that time. But now the question came up again in view of what we know today. So we, Paul Jennings and I, went out and looked at it, and it's clear that the telescope itself is in a rather precarious condition. When they built the thing, their real concern was to be able to adjust it exactly right, not to resist earthquakes--they didn't think there would be anything special in the way of earthquakes. Recently, Clarence Allen of the seismology department was asked to advise on what sort of earthquakes might occur in the general vicinity that could produce strong shaking. Well, he did, and he thought that we couldn't write it off as a possibility, although it's quite unlikely. He thought we might expect one on the average of once in four hundred years, but, of course, since we don't know when the last one was, we can't know when the next one could come. So it's something that you can't neglect. So everyone was wondering what to do. Well, our idea was that what we ought to do is not try to rebuild it to resist the earthquake but try to make sure that if it were over-stressed by the earthquake, the telescope wouldn't fall over. They could put new supports under it so that if it started going, it would come down on the new supports. I was just looking at the engineer's drawings for it, and it seems a quite satisfactory solution. If it happens, it will cost something; there would be a monetary loss--you would have to put it back in place. But it wouldn't be a disaster, whereas if the whole telescope were to fall on the ground, that would be a terrible disaster.

Prud'homme: I have some specific projects you've worked on listed: the BART in San Francisco, the Tagus River long-span suspension bridge, the Feather River Water Project, the Trans-Arabian Pipeline, and nuclear power plants. Which of them were of most interest to you? Can you describe some of them?

Housner: Well, the one that's been of the greatest interest was the Feather River Project. It was a large project; it cost over $3 billion--if you were to do it now, it would probably cost $7 or $8 billion. It has something like twenty dams, several pumping plants for pumping water up over the mountains, and electric generating plants where the water comes down the side of the mountain and the fall is used to generate electricity. Then the aqueduct with the dams is located along the San Andreas fault, and crosses the fault in three places. So the earthquake factor was extremely important. Fortunately, I had been doing the research on the necessary aspects so that when the advisory committee was formed, it was able to advise just what I thought was the right thing to do. That was the first time this approach was used on such a major project. And now, any major dam in any seismic region in the world is handled that way.

Prud'homme: With an advisory committee?

Housner: Well, I don't know about that. I'm thinking of the way it's done--that is, to make the design, the analysis, and so on. It sort of set the precedent for how dams are designed. For example, even the Bureau of Reclamation and the Corps of Engineers, which are government agencies that do the design of federal government dams, have in the last five or six years followed this precedent and began doing it. So that's been a very important and interesting project to me. And I'm still involved. That is, there are no new dams underway, but the state is also responsible for the safety of older dams. They have a program going on, in which they make the dam owner hire an engineer to analyze the dam for earthquakes, and they make a presentation to the Division of Dam Safety. And if they can't show that the dam will be safe against the kind of shaking that might occur, then they have to either lower the water level or strengthen the dam. So I'm involved in that, and that's a very important thing.

Prud'homme: Same is true with the high-rise buildings, in terms of the saving of lives.

Housner: Yes, right, it's very important. The high-rise buildings of 40 to 50 stories in Los Angeles have thousands of occupants each. The very first one to be designed for earthquakes the Caltech way was the Union Bank building.

Prud'homme: Did they come to you?

Housner: The Union Bank building was actually built by the Connecticut General Life Insurance Company, and they told the architect to go to Caltech and ask them how to do it. I think if they hadn't, you know, they'd still be doing it the old way. But when the Company had them come over, Jennings and I then told them just how to do it. On the basis of the identified faults in the vicinity, we estimated what the ground shaking would be if earthquakes were generated and then showed them how to calculate how the building would respond. And we helped them make the design. After that, all the high-rise buildings in Los Angeles were done the same way.

Prud'homme: Is this required under the state codes now?

Housner: No, not the state. The codes are city. After the San Fernando earthquake, when we got recordings in the basements and the upper parts of multi-story buildings, that agreed with what we had been able to calculate, demonstrating clearly that you could calculate the vibrations and the stresses and strains, the city of Los Angeles then incorporated it into their building code for all buildings more than sixteen stories in height, setting the precedent for other cities. So that's been a very satisfying thing.

Prud'homme: You were a consultant to the Japanese Atomic Energy Commission on the design of nuclear reactors in 1965. And the Italian Nuclear Energy Commission.

Housner: Yes, a number of them in this country, too, in the early days. But that's been very frustrating; I got out of that business.

Prud'homme: Frustrating in what sense?

Housner: In the first place, I could see in the early days of the 1960s that the degree of safety required for nuclear power plants was much beyond ordinary buildings. We weren't really prepared to answer the kind of questions that would be coming up. So I wrote to the Atomic Energy Commission and pointed out that they needed more research and they had to get ready but they answered that they already knew everything that was necessary. Then it was clear that what was happening was that you were getting involved in the legal aspects of things, and hearings. The technical things were getting sort of snowed under by the political and legal. So I got out. I haven't done anything in recent years on the nuclear business.

But again, I think it was my advice that started the nuclear power plant people in the right direction, making earthquake analyses of the power plants.

Prud'homme: They had to think about it.

Housner: Well, you see, they didn't know. The people in the Atomic Energy Commission weren't engineers who knew about earthquakes. And those who designed them were engineering outfits that were accustomed to doing it the old-fashioned way with the old codes and so on.

Prud'homme: Are there any other projects you'd like to discuss?

Housner: I was consultant on the design of the Lisbon suspension bridge. That was the first time such an analysis was made for a long-span suspension bridge.

Prud'homme: You had many firsts, or you initiated many things.

Housner: Yes. Well, sometimes they didn't work out too well. Like the original building on the campus [Throop Hall]. It was built in 1910, where the little pond is now. It was of a type which was not good in earthquakes. I wrote memos to the administration pointing out that it was no good.

Prud'homme: This is Throop Hall?

Housner: Throop, yes. It was of the kind of construction that was popular in Central and South America. Every time there was a destructive earthquake there, we saw that kind of building shattered, and I'd write another memo. Nothing happened. And then, of course, came the 1971 earthquake, and Throop was shattered.

Prud'homme: Was it really?

Housner: Oh, yes, shattered. It was the same kind of construction as the Veterans Administration Hospital at Sylmar that collapsed and killed fifty people.

Prud'homme: What is that, unreinforced masonry?

Housner: Well, no, it's where the columns and floors are reinforced concrete, and the walls are of hollow tile. In the old days, they never thought about the columns resisting earthquakes. We pointed out in the memo, if there's a strong shaking, it would be shattered; and if the earthquake is close and there's real strong shaking, it'll fall down. Of course, that's what happened at Sylmar; down it went. Here it didn't quite go down.

Prud'homme: But it was unusable like that.

Housner: Yes. So they tore it down. The same kind of construction had been used--the same architect--in the art gallery at the Huntington Gardens. And Dr. Wark, who was the curator there, asked me to come and look at it. It wasn't as badly damaged as Throop, but again, it was on the verge. So I told him they had to do something. He said, "Well, I wouldn't want these paintings damaged." And I said, "In addition, you know, you have the public coming in." And he said, "You can always make more people, but you could never replace these paintings."

They did strengthen it, so it's all right now. They had a dinner for three hundred of the Friends of the Huntington at a thousand dollars a plate; that was the money they used to fix it up. [Laughter] So that went very well.

Another example was when they built Millikan Library. Professor Jennings said, "Why, they put all those bookshelves in, when they're no good for earthquakes." And he sent a memo to the Buildings and Grounds and nothing happened, and he sent another memo and nothing happened. Then came the earthquake, and they collapsed, and now they're all braced. So I have sympathy for cases where people can't get something done, because we couldn't get things done here either.

Prud'homme: In 1972 you were elected to the National Academy of Sciences. Was this an honor for you? You've received many honors, but which ones have meant something to you?

Housner: I don't know; it's hard to say. I think the ones that meant the most were those on a personal basis, like the award I got for my services during the war, because the people with whom I worked appreciated what I was doing. And the same with the award I got from the Seismological Society--again, these are people who know me. I liked being elected to the Academy of Sciences, although all it really says is that you're generally known and respected but not personally known. More recently, I was awarded the National Medal of Science by President Reagan; and the Earthquake Engineering Research Institute established the George W. Housner Medal to be awarded to a person who has made outstanding contribution to earthquake engineering.

Prud'homme: In '74, you were named the Braun Professor of Engineering to earthquake engineering. Had you had any particular association with that particular engineering company?

Housner: I knew the people there; many of them are Caltech graduates. And I advised them on technical problems. I suspect that I got this because Mr. Braun, of the engineering company, set up the professorship. He wanted an engineer, so he perhaps identified me.

Prud'homme: Do you continue to write?

Housner: Well, some, but mostly things I'm pushed into--like the speech. I'm not very active anymore in research.

Prud'homme: But you seem to be very much still in the public eye.

Housner: Oh, yes, I'm keeping active, as I mentioned before. I'm chairman of the newly formed Earthquake Engineering Committee of the National Research Council, and chairman of the new Committee on Dam Safety of the National Research Council. I just completed service on a special committee on earthquake research facilities for the National Research Council. So I keep busy that way; I'm still active in that sense.

Prud'homme: And is that what you're doing currently? You said you were doing no research.

Housner: Yes. Well, a lot of time the last year has gone into the big earthquake conference we're having next July. It starts the 22nd. So I'm active there; well, many of us here are closely involved in pushing it through. I was one of the founders of the U.S. Earthquake Society. Also, I was one of the founders of the International Association, and so on.

Prud'homme: How would you describe Caltech now? What do you think is the state of the Institute?

Housner: I think it's in good shape. Actually, it's true that I feel that the whole system of engineering education is in sort of a state of turmoil. Changes are going to be made.

Prud'homme: What sorts of changes?

Housner: General engineering education was laid down in the early years of this century, and it's very hard to change. When I was a student, I had to take a course in railway engineering. Well, nobody had designed a railway for fifty years. It takes a long time for stuff to go out. Now, with all of the new developments--the digital computer, and civil engineering with big projects, all sorts of things--I think students need to know different things than they used to. And therefore, I think, education has to undergo some changes in that regard.

Prud'homme: Must they become more specialized, therefore, in order to thoroughly know a branch of it?

Housner: Well, my own thinking is that in the undergraduate years, they should be less specialized, because there are so many more things that a student ought to know something about, just for a general education. Specializing, I think, should go on in the graduate school. I think in the next few decades we're going to see big changes in engineering education.

Prud'homme: Do you think there's any reason for engineering students to have a liberal arts background of any sort?

Housner: Yes. You know, Caltech was the forerunner in that. When Drs. Millikan, Noyes, and Hale laid out the course of the Institute, they said one-quarter of the students' courses should be devoted to the humanities. That was a new concept for engineering and science. And over the years, gradually, other schools began putting the humanities in. Not many require the same number we do, but they followed along our lead.

Prud'homme: You were chairman and secretary of the faculty. What were your duties as such?

Housner: Not too many duties. The secretary of the faculty, first, keeps the minutes. Has Judy Goodstein showed you? The Archives have the whole set of minutes back from Day One. That's really the main function of the secretary. I got into that job more by inheriting it from Professor Martel. He was the secretary for many years; then he was laid up for a year or so and I did it; but then he never wanted to take it up again.

Prud'homme: What did you do as chairman of the faculty?

Housner: When I did it, the chairman didn't do too much. He presided at meetings of the faculty board and meetings of the faculty; and occasionally if some crisis arose, then he would get involved. Now the chairman of the faculty does more because it's actually more of a steering committee than a faculty board, with the chairman as the leader responsible for watching over what's happening. The faculty is now so large that you can't do much in a general meeting. And the faculty board has representatives from all the departments and is so diverse that, again, it's not easy to do something. So that now, the chairman of the faculty and the steering committee are much more closely involved in things; they also seem to get more involved in crises.

Prud'homme: How would you compare Millikan, DuBridge, Brown and Goldberger as presidents?

Housner: Well, you can see the gradual releasing of the grip of the president. When Millikan was president, he ran everything; he took care of all the money, and he had it in different pockets and nobody knew where it was. He would decide everything. Of course, the school was small enough at that time so he could do that.

DuBridge and Millikan were both particularly good public relations people. The community at large thought very well of them.

Prud'homme: And the extended scientific community, too.

Housner: Yes. Harold Brown was a different type. He was not the outgoing type.

Prud'homme: What kind of a person was he? Nobody has given me the same sort of answer, which is interesting.

Housner: He was one of those you'd think of as a scientific type, not an outgoing personality. He came at a time when things didn't look good financially. So he had to do some unpleasant things, like cutting back in certain places. But I think he did a good job. He was just a different type than his two predecessors. And Goldberger is still a different type, and I'm still trying to figure him out.

Prud'homme: One can say the nature of the presidents has changed; but then the nature of the faculty has changed, too.

Housner: Yes, they changed.

Prud'homme: People are a lot more open about their objections.

Housner: Yes. I'm sure Dr. Millikan would be in trouble if he came back now. Of course, in his day, he knew everybody on the staff. But now, Goldberger can't know everybody.

Prud'homme: Have the students changed over the years, in your perception of them?

Housner: Yes, I think so. I think the students are brighter, better prepared now than they were in the old days.

Prud'homme: Do you have any favorite students that you can remember?

Housner: I've had a lot of very good students, yes, a lot of them. They're all over the world and, by and large, very successful. A former student from India just got in and called me; he wants to come and see me next week. He's now director of the Thapar Research Institute--Dr. Navin Nigam.

Prud'homme: Are there any other colleagues that you could tell me about? Or any stories or incidents?

Housner: Well, Dr. Millikan felt that the school took first place; everything should go to fixing up the school. This was back in the late '20s or early '30s. He and Professor [Royal] Sorensen developed a vacuum switch, an electrical switch. One of the big problems in switching high voltage currents is that when you make contact with high voltage few times, you burn it, the switch is all gone. So they invented this vacuum switch with which it wouldn't happen and--of course, I'm only telling you the gossip I heard--they sold it for a million dollars, which was a lot of money. And Dr. Millikan said to Sorensen, "Well, you don't need anymore money; you're all right. We'll just put this into the Institute funds."

Then another time--Fred Lindvall told me this story--Ed Simmons--whom I'll mention later in more detail--was a graduate student then and was scrounging around in the trash bin and found the draft of the minutes of a board of trustees meeting containing the salaries of all the professors. So he came and showed it to Professor Lindvall and said, "What should I do with it?" And Lindvall said, "You'd better just burn it up, or throw it away." Well, he didn't take that advice; he went around and showed it to Professor Sorensen. Sorensen looked at it and saw that Professor Buwalda, who was a geologist, had a bigger salary. So he went to Millikan and said, "How come Professor Buwalda has a much bigger salary than I do?" And apparently Millikan huffed and puffed a little, and then he said, "Well, he has an expensive wife."

Ed Simmons is the "Renaissance man" you see walking around on the campus. Have you ever seen him? In tights? He wears tights, a strange looking sort of garb of the 1400s. I don't know why he does that, nobody knows. I knew him in the early days because when I was a graduate student working for my Ph.D., he was around, and I engaged him to do some work or other. At that time, we thought he was sleeping in the lab. He'd gotten his degree, but he was still hanging around. He was technically a very clever man. When the war broke out, Professor Donald Clark engaged him to work on a research project they had; I think it was war work. He said to Simmons once, "We ought to find some way of measuring what the strains of the material are." And Simmons thought about it, and he took some silver constantine wire that has properties that cause electrical resistivity changes when it's stretched or contracted. So he glued this on, and sure enough, he could measure the strain. Now actually, that was a great invention, because since the war it's being used all over the world--the electrical resistance strain gauge. It turned out to be a very important thing. But the thing got all fouled up when the patents were taken out. Dr. Millikan said, "We'll take the patents out in the name of the school."

Prud'homme: Did this make Simmons angry?

Housner: Yes, and he brought suit. He was his own lawyer. He could show he wasn't hired to make inventions for the school; he was just a guy hired to do things in the lab. In this case there was no patent agreement or anything. So he was awarded the full rights of the patent.

Prud'homme: What happens in such cases? Can a professor collect money on something he invents?

Housner: Well, after that the Institute set up a policy, and when you get hired now, you have to sign an agreement that if you make some invention using Institute equipment and so on, the Institute gets the patent. Of course, if you do something outside . . . .

Prud'homme: Then it's all right.

Housner: Yes. But if it comes out of the Institute, then the Institute gets the patent. And if there's any money, it's split in a certain way.

Prud'homme: I should think this would help prevent jealousy between the pure scientists and those who are more involved in applied sciences.

Housner: Yes.

I remember when I was a graduate student, Simmons always wore the same clothes--dirty yellow corduroy trousers and a knitted green sweater buttoned down the front. You never saw him in anything different, so we thought that was all he owned, and probably that's right. This was back in 1940. Then after the war, around 1950, he was given an award by the American Society of Mechanical Engineers for this invention. And I saw the photograph of him accepting the award at the meeting. And there he was in his yellow cords and his green sweater. [Laughter] And now he wears these strange costumes.

Prud'homme: If you look back on your career, what are you most proud of?

Housner: I don't know. . . I think the research I did on earthquake engieering was certainly satisfying. There again, I took a lot of satisfaction out of my work with the Air Force during the war. Many of the things I did had a very practical result, either in improving the efficiency of the operation or reducing the casualties. Of course, there are many little technical things I did that gave me great satisfaction, and still do. I can't explain to you, but there'd be a technical problem for which I could see the answer, how to solve it. Another thing that I take great satisfaction in is that when we formed our Earthqake Engineering Society in the United States, we were getting only a few interested people--we had like fifteen members. For many years I was president, trying to get it off the ground. After we had our First World Conference we felt there ought to be an international association to encourage people in other countries to do something. And my advice was that the international association should be sort of a confederation of national societies because if you have a national society, that shows there are enough people interested to keep attention going. Now there are some thirty-five different countries that have the societies. So that is, I feel, a real important thing.

Begin Tape 3, Side 2

Housner: I already told you about Professor Daugherty. He said that when they built the Athenaeum . . . --it was finished in '30 or '31--it was a big thing in Pasadena. They had a big banquet celebration, and of course Millikan invited everyone, and the men all came in their tuxedoes and it happened to be a very cold night. Daugherty was there, and Millikan said, "Oh, it's too cold; the women are here in their short-sleeve dresses and they can't get the furnace going. Can't you get it going?" All right . . . Daugherty was professor of mechanical engineering, so he went down and tried to see how he could get it started. The problem was that it had never been turned on before. So, he said, he worked away, taking the thing apart and putting it together, and finally he got it started and got the heat going. Then he washed up and cleaned up and came up, and the party was all over.