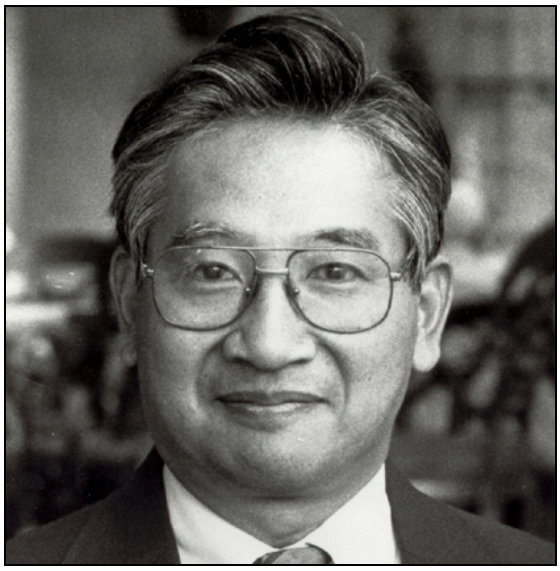

HIROO KANAMORI
(Born 1936)

INTERVIEWED BY
SHIRLEY K. COHEN

April 19 and 26, 1999

ARCHIVES
CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

Subject area

Geology, geophysics, seismology

Abstract

Interview in two sessions in April 1999 with Hiroo Kanamori, John E. and Hazel S. Smits Professor of Geophysics and director of the Seismological Laboratory 1990-1998.

Begins by talking about what it was like to grow up in Japan during WW II; his early education and interest in engineering. University of Tokyo, BS in physics, 1959. As an undergraduate and graduate student, worked with Chuji Tsuboi on building a sea-borne gravity meter (MS 1961). Further graduate work with Hitoshi Takeuchi on geodynamics and seismological projects (PhD 1964). Charles Richter and Charles Hewitt Dix to University of Tokyo as visitors; works closely with Dix on gravity meter and geophysical problems.

At Dix's invitation, comes to Caltech in summer 1965, one-year research fellowship. Spends part of it at the Seismological Laboratory, then on N. San Rafael. Back to Earthquake Research Institute (ERI) in Tokyo in 1966; 1969, goes to MIT as visiting associate professor at invitation of Frank Press; studies very large earthquakes (Chile, 1960; Alaska, 1964). Comments on differences between Caltech and MIT. Back to Tokyo; student unrest disrupts ERI.

Comes to Caltech as full professor in 1972, appointed to Seismo Lab, headed by Don Anderson. Comments on life at the Seismo Lab and interaction

with Richter. Recalls Lab's 1974 move to Caltech campus. Discusses work on quantifying very large earthquakes using long-period waves; work on tsunami (slow) earthquakes. Mount Saint Helens eruption in May 1980 spurs his interest in volcanology. Seismograms after eruption show it was not main event but triggered by a landslide caused by shear waves.

Discusses decision to accept directorship of Seismo Lab; interest in seismic hazard reduction in Southern California; means of reducing seismic risks; 1987 TERRAscope network, joint project with the U. S. Geological Survey (USGS) to collect earthquake data. Discusses Caltech's establishment in 1950s of Earthquake Research Affiliates to fund earthquake study and its reactivation in late 1980s as CUBE [Caltech-USGS Broadcast of Earthquakes], a real-time seismic information system. Comments on interaction with USGS.

Improved earthquake network (TriNet) set up in 1997, with help from Everhart administration and FEMA funds; new participant is state of California, through UC Berkeley's seismic network and California Department of Mines and Geology. He becomes PI of TriNet. Succeeded in 1998 as Seismo Lab director by Donald Helmberger. Discusses outreach efforts to inform public about seismic risks. Collaboration with people in engineering division. Comments on 1995 Kobe earthquake. Discusses his reasons for not having become U. S. citizen. Concludes with his hopes for seismology's future, including ideas of Takuji Kobori, of the Kajima Technical Research Institute, on developing an active control system to protect large urban structures against earthquake damage.

Administrative information

Access

The interview is unrestricted.

Preferred citation

Kanamori, Hiroo. Interview by Shirley K. Cohen. Pasadena, California, April 19 and 26, 1999. Oral History Project, California Institute of Technology Archives. Retrieved [supply date of retrieval] from the World Wide Web: http://resolver.caltech.edu/CaltechOH:OH_Kanamori_H

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

INTERVIEW WITH HIROO KANAMORI

BY SHIRLEY K. COHEN

PASADENA, CALIFORNIA

http://resolver.caltech.edu/CaltechOH:OH_Kanamori_H

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

Interview with Hiroo Kanamori **by Shirley K. Cohen**

Pasadena, California

Session 1	April 19, 1999
Session 2	April 26, 1999

Begin Tape 1, Side 1

COHEN: Well, good afternoon Dr. Kanamori. I'm happy that you're here with us and are going to give us an interview. Perhaps we could start with your telling us about your family—how you grew up and what your parents did—to give us some background.

KANAMORI: All right. Well, I was born in 1936. My father was working for the Japanese government. And after the war—

COHEN: Was he a scientist?

KANAMORI: No, he wasn't. After the war, he became one of the cabinet members, and he contributed a great deal toward the passage of Japan's new constitution. And after that, he became chief librarian of the National Diet Library until his retirement.

COHEN: The National—what is it?

KANAMORI: The National Diet Library is [like] the US Library of Congress. So he worked there. He taught at universities, but I don't think he was very much interested in a teaching job. Oh, he liked teaching, but he was more an artist. He liked painting, and he did some Japanese haikus and those things. Unfortunately, I didn't inherit those talents at all. [Laughter] I'm a very poor artist myself.

My mother was a dedicated housewife. During that time, of course, very few women worked in Japan, so she really dedicated herself almost a hundred percent to her family.

COHEN: And, of course, these were the war years when you were growing up.

KANAMORI: That's right. World War II had a very important and rather interesting influence on me. The war was over when I was in the third grade. But even before and after that time, it was total chaos. I did go to school, but there were not many teachers. And by the end of the war, most of the school buildings had been destroyed, so there were almost no classes and no teachers. So I didn't have much formal education at the elementary school level. But I enjoyed reading books and working on math problems with my friends from time to time.

COHEN: Did your parents contribute to your education?

KANAMORI: No. Actually, I was the fifth child in my family—or even sixth, since the eldest sister had already passed away when I was born. My eldest brother is almost twelve years older than I am, so I was born toward the end of the sequence. [Laughter] So my parents did know, I think, how to deal with their children by then. They let me do whatever I wanted to do, as long as I didn't do anything harmful—which I appreciated. So during wartime, I basically studied on my own. And I enjoyed it very much, actually—though life was chaotic. Our house was burned, so we moved from one place to another. There were not many books, or even paper to write on, so I wrote a lot of equations on the backs of wrapping papers. I still remember that. [Laughter] Maybe those were the most productive times of my childhood, in a way. The only real problem was that there was nothing to eat, so I was hungry almost all the time. I really admire my mother's skill in, basically, feeding us properly. It must have been extremely difficult. I can't imagine how she did it.

By ordinary standards, it was a terrible time. And yet I sort of enjoyed myself. I was independent and did a lot of work assembling some small tools and machines—some surplus material from the military. [Laughter] So in a way, those six or so years, when you come to think about it, had a pretty important influence on me, because I learned how to do things without being taught. And I acquired a habit of thinking [for] myself, without asking anyone.

Of course, it was always helpful to ask someone, but it was important to think first for yourself. Then, if you couldn't find a solution, you might want to find someone who could teach you. But that kind of basic attitude I think I got around that time.

COHEN: Yes—a very important time.

KANAMORI: So without that war, my life might have been very different. I might have gone to a more regular school, but I might not have gotten this habit of chasing something until I found the solution.

COHEN: And of working by yourself.

KANAMORI: Yes.

COHEN: So then, by the time you finished high school, things were a little bit back to normal?

KANAMORI: Yes. Even by middle school, things were much better. But around that time there were not many teachers of English who had actually spoken to native English-speaking people. So English teaching up through middle school wasn't complete. But still, my schooling improved. And in high school, obviously, I got very much interested in science and math. Also, I liked the outdoors. So I did some climbing, just with simple equipment. I liked spending time outside. And I wanted to do math and science. So the combination of the two probably brought me to geophysics, I guess, come to think of it.

COHEN: I see. So did you work with your brothers or your sisters at all?

KANAMORI: Not really. I have two brothers. My eldest brother is an economist. Now he is retired, but he is still doing some government work. And he's twelve years older than I am.

COHEN: That's another era.

KANAMORI: My second oldest brother was a physicist. But still, he was eleven years older than I am. And my eldest sister was an artist. She's seven years older than I am. My youngest sister is five years older than I am, so of course, because she was closest in terms of age, I spent a lot of time with her.

COHEN: That was your closest sibling, who was five years older?

KANAMORI: That's right.

COHEN: That's still a big age gap.

KANAMORI: That's right. So I didn't really do too much with my brothers—but, in a way, that's the style of my family. My parents really didn't keep after us, just "Let them do whatever they want to do, [laughter] until they do something bad." I hope no one did anything really bad.

COHEN: Well, living must have been so hard. There wasn't time.

KANAMORI: And also I think it was my father's style. He really didn't want to put too much influence on anyone. My mother was a very dedicated mother, so if we went in some wrong direction, somehow she would correct it without telling us.

COHEN: She knew how to do that.

KANAMORI: That's right. She knew [laughter] how to do that kind of thing. I was very lucky to be brought up in that kind of family.

COHEN: So then you finished high school, where you already were interested in geophysics.

KANAMORI: Or engineering. I couldn't quite tell, because I really liked to assemble a lot of things; I liked electronics. So I wasn't quite sure which way I wanted to go. Then I went to college, and for the first two years—I think that particular two-year course was called "general

education." We didn't have to decide [on] an exact field. I was in science but not in engineering and not in geophysics, just science in general.

COHEN: This is at the University of Tokyo?

KANAMORI: The University of Tokyo, yes.

COHEN: Was it difficult to get into that university?

KANAMORI: Yes, very difficult. Even now it's very difficult. The Japanese entrance examination system is extremely difficult. The competition is very stiff. Fortunately, I was admitted—it wasn't really that bad for me.

COHEN: Now, was admission just by examination?

KANAMORI: A written exam—and some records from high school—but almost a hundred percent by written exam. In a way, it's a very fair system, completely objective. There's no subjective judgement involved. But sometimes some real talents who may not do very well on a written exam will have a hard time getting into that kind of system.

COHEN: So you don't have all the sympathy for dyslexia that we have here? [Laughter] But you miss good people.

KANAMORI: Sometimes there are really good people who are very intelligent and creative, but you need to be good in all subjects to be admitted. I had to take exams on two science subjects: I took physics and an earth science. And I had to take two math [exams]: geometry and a calculus-type thing. And I had to take two social science [exams]. I had to take one foreign language, which was English. And I needed to take two [exams] in the Japanese language. So you have to be good all around. And you may know that some innovative, creative scientists are really good in some subjects but not in everything. This happens all the time. So for people like that, it's very difficult to get into the Japanese university system, and I think that's an unfortunate thing. But that's still the system, I think. And I'm not sure whether it's really a

good thing or not, because people who are good in everything may not be spectacularly good in one thing.

COHEN: Tell me a little bit about your university years.

KANAMORI: Tokyo University was considered to be the best university in Japan. However, at that time and maybe even now, the Japanese system is very different from here. To be admitted is extremely difficult; however, once you are admitted, they don't force you to study too much, and it's very easy to graduate. We didn't have much homework, and we didn't have to go to classes [laughter], so when I was there it was very easy.

COHEN: I see. Well then, did the professors give their lectures?

KANAMORI: They gave their lectures, and that was it. [Laughter] There were some exams, but they were not that difficult. Even if you didn't do well, normally you'd pass.

COHEN: So once you're there, you're there.

KANAMORI: You are there. And you can usually graduate in four years, and that's what I did. I didn't find the university very interesting, actually. Somehow I didn't really like it very much. But I did read some books on my own, in math and physics. I basically liked to look into these things myself.

COHEN: So you just continued doing what was already your habit.

KANAMORI: That's right. And I liked traveling, so I did a lot of traveling around that time—mainly in Japan, of course. But toward the end of my undergraduate program, one of the professors in geophysics discovered me. The reason was because I was very good at assembling things—electonics devices and apparatuses and things like that. I was really good at using my hands. And in one of the lab sessions during our undergraduate program, we built some device to measure gravity—the Earth's gravity field. And Professor Chuji Tsuboi had a big program around that time to build a gravity meter that could be used on boats, on surface ships, so that

they could do gravity measurements at sea. So I was recruited. [Laughter] I didn't really have much [of a] strong sort of direction myself.

COHEN: This was for your graduate work?

KANAMORI: As an undergraduate, I was working on that in the lab. Then he discovered me and encouraged me to go to graduate school in his lab, to continue that work. And, as I said, I didn't have a very strong direction myself. No matter where I went, I could always find something interesting to do. So I said, "Well, yes," and I went there. [Laughter] And in two years I got a master's degree with that work.

COHEN: And you completed this instrument?

KANAMORI: Yes, yes. Around that time, however, Professor Tsuboi retired. He was toward the end of his tenure at age sixty. Japanese universities are—

COHEN: Very strict about retirement.

KANAMORI: Yes, that's right. So then [I went to work with] another professor, Hitoshi Takeuchi. He was more of a theoretician. I liked to work on math problems myself, so I transferred to his lab after Dr. Tsuboi's retirement. I did some problems in seismology—not quite seismology, more what we call geodynamics.

COHEN: Geodynamics?

KANAMORI: Yes. Dynamics applied to the earth. And then I finally worked on some seismological projects and got my PhD in 1964. And an interesting thing happened, actually. Around that time Dr. Charles Richter [then professor of seismology at Caltech] was in Japan as a Fulbright scholar for a year. And of course Richter was very famous. I'd never met him, and I had just graduated, so I didn't really talk to him very much. But he was at the university to study Japanese seismicity. He really understood everything. I was very impressed. Although I didn't have much of a chance to talk to him, because I was still a student and he was a very famous

professor. And then Dr. Dix came—you know, Charles Hewitt Dix [Caltech professor of geophysics]. He came to the university as a visiting professor; he was a Fulbright scholar, too. So at one time we had two professors from Caltech. And Dr. Dix brought a huge gravity meter with him. I don't know exactly what he had in mind, but he wanted to run that gravity meter in our lab to do some measurements there. But he had a lot of problems because of the power supply: the Japanese have 100 volts and here it's 117. And there are a lot of differences, so it didn't work very well. So, again, I was pretty handy. [Laughter] I was a handyman.

COHEN: So you met Professor Dix?

KANAMORI: I started working with him. I talked to Dr. Dix quite a lot—but not to Dr. Richter. Richter was pretty difficult to talk to, anyway. But I worked with Dr. Dix, not only on this instrument but also on more general geophysical problems. Dr. Dix was a theoretician, and I liked to work on theoretical problems, so I enjoyed talking to him. And then he invited me [to come to Caltech] after he left and came back to Pasadena. So I came here in the summer of '65 as a research fellow.

COHEN: Do you know that Professor Dix found Jim Westphal [Caltech professor of planetary science] also?

KANAMORI: Oh, yes. And Jim also visited Japan before I decided to come to Caltech. And Heinz Lowenstam [Caltech professor of paleoecology]. I don't know why Lowenstam and Westphal came to Japan together. Maybe there was some meeting or something—I can't remember exactly what. So I spoke to them, too. And I thought it was an exciting opportunity, so I came here.

COHEN: As a postdoc?

KANAMORI: As a postdoc, but slightly different from an ordinary postdoc, because I had a position in Tokyo. So it was a kind of leave. The Japanese positions are all tenured, in a way.

COHEN: Once you have this position, you have it?

KANAMORI: That's right. So I couldn't take a long leave. I was given only one year, actually.

COHEN: Was it a research position that you had at the University of Tokyo?

KANAMORI: Yes. I was called a research assistant, but it was a PhD position. Before you become a professor, you usually have an appointment as a research assistant—mainly to take care of the students' lab work, to do research, and that sort of thing.

COHEN: Like an instructor here?

KANAMORI: That's right. So then I went to Caltech. Actually, during my master's program, we had tested this seagoing gravity meter onboard ship, and I had crossed the Pacific to California from Japan. We came all the way across to test it. It took us two weeks. And around that time, Dr. [Keiiti] Aki was a postdoc here. He went to MIT later [1966], to become a professor [of geophysics]. So he actually showed me around Caltech.

COHEN: Ah, so you had seen Caltech already?

KANAMORI: Yes, but I was here only for two or three days. It was a short visit—only a half-day or something, in June of 1960. So I knew more or less what kind of place it was. I really found Caltech very exciting, so in 1965 I decided to come. In the beginning, my office was on campus here. At that time, the Seismo Lab [Seismological Laboratory] was about three miles from here, on San Rafael.

COHEN: Was your research fellowship with the Seismo Lab?

KANAMORI: No. I don't know, actually. I think my postdoc fellowship came from the [Geology] division. At that time those things were fairly flexible. I wasn't working with any particular professor or anything; I was pretty much independent. And Dr. Dix told me that I could do whatever I wanted to do.

COHEN: Which is the way you liked it.

KANAMORI: Yes. For about six months or so I was on campus, but later I spent most of the time—

COHEN: Up on San Rafael.

KANAMORI: Yes. And that was an exciting place.

COHEN: And who was head of the Seismo Lab?

KANAMORI: The interim director was Clarence Allen [1965-1967].

COHEN: Ah, OK. This was after Frank Press left.

KANAMORI: Frank Press [director of the Seismo Lab, 1957-1965] left in ’65, just before I came. Of course, I knew his name and I had read his papers—many of the papers he wrote at Columbia, before he came to Caltech, and many papers he wrote here. I really liked the style of his science. His style was very attractive to me, because he applied elegant mathematics to earth science problems. And also he built an instrument [the Press-Ewing seismograph], so he combined theory, observation, and interpretation. Everything worked very elegantly.

But around that time, Don Anderson, who had just got his PhD, was a young associate professor at the Seismo Lab. And a few other professors, who were also young, [were there], so it was a very exciting place. Also, there were some graduate students who were very active. The atmosphere there was very good. One interesting thing is that my main office, here on campus, was Frank Press’s old office. [Laughter] In fact, his name was still on the door while I was there. So when people came in, they were rather surprised to see me. [Laughter]

I did not have an office in [the] Seismo Lab, because my formal affiliation was on campus, so Don Anderson gave me a small desk in the corner of a big conference room. There were several students who had desks in there, so it was a nice place, where I could interact with people. And this conference room was used for seminars; many very famous, distinguished people came to visit. So I had a very good time there.

COHEN: A front row seat!

KANAMORI: That's right. And I could do whatever I was interested in. I didn't have to think about whether a project [would] lead to some important discovery or would be a big source of funding. I was just driven by my curiosity and my interests.

COHEN: Well, that's proper for a research fellow.

KANAMORI: And a lot of people there were working in that way, so I really liked the atmosphere. It was just unbelievably good.

COHEN: Now, did you have any problems with language, with your English?

KANAMORI: Of course I did. Language was always a very difficult problem, because, as I said, at my elementary school and junior high and middle school there were no teachers who could speak English fluently. And also, as you know, during World War II English was banned.

COHEN: I can imagine.

KANAMORI: Nothing. No newspaper, no signs, no radio, nothing. And by the time you graduated from elementary school or junior high you were twelve or fifteen years old, and if language isn't taught before that, it's very difficult to pick up. That was a problem, so I studied very hard during high school. But it was a bit too late, because you really need to be exposed to new languages at a young age. So it was difficult, of course, the first year I was here. Even now, it's difficult, but particularly when I came here in '65 it was very difficult.

COHEN: Were you married by this time?

KANAMORI: Oh, yes. I had married in '64.

COHEN: Did your wife come with you?

KANAMORI: Yes, yes. But she had much better English, because she lived in England with her family for three years after the war. Her father was working at the Japanese Embassy in London. So she graduated from an English junior high school.

COHEN: So she had a big head start.

KANAMORI: About two or three years, yes. And then she returned to Japan and finished at a university. But she had real training in the English language, so I don't think she had much difficulty with language here.

COHEN: And she could help you?

KANAMORI: Well, yes. But anyway, about '65 to '66—in a way, that was the most wonderful time that I've ever had. I went to an AGU [American Geophysical Union] meeting in April. I think Bob Sharp [chairman of the Geology Division, 1952-1968] suggested that maybe I should drive all the way to the East Coast and back so that I could see all the different parts of the country.

COHEN: One of your articles here says you traveled a lot.

KANAMORI: Yes, I traveled around. And this cross-country driving was really exciting, because I had never seen anything like that in my life. I spent four weeks going to the East Coast and back.
But overall, I was in the US only around thirteen months.

COHEN: Not a long time.

KANAMORI: No, but I enjoyed it very much.

COHEN: Now, did you have to go back to your position in Tokyo?

KANAMORI: Yes.

COHEN: Because you could probably have stayed here longer.

KANAMORI: That's right. I had to go back, but I didn't stay there for too long. [Laughter] Then Frank Press invited me to MIT, because he knew my work. When I was at Caltech as a postdoc, I didn't do too much, actually, because it was so exciting. I was just busy absorbing things; I didn't have time to really write. I mean, [in] one year it's kind of hard to complete something.

COHEN: This was a learning time for you.

KANAMORI: That's right.

COHEN: But Frank Press knew your work already, in Japan.

KANAMORI: In Japan, and also he may have heard [about] the work I was doing here. So he invited me to MIT as a visiting associate professor. I went there in '69.

COHEN: You took another leave?

KANAMORI: That's right.

COHEN: And that was all right with the people in Tokyo?

KANAMORI: Well, by then I was at a different institute. The University of Tokyo had a Department of Geophysics as well as an Earthquake Research Institute. I moved from the department to the institute in '66, immediately after I went back. I had an assistant professorship at the Earthquake Research Institute. And by that time, it was easier for us to go abroad, because they wanted to send people abroad so that they could get more experience. So I went to MIT and was there for about ten months. That was also exciting.

COHEN: But very different from Caltech?

KANAMORI: Very different. Everything was different, particularly the structure of the research institute. As I said, the Seismo Lab here was a wonderful place. I could talk to the people there very easily and freely—it was a relaxed atmosphere. But at the same time we did a lot of science. And also there were earthquakes here. I mean, you can see [evidence of them]. You can go out and look at faults and other things.

COHEN: The laboratory is all around you.

KANAMORI: That's right. But MIT is very different. Do you know the Green Building at MIT? It's a tall building. And once you have an office on one floor, it's very difficult to see people on other floors.

COHEN: I've talked to Don Anderson, and he says that the stairway at the Seismo Lab gave everybody a chance to see each other. And then we talked about how different it was from the Green Building—which I have seen also.

KANAMORI: So although I did enjoy MIT in a way—I could talk to Frank Press, and by that time Dr. Aki was there, too. He had moved from Japan to the US as a professor of seismology. A lot of people were there, but there wasn't much interaction, because of the building's structure.

COHEN: So after ten months, you went back to Tokyo?

KANAMORI: Yes, I went back to Tokyo. Caltech had offered me a job here, even before I went to MIT, but I decided not to come. I thought that in Japan I could do interesting things, because Japan is interesting in many ways, so I decided to stay there. I had to go back to Tokyo for two years, in any case, because of the visa. So Bob Sharp told me that I could come back in two years as a professor here, but I decided to stay in Japan for several reasons. I thought it was important to promote science in Japan.

COHEN: That was one reason. What were the other reasons?

KANAMORI: That's one reason. And in terms of seismic activity, I thought it was probably interesting in Japan. So it was a combined decision. And also, you know, my lack of English was still a problem. So I decided to stay in Japan. But then, what happened? I had a second offer from Caltech, but I still decided to stay in Japan.

COHEN: But you thought about it again?

KANAMORI: Yes. Then, around 1970, some strange things happened at the ERI [Earthquake Research Institute]. It started as some sort of labor dispute. And around that time there were a lot of radical ultraleftist groups in Japan. Destroying parts of the university, just like what happened in Berkeley in the 1960s.

COHEN: Well, this was part of a worldwide movement.

KANAMORI: Yes. But it happened a bit later in Japan. And the Earthquake Research Institute became the target of this activity. The students occupied the building, and I couldn't get into my office for almost two years. Actually, the whole thing lasted for almost five years, but I left in the middle. It started in '70, and in '72 it got so bad that I couldn't even get into the building, so I had to work outside. [Laughter] It was a pretty productive time. I stayed half-time at home; I could read papers and do other things. And also I was using the computer center at some other facility, because I couldn't get into the university.

COHEN: So all research stopped in Japan?

KANAMORI: Well, no. But at this particular institute—the University of Tokyo's Earthquake Research Institute—the whole building was occupied. So I set up a kind of office in my car, with a small computer. Around that time, we were using IBM punch cards. I had a small card-punching machine [laughter] and I worked. I would take the deck of cards to a computer center somewhere. So in a way I was working on the street [laughter] for two years.

COHEN: That's terrible! Your office was in your car!

KANAMORI: Yes, that's right. But there were some people who helped me. My secretary at the ERI—the strange thing was that only professors were shut out; secretaries could stay in the building. So she could get books and other materials for me. So I would bring them home and work there. It was kind of chaotic. But again—my wife used to tell me [laughter] that that was the most productive time—

COHEN: Well, nobody asked you to do anything.

KANAMORI: But still, I got tired of it toward the end.

COHEN: Oh, sure.

KANAMORI: Then Caltech called me again. This time I decided to come. This upheaval was not the whole reason; I had always been interested in coming to Caltech. But partly because of this problem at the ERI, I finally decided to move. That was in December of '72.

COHEN: And the government hadn't stepped in and tried to do anything?

KANAMORI: Well, it's a very strange thing. The government was concerned about it [what was going on at the ERI], but they couldn't take any real action. I could never understand that, actually.

COHEN: The government didn't feel they should do anything?

KANAMORI: No, nothing was done for almost five years.

COHEN: I'll bet you were not the only one that left. I'll bet other people left, too.

KANAMORI: A few others left, yes. This Earthquake Research Institute is a great institute. I think, in terms of the facility, it was very good. And also the support staff were very helpful—the secretaries and the libraries. It was a very good place to do research. That's one of the reasons why I had decided to stay there.

COHEN: Originally?

KANAMORI: Yes. But because of all these other things, I finally decided to come to Caltech—and partly because I had had such a wonderful experience in 1965-66. I'm still interested in the ERI, because in Japan seismology is very important. And it's even more important now, because now the cities are bigger than cities twenty years ago, and their infrastructure depends completely upon all sorts of sophisticated communication systems and so forth. So in a way, the threat of earthquakes is even bigger now. So it was important for Japan to develop a very good seismological program. Unfortunately, my judgment is that for the last twenty-some years it hasn't been very effectively done.

COHEN: Maybe they didn't have the right people there.

KANAMORI: Well, the leadership is missing, yes. Things are slowly improving, but it's not as good as—

COHEN: As it could be.

KANAMORI: Yes, as it could be.

COHEN: So in 1972 you came here to stay?

KANAMORI: That's right. In '72, it was permanent status.

COHEN: And they gave you a better office, maybe?

KANAMORI: Oh, yes, yes. Well, because I came to the Seismo Lab—

COHEN: Ah, so this time your appointment was with the Seismo Lab?

KANAMORI: That's right. And the Seismo Lab was a fairly small building, and it was incredibly crowded, and there was no empty space or office for me. It was a mansion, with a lot of offices

with adjoining bathrooms. And Don Anderson, who by that time was director [1967-1989] converted Dr. [Hugo] Benioff's bathroom into my office.

COHEN: [Laughter] Oh, dear.

KANAMORI: It was very nicely decorated.

COHEN: And it was a good-sized room, I would guess.

KANAMORI: Yes, it was a very nice room, and I was very happy with it.

COHEN: They took out the plumbing and put in a desk?

KANAMORI: There was no way to tell that it had been a bathroom. The only thing was [laughter] that in the first two months or so a lot of people rushed into my office. Without saying anything, they'd turn around. [Laughter] I used to wonder why those guys were rushing into my office.

COHEN: [Laughter] Well, that's very funny.

KANAMORI: But anyway, it was a very nice office. And I really liked that place.

COHEN: Don Anderson has told me about the coffee in the morning and the coffee in the afternoon—a lot of talking.

KANAMORI: Yes. It was a very important mechanism to promote interaction and develop new creative ideas into more substantial papers. To be honest, I think ten papers of mine probably originated from the conversation during coffee break. You have to follow up. I mean, we talk a lot, but if you don't follow up, it will disappear. So whenever we found it interesting, I sort of followed up, and a lot of those things worked out very well. That was certainly a unique thing about the Seismo Lab.

COHEN: Now, was Dr. Richter still there at this time?

KANAMORI: Yes.

COHEN: What did he contribute to this?

KANAMORI: I don't know exactly what his status was. Maybe he was emeritus [Professor Richter became emeritus in 1970—ed.]. I don't know. But he spent a fair amount of time in the measuring room there.

COHEN: Measuring?

KANAMORI: Yes. He was reading seismograms all day. And he occasionally came to a coffee break and gave us some interesting ideas and data, but I don't think he very actively participated in it. He liked to work all by himself. Very often he talked to himself. It was a bit scary, I found. [Laughter] But I think he was, from time to time, a part of this group. [Tape Ends]

Begin Tape 1, Side 2

COHEN: You were telling us about Dr. Richter.

KANAMORI: Well, I had some interaction with him after I came here, because, as I said—

COHEN: You already knew him from before.

KANAMORI: Yes. But when I was in Tokyo, as I said, I really didn't have much time to talk to him, because in Japan students don't talk to professors too much. So I didn't really have much opportunity to talk to him. But when I came here, there were a lot of occasions on which I talked to him. And he was very knowledgeable. But I think he was emeritus at that time, so he was more or less doing what he wanted to do.

COHEN: Just looking at his records, I guess.

KANAMORI: Yes, that's right. Yes, I think he liked to be left alone instead of being bothered by students and other people too much.

COHEN: So you don't think it was ever a desire of his to be head of the Seismo Lab?

KANAMORI: I don't think so. He liked to talk to the media and the public, but I don't think he liked to manage in the kind of—

COHEN: Be an administrator.

KANAMORI: Yes. And he sometimes forgot things. [Laughter]

COHEN: [Laughter] It sounds like you're being kind.

KANAMORI: When he was getting ready for some party or so, he forgot that he already had on a tie, so he put on a second tie on top of the one he was wearing. [Laughter]

COHEN: Do you mean that when he went to a party, he came in with two ties?

KANAMORI: That's what I was told. So he was absentminded in many ways. I don't think he would have enjoyed administrative responsibilities, but I don't know.

COHEN: I don't know, either. I asked Don Anderson about it, and he didn't know whether Richter had been asked or not asked. It's really strange. But I understand he was not too organized, as far as running something.

KANAMORI: Although he remembered things. Whatever he needed to remember, he had a computer memory for, but he didn't want to remember everything. [Laughter] And sometimes, if you're a director or in management, you need to remember what you don't necessarily want to remember. That's the difference.

COHEN: So you were over at the Seismo Lab on San Rafael.

KANAMORI: Up to ’74, and then we moved here [252 South Mudd]—the whole Seismo Lab.

COHEN: Right. Were you teaching at this time?

KANAMORI: Yes.

COHEN: Yes, everybody teaches.

KANAMORI: That was pretty difficult, because you had to come over to the campus for teaching, and we were up on San Rafael. That’s one of the reasons why they decided to move. For teaching and meetings and the computer center, we had to drive to the campus.

COHEN: So you got this nice new building here.

KANAMORI: Yes, this building was pretty good.

COHEN: And when did you become director of the Seismo Lab?

KANAMORI: That was in ’90.

COHEN: Oh, so we have many things to talk about before then. Tell us something about the work you were doing when you came here.

KANAMORI: Well, when I was in Japan in 1969-70, and also when I was at MIT, I decided to study the biggest earthquakes in the world. And the reason was that before that, the approach to determining the size of earthquakes was what we call somewhat empirical. “Empirical” means you just plot out the data and find some relationship and use that as the measure. And I thought that was a bit unsatisfactory. For one thing, in the 1960s the seismographic instruments became very good. There was a worldwide network of very advanced seismographs, so the quality of the data improved tremendously. And, secondly, computers became available—and, of course, theory improved. So I thought we could use much better method and theory to quantify our greatest earthquakes. And the [May 22] 1960 earthquake in Chile was the largest earthquake.

COHEN: But let me just ask you a question.

KANAMORI: Yes.

COHEN: Because we all know the Richter scale.

KANAMORI: Yes.

COHEN: This was an empirical scale, you are saying?

KANAMORI: In a way, yes. And also it was developed for Southern California to begin with. So it was a kind of useful scale, but there wasn't really much physics involved. Richter measured the amplitude of seismic waves on the record and plotted them out as a function of distance, and if the curves were higher, he'd say that the earthquakes were bigger. So it was a useful scale, but there wasn't really much in the way of basic physics or theory. And of course that was inevitable, because the quality of the records was not very good. And also, even if he had wanted to construct some theory, seismology had not developed well enough.

COHEN: So for what he had, it was good.

KANAMORI: Oh, yes, it was very important. And the reason I wanted to do more is—I have to go back and give you some history.

COHEN: Yes, that's good.

KANAMORI: Dr. Tsuboi, my professor [at the University of Tokyo], was a seismologist. He often told us that there is some limit to the size of the crustal block—that the crust behaves as a unit and you can't have a very big unit. So he said that in Japan there was a limit to the size of earthquakes. I think what he said was that the earthquake name always carries the name of the city or something. Because the size of the block of crust is limited. So earthquakes can't be too big and there was no earthquake called, say, "the Japan earthquake" or "the American earthquake." That's what he thought. And then, in 1960, this Chilean earthquake happened, and

Chile's a whole country. [Laughter] So suddenly it was much, much bigger than anything we had experienced in Japan. And in [March 27] 1964, the Alaskan earthquake happened, and that was the second-biggest earthquake in the century. And Alaska is a huge area, larger than Tokyo. So even if what Dr. Tsuboi told us was correct [about Japan], in some other places you could have much, much bigger earthquakes. However, instrumentally, if you looked up on the Richter scale's magnitude scale, the Chilean earthquake and many of the Japanese earthquakes were given about the same magnitude. Now, I thought this was unreasonable, because we know the Chilean earthquake and the Alaskan earthquake involved much, much larger areas. They extended over a thousand kilometers. In the case of the Japanese earthquakes it was only a hundred kilometers, but still they were all given the same magnitude. I felt something was wrong. And that was a beginning. The reason it was wrong was that we were using relatively short-period seismic waves and an empirical method. So with that kind of scale—the scale doesn't have very big numbers, it saturates or something—if the earthquake is bigger than some limit, all the earthquakes will be given the same magnitude, because the scale saturates, you see. So if you use this kind of saturated scale and you look at the map of earthquake activity worldwide, you don't get the right picture, since you are looking at things through a highly distorting window, in a way. You can't see the whole thing properly. I wanted to correct that. And beginning in '69 or '70, I started doing that sort of thing.

COHEN: You were looking for another way to measure earthquakes?

KANAMORI: A more quantitative [way], and one that would take advantage of a theory that became available, and new computational facilities. And I continued to do this work when I came here in '72. I worked on the Chilean earthquake, and I extended it to other events. I wanted to establish some new way of looking at really big earthquakes. And, of course, in doing that I needed to study the really large earthquakes one by one. There have been a lot of them since '72. Let's see. There was a big earthquake in Guatemala in [February] '76. The Tangshan earthquake in China was in [July] '76.

COHEN: Did you feel the need to go to these places to look at them physically, or you just had the records?

KANAMORI: No, I could do my work by looking at the records, because the records were very good. I did go to Guatemala to look at the fault and things. But my work was mostly on the basis of quantitative [records]. So then I wrote a paper in 1977 to establish what we call the quantification—basically, how to determine the size of the world's greatest earthquakes so that we can have the correct picture of seismic activity ["The energy release in great earthquakes." *J. Geophys. Res.* 82:2981-87, 1977; "Quantification of earthquakes." *Nature* 271:411-414, 1978]. Before that, the scale was inadequate—the inadequate magnitude—and everything was distorted.

COHEN: So now you're going to have to explain it to me, because when I hear about an earthquake they're still giving me the Richter scale.

KANAMORI: Yes. That name is OK. "Richter scale" is the name still given to a general way of quantifying, and certainly Richter started it. When we say "Richter scale," it means the numbers that seismologists give to the public, or to the media. It doesn't refer to some specific measure—it's a sort of concept, and that's OK.

COHEN: So you mean, when I'm getting this number—

KANAMORI: It's a way to measure.

COHEN: But it's not a scientific way, is that what you're telling me?

KANAMORI: Earthquakes are measured scientifically in a different way, but it's the same thing in a sense. The Richter scale is a number given by seismologists to the media or to the public to tell them how big the earthquake is. And lots of times I have been asked by media people exactly what the Richter scale means. It's not at all clear, actually. If you ask different people, the answer to that question will be different. But my definition of "Richter scale" is whatever the number [is that] professional seismologists give to the media or to the public. The way earthquakes are measured now is very different. [Laughter] But that's OK. Earthquake science is slightly different from other kinds of science, because we are dealing with the public and the media, and the exact scientific significance is difficult to get across. I mean, [the magnitude of an earthquake] is really determined in a very, very complicated way. But what is important is to

give people some idea of overall size and effect. In that sense, I think [the Richter scale] is perfectly OK.

COHEN: So tell me something about how you measure earthquakes scientifically now.

KANAMORI: Well, basically, to put it simply, people once used a twenty-second wave—a period of twenty seconds—very gradual shaking. But a twenty-second wave has a wavelength of about a hundred kilometers or so. However, as I said, the Chilean earthquake spread over a much, much bigger area. So if you use only a twenty-second wave, you can't measure such a big thing. Of course, the situation is a bit more complicated, and this is a simplified explanation. I decided to use much longer-period waves, like 100-second or 300-second waves. In that case, the wavelengths are 1,500 kilometers or so. So basically, in order to measure the overall size of big earthquakes, you need to use waves with wavelengths comparable to that.

COHEN: Comparable to the size of the earthquake?

KANAMORI: Yes, although it's somewhat more complicated. But to use that method, you need to have reasonably good theory and good instruments, and both became available around that time.

COHEN: And you worked on this theory also? This was also yours?

KANAMORI: Not really. The theory had been developed piece by piece. The name I mentioned: Dr. Aki?

COHEN: Yes?

KANAMORI: He contributed a great deal. He wrote a paper in 1966, I think ["Generation and propagation of G waves from the Niigata earthquake of June 16, 1964, Part 1." *Bull. Earthquake Res. Inst. Tokyo Univ.* 44:23-72, 1966]. It was a kind of beginning for this whole thing. But I used that paper to quantify the global picture.

COHEN: So this was your work for quite a long while?

KANAMORI: Of course, there were other things, but when I wrote the paper in ’77 I’d say that was the main part of my work, yes. Although I was interested in a lot of different things. One thing, which I continued to be interested in when I came here, was what we call tsunami earthquakes. A tsunami earthquake is different from a tsunamigenic earthquake. A tsunami earthquake is a kind of slow earthquake. If you look at earthquakes, they move very rapidly; the faulting happens very fast. But I found in 1972 that there were earthquakes which seemed to have happened very, very slowly, so that you didn’t feel the earth shaking very strongly. ["Mechanism of tsunami earthquakes." *Phys. Earth Planet. Int.* 6:346-359, 1972] But they still produced a very large amount of deformation. And if these events happened on the seafloor, it [would] generate big tsunamis. There was a very important event in 1896 in Japan. It’s said that people felt it as a very slow motion but didn’t pay much attention to it. And thirty minutes later, a huge water wave—a tsunami—came, and more than 20,000 people were killed. And in 1946 there was a magnitude 7.4 earthquake in the Aleutian Islands. And a 7.4 earthquake isn’t particularly large, but a big tsunami came to Hawaii. This tsunami was probably the largest in Hawaiian history for the last few thousand years or so, or maybe even for longer.

COHEN: That was in Hilo?

KANAMORI: In Hilo, yes.

COHEN: Yes, I saw that. I mean, not the tsunami—I saw the plaque. [Laughter]

KANAMORI: Oh, the plaque. There’s a plaque for the 1946 and 1960 tsunamis. And that 1946 tsunami was a kind of mystery. Why did this relatively slow motion produce big earthquakes? So I looked into that in ’72, just before I came here—when I was locked out of my building at the ERI, actually. [Laughter]

COHEN: In your own tsunami, OK.

KANAMORI: And I continued to look at that when I came here. So it's another aspect of quantification—a different class of earthquake, in which crustal deformation happens very slowly.

COHEN: Are these earthquakes very common?

KANAMORI: Well, actually there have been several. The most recent example was the 1992 Nicaragua earthquake, which I wrote a paper on [Kanamori, H., and M. Kikuchi, "The 1992 Nicaragua earthquake: A slow tsunami earthquake associated with subducted sediments." *Nature* 361:714-716, 1993. Also Kikuchi, M., and H. Kanamori, "Source characteristics of the 1992 Nicaragua earthquake inferred from teleseismic body waves." *Pure Appl. Geophys*. 144:441-453, Aug. 1995]. Of course, it was rather anomalous. However, in the last hundred years or so, there have been two really large tsunami earthquakes—in 1896 and 1946—and there have been five or ten medium-sized events like [the one in] Nicaragua in 1992. So they are relatively rare, but still frequent enough to cause tremendous damage.

COHEN: Now, do they take place also on the tectonic plates?

KANAMORI: Yes. Of course, they happen on the boundaries of the tectonic plates—what we call subduction boundaries, where one plate is going down. But you're probably asking whether those events can happen on a San Andreas type of boundary. Actually, a few years ago, there was an event in Northern California, near San Juan Bautista, which happened very slowly without producing the strong seismic shaking. So it was a similar kind of event, but I didn't study that one myself.

COHEN: That was the same thing, but on land, so there wasn't the accompanying water wave?

KANAMORI: That's right. In general, these earthquakes are called slow earthquakes, because the motion is slow. That's the sort of thing I was interested in, and now, I think, it's generally established that we do have these slow earthquakes which contribute to tsunami generation.

COHEN: Now, how about volcanoes? That didn't interest you?

KANAMORI: I was always interested in volcanoes, but I didn't do much work [on them] until the early 1980s. And that came about in a rather strange way. This was Mount Saint Helens, on May 18 of 1980. And of course that was a spectacular eruption. I hadn't done much work in volcanology, but after that I began looking at the seismograms generated by the eruption, for an entirely different purpose. Let's see, how shall I put it? Around that time, there was some interest among seismologists in detecting free oscillation of the earth, which involves contraction and expansion of the earth.

COHEN: Do you mean the whole earth?

KANAMORI: Yes. This was well known, and what we call normal mode. The period of this oscillation is about twenty minutes, and this was known, of course. However, we wanted to get some better data to understand the internal structure of the earth. And then this Mount Saint Helens eruption happened. Most earthquakes don't excite this oscillation very much, because most earthquakes are shear motion—a horizontal motion. To generate this kind of oscillation, some big explosion inside the earth [is needed]. The shearing motion doesn't produce it very efficiently. But if the source is expansion, or explosion, it can generate or excite this kind of oscillation more efficiently. We thought the Mount Saint Helens eruption was ideal, because it was expansion-explosion. That's what we thought. So I started looking at the seismograms after the eruption of Mount Saint Helens, and it turns out I didn't see the expansion-contraction-type oscillation. Instead what we saw was a kind of shear wave that could be generated most efficiently by sideways motion, the shear motion. So that was a big mystery, because we thought Mount Saint Helens was an eruption that would have excited this expansion-contraction-type mode. But instead what we found was the motion caused by shear motion, the horizontal motion.

COHEN: Like an ordinary earthquake?

KANAMORI: Well, actually slightly different, but still it must have involved a large horizontal motion. And that was a big mystery. So we brought it up at coffee break, and, again, the coffee

break helped.. All kinds of strange models were presented. [Laughter] And it turned out that this shear wave was really caused by a landslide associated with Mount Saint Helens.

COHEN: Yes, a whole piece of the mountain fell away.

KANAMORI: Yes, Mount Saint Helens was like this, and magma came up. But what happened was, [the landslide] was not really caused by the explosion itself. Because of the magmatic pressure, a top portion of Mount Saint Helens became unstable and slid off. Then that exposed the head of magma and triggered the eruption. So the eruption was, in a way, the secondary phenomenon. Sliding was the main process. And that's what we saw. And it took us a whole week to figure that out, because I never expected it. And this effect was observed all over the world. Around that time, of course, seismic instruments were very good and we could observe these waves at many stations in the world. So we analyzed this in great detail and came up with this model, which really explains it very well.

COHEN: So it was called a sliding earthquake?

KANAMORI: Yes. And this is very different from ordinary earthquakes. This was probably the first example in which large-scale sliding produced seismic waves which were observed all over the world.

COHEN: Do you get those waves with huge avalanches, like the ones in Switzerland this winter?

KANAMORI: You need to have a big mass, and Mount Saint Helens is rock, instead of snow. So in terms of the amount of mass, it's very much bigger than an avalanche in Switzerland. But of course, you know, anything can produce seismic waves—the question is whether they are observable with instruments. So that was the beginning of my exposure to volcanic eruption, in a way. The event happened in 1980, but I think we wrote that paper in '83 or '84, I guess [Kanamori, H., and J. W. Given, "Analysis of long-period seismic waves excited by the May 18, 1980, eruption of Mount St. Helens." *J. Geophys. Res.* 87:5422-5432, 1982; Kanamori, H., J. W. Given, and T. Lay, "Analysis of seismic body waves excited by the Mount St. Helens eruption of May 18, 1980." *J. Geophys. Res.* 89:1856-1866, 1984]. The reason we found it

interesting was—well, seismology is, of course, the study of earthquakes to begin with. However, as the instruments became very good, we could see a lot of other things by looking at the waves. So in a way seismology started out as the study of earthquakes, but with these instruments we could study not only earthquakes but also volcanic eruptions of this sort—or later, with Mount Pinatubo, atmospheric oscillation, actually. As we saw these things, we developed some theory to relate these kinds of processes to seismic waves. We could expand seismology a great deal to understand all kinds of processes occurring in the earth's interior. That's why seismology is so exciting.

COHEN: I think this is a good place to stop, Dr. Kanamori.

KANAMORI: OK. [Tape is turned off.]

COHEN: [Tape is turned on.] You wanted to say something. Another story. Go ahead.

KANAMORI: When Caltech offered me a job, I finally said yes, but I had one condition. I thought I'd probably do all right in teaching and research, but I told them that I was not a very good administrator. So I asked them how much administrative work would be involved with this professorship. I wrote this letter to Gene Shoemaker, who was chairman [of the division] at the time. And Gene told me that because of Caltech's structure, Caltech professors are not involved in many administrative things. So that's the reason I decided to come. [Laughter] I never thought I'd be involved in the administration of the Seismo Lab.

COHEN: Well, things evolve. [Tape is turned off.]

HIROO KANAMORI

SESSION 2

April 26, 1999

Begin Tape 2, Side 1

COHEN: I thought maybe we could talk a little bit about when you became director of the Seismo Lab [1990].

KANAMORI: OK.

COHEN: How was that decided? How did you accept this invitation?

KANAMORI: Well, of course, I had spent almost twenty-five years here, and I liked Caltech. Also, I really wanted to contribute to seismic hazard reduction in California using our scientific knowledge. And I thought the Seismological Laboratory was ideal for that, because we have good people, we have some structure, and we have a long history and tradition. However, when I was asked by our division chairman, David Stevenson, I really hesitated, because I knew that I wasn't very good at management and administration. I liked doing science and I liked teaching, but administration had not been part of my life.

COHEN: You had never done anything like this.

KANAMORI: That's right. But after having thought about it—well, I had been here long enough, and I thought it was going to be exciting to use seismology for seismic hazard reduction in Southern California. So I decided to try.

COHEN: Can I back up a little bit?

KANAMORI: Yes.

COHEN: When you say "seismic hazard reduction," do you mean building better buildings or having a better warning system?

KANAMORI: Well, that's part of it. But basically seismology has two aspects. One is the science aspect. We wanted to understand the physics of the process—how earthquakes happen and how the waves are generated—the physics involved. The other aspect of seismology is to use it for reducing seismic risk for the benefit of society. And this has been the case in Japan, because in Japan there have been quite a few damaging earthquakes, so they really wanted to reduce seismic risk. In the US, of course, there have been damaging earthquakes—San Francisco, Long Beach, San Fernando. But I think the earthquake problem hadn't been as serious as in Japan, partly because the population density is much lower here and people are more spread out. So even if we have a big earthquake the effect is less. But still, the important thing is that our society is changing. Cities are getting more complex, with very sophisticated communication systems, lifelines, airports, and all kinds of things that didn't exist, say, fifty years ago. And damage caused by an earthquake then was limited. It was a fairly simple society. But now, if an earthquake is [of] the same [magnitude as those earlier ones], the effect can be far more serious. And we wanted to use what we had learned in our seismological research to reduce the impact of earthquakes on our society. It's a very important issue. And of course there was some argument that Caltech is an academic institution and we shouldn't be too deeply involved in the operational aspect of this problem. Well, that's to some extent true. I think our main role is to produce good students and create some new fields. At the same time, unless we show that we can make good use of seismology, nothing is going to happen. So we really wanted to take the lead in using seismology to reduce the impact of seismic activity on human society. That's the sort of thing that motivated me to take this job.

COHEN: You felt you could make a contribution.

KANAMORI: Yes. And there were several other factors. In 1987, with the leadership of Dr. Anderson, we started a TERRAscope project, which was primarily funded by the Whittier Foundation. And that really changed the way we do seismology. The TERRAscope was a

digital instrument, a state-of-the-art instrument. With that kind of instrument, we could process data more rapidly and also produce higher-quality results.

COHEN: Who built and designed this instrument?

KANAMORI: Well, it's kind of a package of everything. The seismometer itself was built in Switzerland. And the data-processing unit was produced by a company in Massachusetts. So we didn't really do much development of the hardware ourselves. It was sort of more the development of the concept, so that we could put those available technologies together to make good use of the science of seismology for this kind of purpose. And in '88 and '89 the TERRAscope network expanded.

COHEN: And this TERRAscope network was part of the Seismo Lab?

KANAMORI: That's right. It was a joint project with the local USGS [United States Geological Survey] office in Pasadena. We talked to the scientists at USGS—in particular, Tom [Thomas Harrison] Heaton, who was in charge of the office. So I was talking to Tom Heaton around that time about real-time seismology. That's basically the feeding of real-time information about earthquakes to the outside world.

COHEN: Do you mean that the data comes in and you announce it immediately?

KANAMORI: That's right. There are several reasons for that. Of course, traditionally, when we talk about earthquake hazard mitigation, everyone thinks of earthquake prediction—the evacuation of towns, or houses, or whatever. And of course, that was an interesting scientific subject. But after some years of research, it became fairly clear that we could make some predictions, but there are so many elements in earthquake processes that that kind of prediction cannot be completely certain. We have to live with a fairly large amount of uncertainty in any prediction of seismic activity. So then the question is—it's really not quite a technical question—whether that kind of prediction is really beneficial to society. Maybe fifty years ago it would have been useful: if we saw some anomalous thing which we thought was a precursor to

an earthquake, we could tell people and then they could sleep outdoors for maybe two weeks or so. If nothing happened, they could come back and resume their life.

COHEN: That's what they do in China.

KANAMORI: In China. So even now, in some parts of the world, this kind of prediction can be useful. But in a highly industrialized society—like California or Japan—if the prediction is that uncertain, it's probably not going to be very useful, because it may cause panic, it may cause financial loss, and all kinds of things. So we thought the standard prediction mode alone wouldn't be very useful. There were a lot of people talking about prediction, but Tom Heaton and I thought that just taking that approach alone wouldn't be helpful, that we couldn't make a big difference. So we decided to include real-time seismology in seismic hazard reduction. And Caltech could take the lead, because we had this sophisticated digital seismic network, TERRAscope, and also Caltech had pretty good development support. In the 1950s, Bob Sharp, then the chairman of the division, had started a program called Earthquake Research Affiliates. This is a program to involve private companies in forming a group to donate some funds to us. We have field trips and seminars every year so that we can develop this kind of academia-industry relationship.

COHEN: This is education for the people who are contributing gifts?

KANAMORI: That's right.

COHEN: And then they feel they're part of it because they've given some money?

KANAMORI: That's right. So this program was there, although toward the end of the 1980s it wasn't very active. But when we thought about this real-time thing, we thought maybe we could reactivate this program by introducing this new concept—CUBE [Caltech-USGS Broadcast of Earthquakes]. Caltech already had this very good outreach structure, and we had the new instruments, the new seismological development, and I was talking to USGS. It was a good time to start this kind of program. So conceptually CUBE was a very rapid, reliable real-time seismic

information system. And we involved all of these companies. And basically, we send information. And we develop some software.

COHEN: So you took this original list of companies that had been involved?

KANAMORI: That's right. And also we expanded it tremendously, because this attracted—

COHEN: When you say "we," who else besides you did this?

KANAMORI: "We" means Caltech and the USGS. Sometimes the government and universities don't work very well [together], but we had built up this good working relationship for years between the USGS and Caltech. The USGS has its mission to use seismology for the public welfare, and of course they do research, too. But if we worked together, we could do this more effectively, and that's how this whole thing got started. So the TERRAscope and CUBE are different things, but they're very closely related, partly because at that time we had these good instruments and also a concern about the effect of big earthquakes on highly industrialized cities with a large concentration of population, infrastructure, and communications systems. It was an important time to get this kind of project started.

COHEN: Yes. Now, coming back to the USGS—of course, their place is right here next to Caltech, on Wilson.

KANAMORI: That's right.

COHEN: They wanted it that way, I would assume.

KANAMORI: That's right. This program was started in the 1970s, when the USGS decided to have a seismic network in Southern California. So there was a fairly complicated negotiation between the Caltech geology department and the US Geological Survey around that time. By the time I came [1972], this had already been started, so in a way, there was some structure already.

COHEN: Do you look at the people that the USGS hires? I mean, because you have to work with these people, do you have anything to say about this?

KANAMORI: Yes. In many cases, when they wanted to hire someone, one of us usually was involved in the search committee.

COHEN: Did it work the other way around? Probably not.

KANAMORI: No, not formally. Actually, our interaction has been quite informal. We didn't really want to make any complicated rules. We just talked to them every day, very closely, and this informal structure without any rules worked out very well. It's a unique set-up—the government and an academic institution working together without defining every detail. [Laughter]

COHEN: The best way.

KANAMORI: The best way, yes. So it was exciting, but still I was worried about taking on this administrative responsibility, because I wasn't very good at it. But, of course, Caltech is a good place, because any director needs a very good administrative assistant. And we have Cheryl Contopoulos. I don't know whether you know her or not. She has been the director's assistant; I can't remember exactly what the formal title is. She has been here at the Seismo Lab for some years. She knows all the details.

COHEN: So she worked with Don Anderson?

KANAMORI: That's right. She helped me a lot in terms of dealing with administrative things. And also the Caltech administration was very helpful. Dr. Tom Everhart [Caltech's president, 1987-1997] helped us a great deal.

COHEN: When you say that he helped a great deal, what does that mean?

KANAMORI: In terms of raising funds from outside. Because, you know, in order to develop this kind of concept, we needed help from the Caltech Development Office, and of course we needed help from the Caltech administration to do that. The division chairman then was Dave Stevenson, and he basically let us do whatever we wanted to do, so it worked out very well.

COHEN: So you never had any problems in raising money?

KANAMORI: It wasn't easy, but we worked very hard. In particular, after the 1992 Landers earthquake, even with the TERRAscope, the large portion of our network was still a very old analog network. It's still a main part of our operation. The TERRAscope was introduced more or less as a research tool. But for the operational portion, in '92 we were still relying—and do even now, actually—on the old-fashioned analog network.

COHEN: On the old sensors that you have up there?

KANAMORI: Yes. And in '92 they worked OK. It didn't really damage Caltech's reputation, but there were some limitations with the old instruments.

COHEN: It wasn't as good as it should be.

KANAMORI: That's right. So we made a presentation at a board of trustees meeting, and Dr. Everhart understood our need. He helped us to go for funding. We basically expanded this CUBE-type structure. We talked to telephone companies, we talked to utility companies, and we talked to transportation companies. We basically tried to get funding for an improved network. This effort resulted in TriNet, which was set up in 1997 with FEMA [Federal Emergency Management Agency] funding. We expanded the program to the state of California level. Before that, Caltech and the USGS were the main players in this project. But of course, an earthquake program means a California program, and it made far more sense for us to work with the state of California. So "TriNet" means three—three organizations; we basically expanded this joint project. The state program works slightly differently. It's what we call a strong-motion program, rather than standard seismology. They deploy some strong-motion instruments, which record very strong motion from nearby earthquakes. So they provide that kind of data—to

an engineering committee rather than to seismology. Their program was geared more toward engineering.

COHEN: So they weren't interested in research. They just wanted—

KANAMORI: Well, the state's contribution to seismology is through the University of California at Berkeley.

COHEN: Ah. I was going to ask you where they are located. Up near Berkeley—in the Bay Area?

KANAMORI: Oh, do you mean the state office?

COHEN: Yes.

KANAMORI: It's in Sacramento. The state of California provides funding to the University of California at Berkeley. And Berkeley has a seismic network, more or less similar to our network, in Northern California. So the state contribution is going to UC Berkeley. And UC Berkeley runs the seismological network. But the state itself—MG, the California Department of Mines and Geology—runs the strong-motion network. So TriNet is Caltech, the USGS, and the CDMG. It's a three-organization coordination of efforts. And in a way—technically, of course—that's better. Caltech is an academic institution, so it's not particularly suited for operational things. But the government's responsibility, of course, is to work in the real world, so it's best if we work together.

COHEN: So with the state coming in, you had a whole other set of people to deal with.

KANAMORI: That's right. The downside is that we had to have more meetings. [Laughter] But so far, TriNet is working very well. We now have many very good stations, and we're working together, so the information is going out more rapidly and more reliable information is coming in. So overall, I think it's working out well, but still we need to worry about the future: What do

we want to do? Because TriNet funding will end two and a half years from now; it's a five-year project. We have funding for five years, but after that—

COHEN: And the funding is from the state, or does everybody contribute?

KANAMORI: The biggest portion came from FEMA.

COHEN: But they usually respond after the fact, not before.

KANAMORI: Yes, that's right. So there was some question [about] whether TriNet was appropriate for this kind of support or not. But overall, I think, after Northridge [January 17, 1994] and after Kobe [January 17, 1995], everyone became aware of this kind of project. And of course, in Kobe—certainly after Kobe—everyone in Japan became very aware of the importance of this real-time information system, because the Japanese post-earthquake operation was not very effective. Information didn't get to the right organizations immediately after the earthquake, so the full-scale rescue operation didn't start until maybe a few hours or ten hours after the event. And in the case of a big earthquake, or in the case of any emergency, a rapid operation is so important. And of course the US government and FEMA became aware of the importance of this.

COHEN: Now, how much of your time did TriNet take?

KANAMORI: TriNet is such a big project that it involves a fairly large portion of the Seismo Lab. So in a way I became the principal investigator of the project because I was director of the Seismo Lab. We considered it a Seismo Lab project rather than just *my* project, because it involves so many people. Now I'm still PI of TriNet and Dr. [Donald V.] Helmberger has taken over my position as director of the Seismo Lab. I really wanted to go back to research after my second term.

COHEN: That's what I wanted to ask you. Did you do very much of your own research when you were lab director?

KANAMORI: Well, I managed to do some research. Of course, to be honest, I didn't mind spending time on running the Seismo Lab, but the psychological pressure was more an issue than time. A lot of the Seismo Lab staff members are very dedicated—they are very competent, conscientious people—but they are all supported through these TERRAscope and TriNet projects. And if, for some reason—

COHEN: Many staff members are largely on soft money?

KANAMORI: That's right. So if I failed to raise funding, it would be a disaster, and in many ways, because if something stops we can't restart it very easily. So every day I was worried about supporting the project.

COHEN: Supporting all these people. So psychologically that was difficult.

KANAMORI: That's right. What I was really worried about was failing to raise enough support for people. That's a very painful thing. During my tenure, things worked out all right. We didn't have anyone we wanted to fire. I mean, everyone is so good there. The morale was extremely high. We really didn't want to lose anyone. And fortunately I didn't have to. We could maintain our support.

COHEN: Well, if you couldn't maintain it in seismology in Southern California [laughter], I don't know where you could maintain it.

KANAMORI: [Laughter] Yes, but the competition was getting hard.

COHEN: There were other places doing these things?

KANAMORI: Yes. So in a way, that was the most difficult thing about being director. So at the end of my eighth year, I thought it was probably better for me to go back to my original responsibilities: teaching and research. Once you start some project, it [takes] five years or so to realize it. So if I were to continue, that would mean another five years, if I wanted to go in some

direction after the end of the eighth year, and that probably was not a very good idea, considering my age. And also [the] Seismo Lab needed some new direction.

COHEN: So you thought eight years was a good time to leave?

KANAMORI: Yes. But because of this strange transition, I'm still PI of TriNet. Of course, in TriNet we divide responsibilities among a lot of people. So in terms of demands on my time, it's not too much. But I'm involved in the research part of TriNet, so that's OK.

COHEN: Do you have regular formal meetings, at which everybody comes together?

KANAMORI: Yes, we have a steering committee for TriNet, [as well as] an advisory committee and working groups. There are all kinds of structures there.

COHEN: Was there ever any problem—I don't know how to ask this in a nice way—of the rest of the geology department feeling that the Seismo Lab was getting too much money at the expense of the rest of the department?

KANAMORI: I sometimes heard that. I don't know exactly how the allocation works. Of course, seismology is probably more visible, at least to the outside world, so everyone thinks that it's easier to get money for seismology, and the development people probably said so. So that was probably the case, but I didn't quite understand why, if seismology got money, the rest of the division wouldn't. I really don't think [that's the way it works]. If seismology gets wealthier, in a way, the division should also benefit. So we worked very hard [laughter] on the fund-raising for the Seismo Lab, and we were very successful.

COHEN: Now, are there a lot of demands on you to come and talk to many groups?

KANAMORI: Oh, yes. I spent a fairly large part of my time on that. We needed some grassroots kind of activity. We needed to talk to the public, talk to the utility companies, talk to some people in Washington, talk to the people abroad. A lot of people came over from Japan, particularly after Kobe, because they had become aware of the importance of the CUBE project.

We had almost a continuous flow of people after Kobe. And in a way it looked as if this was a waste of our time, though I don't think I thought about it that way; I just wanted to help them. So whenever they came we really made an effort to spend time [with them]. However, it so happened that it actually worked out well for us, too. They went back to Japan, and of course they talked about the CUBE project to their government, and there was a government-to-government meeting between FEMA and the Land Management Agency in Japan. So the FEMA people heard that the Japanese thought the CUBE project was very important in a Kobe-type situation.

COHEN: So you don't know what's going to turn out to be helpful.

KANAMORI: That's right. And we already had this structure, the Office of Earthquake Programs. It's a kind of outreach structure, initially under the Development Office, that helps only the Seismo Lab. Do you know Jill Andrews? She was working at the Corporate Relations Office, and she was very active and important in starting the CUBE project. She got interested in the project herself, so she worked very hard. She should get credit for that; she worked very hard. But unfortunately she left for the Southern California Earthquake Center at USC. And then we had Karen Luethky. She also worked very hard. Then she left. And now we have Jim Goltz.

COHEN: Now, these are the business administrators?

KANAMORI: They originally worked for the Development Office.

COHEN: Oh, Development.

KANAMORI: But now the Office of Earthquake Programs belongs to the Seismo Lab. Before, it belonged to the Development Office. And they helped us, but the staff structure didn't work very well. I thought it worked very well, but from the Development Office's point of view it was a strange structure, because it was part of Development but it was working only for the Seismo Lab, not for the entire Caltech campus. So now this earthquake office belongs to the Seismo Lab. Actually, it's only a one-manager-one-secretary office—a half-time secretary, even. But it helped a lot in dealing with visitors from foreign countries and others.

COHEN: Ah, so the foreign visitors didn't take all your time.

KANAMORI: Well, a lot of the time we talked to them directly, because we wanted to use seismology to address real problems. And as I said, modern cities are changing—they're really nothing like the cities of fifty years ago, when there were no high-rise buildings. When I came here to Caltech—in 1965, even—there were no high-rise buildings. I think the City Hall and the Hilton were the tallest buildings in the downtown area, but now you can't see them anymore. [Laughter]

COHEN: That's correct.

KANAMORI: So the city has changed. And obviously that means that the effect of any big earthquake can be much, much more serious. So seismologists have to take the lead in changing things.

COHEN: That brings up another question. How much do you have to do with the structural engineers and the engineering people? Because all those people are working on earthquakes, too, in some sense.

KANAMORI: Well, again, we need coordination. And this is another good thing about Caltech. Because Caltech is small enough, we can interact with people in [the Engineering Division] tremendously. I worked with Paul Jennings [professor of civil engineering and applied mathematics] many times, and we had some joint papers. And a lot of engineering students are taking, say, my course in seismology. So, for that reason I was at many of the exams over there. There has been a lot of interaction. So we don't work directly on buildings, but since we work with them, we know what they need.

COHEN: Did they have anything to do with CUBE or TERRAscope?

KANAMORI: Yes. This program I mentioned involves both the Seismo Lab and Engineering. So they are part of the CUBE project. Although the seismologists are in charge of the actual

operation of CUBE, in talking about potential membership and the direction we wanted to go, we involved the Engineering Division people.

COHEN: Of course, there are many people in that division devoted to earthquake research, too.

KANAMORI: That's right. In different areas of the earthquake program. We took advantage of that, certainly. The only problem is that everyone is getting so busy. So as you expand the scope of the project, you have to spend more time on coordination, which is not directly related to research. In a way, everyone is interested in doing research, so that's a potential problem.

I was quite lucky, because Don Anderson wanted to move in this direction in 1987, so his leadership was very important when we decided to go to this digital seismic network. The TERRAscope was started in '87 and developed in '88 and '89. Then, I took over in 1990. So in a way I was quite lucky, because I really got into it at the right time and the right place.

COHEN: And of course, it was of some benefit that you could speak Japanese to all these people from Kobe. [Laughter]

KANAMORI: That's right. I really wanted to do something before the next big earthquake, because we now know a lot of things. And we thought if you do this and this, it will help tremendously to reduce damage in the next earthquake, but unfortunately the government doesn't work that way. The government can't decide anything until it sees something. So in a way we're always one step behind, and I don't like that. [Laughter] I want to convince them that if they do this now, before the next earthquake—

COHEN: Well, what sort of thing can they do before the next earthquake? What are you speaking of?

KANAMORI: Well, like this real-time system. We had been saying all along, before Kobe, that during a big earthquake a lot of things can happen and you don't know what's going to happen next, so you need to have rapid information after the quake. But the Japanese government didn't pay enough attention to that. And then Kobe happened, and they became aware that real-time information is important.

COHEN: When you said that they didn't have information, [did you mean that] they didn't know where the damage was or in what direction the seismic waves were going?

KANAMORI: That's right. Where the shaking was strongest, for example. In the case of Kobe, for the first few hours the authorities didn't even know how extensive the damage was, because the communications system had been cut off. That's why real-time information is so important—because we have to deal with all kinds of situations, and many are not predictable, so we have to have correct information rapidly. If they had had a CUBE system in Japan before the Kobe earthquake, I think the results would have been very different.

COHEN: They could have saved more lives and known where to respond.

KANAMORI: Yes.

COHEN: Now, that's in place for us? I mean, if we have a big earthquake tomorrow, the system is in place?

KANAMORI: If the system works as we planned some five years ago, certainly it will be much better. However, I think there are still more things to do. For instance, we don't know much about the strength of ground motion during a really big earthquake, because we haven't experienced it yet. In the future, there may be even bigger earthquakes. And we know from the theory of seismology that to some extent we can make reasonable estimations of what's going to be the biggest ground motion in some particular area, but usually that information is not utilized until it happens.

COHEN: It seems to me that whenever there's a quake now, it's always on a fault that nobody knew about.

KANAMORI: That's right. So I think our knowledge is limited, but still we are gaining a lot of new insights and data. Unfortunately, it takes a long time before those new results are implemented in practice, but to some extent that's probably inevitable.

COHEN: Yes. So you gave up being head of the Seismo Lab in ’98.

KANAMORI: Yes.

COHEN: But you still continue to be very involved in these programs.

KANAMORI: Yes. I’m still involved in TriNet.

COHEN: So how has your life changed?

KANAMORI: Well, actually, nothing has changed very much. I was doing research even during my directorship. So I’m continuing to do research, and I’m teaching. That part hasn’t changed. But, as I said, the psychological pressure is gone. I really don’t have to worry so much about daily [things].

COHEN: You don’t worry about having to support all those people.

KANAMORI: No, because the management is in good hands now.

COHEN: How many people work on these projects?

KANAMORI: Oh, TriNet itself is fairly large—

COHEN: That are Caltech employees?

KANAMORI: Egill Hauksson is a senior research associate, in charge of the seismic network. So, in a way, he is the project manager. But in addition to him, Tom Heaton [professor of engineering seismology] and Rob [Robert Webster] Clayton [professor of geophysics] and myself are part of the TriNet group. So four of us from Caltech work on the TriNet project.

COHEN: I see. Now, do you have graduate students?

KANAMORI: Not directly; they use TriNet data, but they're not involved in the operational aspect of it.

In terms of the amount of time I was spending at Caltech, nothing has changed. I tried to shift from worrying about [administrative matters] every day to a more research-oriented thing. And I'm happy about it.

COHEN: [A few people have asked me] how you yourself would prepare for the next big earthquake. What do you do with your house? I think you've said that you have just a small house that's very simple, and that's the best way to live. Do you still feel that way?

KANAMORI: Yes. Well, there are other kinds of disasters, too—not necessarily just earthquake problems. Anything can happen. So if you don't have too much to lose, you are always happy; you have peace of mind. And what I really think is the most important is a good family. My children have had a good life, and they're well educated. And those things are very important. But material things I really don't worry about. Basic simplicity of life is—

COHEN: What's important.

KANAMORI: Yes. And my wife lives by the same principle. [Laughter] That helps.

COHEN: Yes, yes. That's very good. So now you are just a professor.

KANAMORI: That's right.

COHEN: You actually have a named chair [John E. and Hazel S. Smits Professor of Geophysics]. That's more than just a professor.

KANAMORI: That's right.

COHEN: So if we look back at many of these honors that you have gotten and these awards that I have written [down here], which of them—tell me about them a little bit. What was very important to you, in recognition of your work?

KANAMORI: Well, actually, to be honest, that's all a Caltech effect. Whatever I do at Caltech, people think that I'm good. [Laughter] These are all falling from the sky, simply because I work at Caltech. [Laughter]

COHEN: Well, not exactly.

KANAMORI: Of course it's nice to be recognized.

Begin Tape 2, Side 2

COHEN: Let me ask you a question you may not want to answer. I don't see the National Academy of Sciences, for an obvious reason—because you are not a citizen.

KANAMORI: That's right.

COHEN: Is there a reason why you don't—I mean, you obviously are not going back to live in Japan. Or maybe you'll retire in Japan, I don't know. How do you feel about that? That's a delicate question.

KANAMORI: Not really delicate, actually. I haven't done anything. [Laughter] I mean, to some extent I have been too busy to worry about citizenship.

COHEN: So it's not on principle?

KANAMORI: No, not at all. For example, both of my sons were born in Japan, so they were Japanese citizens. But they think that now that they live in the States, they should be American. So both of them became American.

COHEN: On their own, they became citizens.

KANAMORI: Yes, that's right. But I, partly because I have been too busy to worry about it, didn't do anything. One time I looked into it. [Laughter] It turned out that the paperwork can

be incredibly cumbersome. I don't know whether that's still true or not. You had to report all foreign trips and you had to tell them what port you came back to, whether Los Angeles or New York or San Francisco. You had to list all your trips, and it was impossible for me to remember those things. [Laughter] So [it was] partly because this paperwork scared me, actually, [and partly because] I just didn't have time to think about it. So there's nothing really very profound about it.

COHEN: You just didn't want to be bothered to fill out the pieces of paper?

KANAMORI: That's right. Well, I sort of feel guilty about not doing my duty as a US citizen—like not serving on a jury and not having a vote. At the same time, I haven't seen any difference [in how I live]. I mean, this is a very unusual country.

COHEN: Yes. You might talk about that a little bit, because I did read that in one of your citations.

KANAMORI: Yes. It's really amazing. Japan is very different. Even if you are granted citizenship there, you will still be regarded as someone from outside.

COHEN: It's a much more homogenous society.

KANAMORI: They will treat you very well, and they will be very polite to you, but somehow there is a difference. Sometimes it may be better, but still there is a difference. And here it's really unbelievable.

COHEN: It's a country of immigrants.

KANAMORI: Well, to some extent that's true. But [it's] just [that], basically, I have never been treated differently in that regard. So that's really quite surprising, and that's one of the greatest things about this country.

COHEN: That people are accepted for who they are?

KANAMORI: That's right.

COHEN: At least in the academic world that's certainly true.

KANAMORI: That's right. I don't know about other parts of the world.

COHEN: Well, as you get into less education, I think you find less ability to absorb differences.

KANAMORI: Well, one of my students here at Caltech, Bob Geller, actually took a professorship in Japan. He's now a professor there at the University of Tokyo. I think he's the second permanent foreign faculty member in Japan.

COHEN: In the whole university system?

KANAMORI: I think so. At least around the time when he was appointed—oh, about ten years ago. He studied Japanese, so he can speak fluent Japanese. But as far as I can see, he's still treated as a different person. So it's very, very different.

COHEN: How about your wife? Is your wife a citizen?

KANAMORI: It's more or less the same thing—no. She's also very busy. We haven't really done anything.

COHEN: OK. Because this does come up. I know the astronomy department has many people who are not citizens either.

KANAMORI: Oh, really?

COHEN: And I've heard some of them say, "Oh, well, it's sort of the last bit of "—you know, you've left your native land and maybe you feel a little bit guilty. So it's the last act of betrayal. I mean, I've actually heard this from people who are reluctant to become citizens or to leave their original citizenship.

KANAMORI: No. I don't have any—

COHEN: Any feeling like that. So you really think of yourself as an American person?

KANAMORI: Yes. I live here. But my sons certainly thought that they should be American citizens. So both of them went ahead themselves.

COHEN: Well, they never had to make so many trips abroad. [Laughter]

KANAMORI: [Laughter] That's right. That helps.

COHEN: What sort of future do you see for the Seismo Lab?

KANAMORI: Well, my feeling is that seismology is getting very important, because, as I said, the cities are changing—our life environment is changing very, very rapidly. We never had this big airport. We never had these complex freeways. We never relied on telephone lines this much. And a single big earthquake can disrupt everything. Again, people probably are not that aware of that problem, but a big earthquake can really wipe out everything. So in that sense seismology is getting very important. But you can't keep doing the same thing. The old-fashioned seismology is not going to be useful. We have to modernize it, and we have to integrate technology so that we can use science for the benefit of society.

COHEN: When you say "modernize," do you mean better detectors, better sensors?

KANAMORI: Communication, sensors, and also, the most important thing is how to relate the result to the end users. In Japan, actually, I have been talking to the head of Kajima Corporation. He's not quite the head; he's head of the Kajima Technical Research Institute. The Kajima Corporation is a big construction company in Tokyo, and they have a huge research institution. They are always looking ten or twenty years ahead. This particular person is Dr. Takuji Kobori; he is head of this institute. A lot of engineers here know him. He's a strong proponent of what he calls the "active control system," which has some capability to change the [structural characteristics] of a building. It senses ground motion and avoids resonance by changing the

building characteristics. In many cases, if the ground motion has a period that's the same as the building, the motion will affect the building more. So you want to avoid resonance, to reduce damage.

COHEN: Because it just adds?

KANAMORI: That's right. So this active control structure has a device that senses ground motion, and depending on the frequency content of the ground motion, it changes the property of the building so that the building goes out of resonance. If the ground motion has a period close to the resonance period of the building, the system shifts the period of the building away from it.

COHEN: And they can do this with some apparatus?

KANAMORI: Yes.

COHEN: I mean, it doesn't have to be huge?

KANAMORI: They have to build the building that way. So in terms of investment, it's more expensive. That's why I said that they are looking ten and twenty years downstream. They think this system is going to be very important. In the long term, it's cost effective. I was quite impressed with this philosophy. But to make it useful, it's very important to link seismology directly, because for a large structure they have to sense ground motion some distance away from the building and then before the wave gets there they have to change the building structure. That's why Dr. Kobori is very much interested in what we're doing. And I'm quite impressed with their insight. The next step is to change structures so that the impact of big motion will be reduced. That's a new direction.

COHEN: It sounds very expensive.

KANAMORI: Well, of course it is expensive, but if the building is destroyed [laughter] it's even more expensive. And in a way, it's a kind of dream to build a city that doesn't shake during an earthquake except [for the] seismometers, of course. [Laughter] Only the seismometers will

sense the ground motion, and they will control all other structures so the other structures don't shake. It's kind of a dream, but that's the active-control concept, linked directly to modern seismology. So at least in that sense, people wouldn't feel earthquakes. And earthquakes are really worrisome, because modern cities rely on so many things: telephone lines, computer networks, communication, transportation, airports, freeways, lifelines, water, electricity, gas—all kinds of things. And therefore they are very vulnerable to this kind of natural disaster. So we need to be prepared, and certainly we can move in that direction.

COHEN: And you feel that Caltech should be in the forefront of these efforts?

KANAMORI: We have been. Of course, there has always been some conflict between pure science and application. And it is true that there is some difference between disciplines. For example, in the case of theoretical physics, that's a very basic science. And in chemistry it's probably half and half—chemical engineering and chemistry. In the case of seismology, certainly half of seismology is [pure science], but still it has some application.

COHEN: And you think there's an obligation?

KANAMORI: That's right. Seismology has these two aspects. So even if Caltech is an academic institution, we need to show how we can make use of seismology. And once we can demonstrate something, then maybe someone else can take over. But I think some academic institution like Caltech should introduce new concepts into this application. Unless they do, nothing's going to happen. I always say that in some fields, like semiconductors, if you develop some innovation at an academic institution and it's good, industry will take over, even if you don't do anything. However, in the case of the earthquake problem, if we develop some concepts but don't do anything about them, industry won't pick them up, so we really have to do something here so that we can demonstrate that this is good for society. Beyond a certain point, of course, the university can't promote this, but at least we need to show what can be done; that's still a very important role for the academic institution.

COHEN: To lead the way in developing ideas?

KANAMORI: In some direction, yes.

COHEN: I see. So that is quite different from other disciplines.

KANAMORI: I think so, in this sense. This field is different because in a way it's disaster-directed. [Laughter] So in our field, application is part of the basic science. I mean, we are trying to develop some theory of how to use our basic understanding of the process for the benefit of society. And I have been quite happy that Caltech allowed me to go into that, with the help of the Development Office and the TriNet project. Certainly by any ordinary standards TriNet is bigger than all other projects that most earth science departments are involved in, because it has a fairly big application to society.

COHEN: Where is the headquarters?

KANAMORI: Here.

COHEN: OK. So that means the people have to come down here for your meetings?

KANAMORI: That's right. Although we sometimes go to Sacramento to meet.

COHEN: I see. I don't think that's very well known—TriNet.

KANAMORI: Well, compared with some really gigantic projects, it's not that big. It's only $20 million for five years. Also, we view this as a university program, so even if it has some operational aspect it's not entirely operational.

COHEN: OK. We always finish here: Are there any people that you think of immediately if I ask you the question, "Who has had a great influence on you?"?

KANAMORI: At Caltech, Don Anderson certainly. He made a tremendous difference. I didn't know him very well when I came here in 1965.

COHEN: You came because you just liked the whole atmosphere of the place.

KANAMORI: That's right. So in terms of my science, certainly he had tremendous influence. And also, in application of seismology for the real-time problem—

COHEN: Of course, he has told me that you have had a great influence on him.

KANAMORI: Oh. [Laughter]

COHEN: So I think we've got a symbiosis there.

KANAMORI: I think his vision and leadership have had a very strong influence. And for the last ten years, Tom Heaton—who was in charge of USGS when we pulled him into Caltech; he's now half-time engineering and half-time seismology here—and I worked very closely with him on this real-time aspect.

COHEN: Those were the people that really influenced you at Caltech?

KANAMORI: I think so.

COHEN: So you have only good things to say about Caltech?

KANAMORI: Well, Caltech is a pretty wonderful place, yes. The only thing that's bad [laughter] is that people are *too* good, so I feel some pressure. Because whichever way you look, there are bright people, so sometimes you feel a bit of pressure, actually.

COHEN: So it's been a good stay here?

KANAMORI: Oh, yes.

COHEN: And you are certainly not planning to go anywhere. Now, let's just back up a little bit. You've had some leaves—you've been away for a while. Have you spent any length of time anywhere else?

KANAMORI: No. Actually, I have never taken any sabbatical.

COHEN: You haven't taken any sabbatical?

KANAMORI: No, not at all. I have been kind of tied up with all my research here.

COHEN: With these long-term programs.

KANAMORI: Yes, that's right. And also, everyone visits here from all over the world. So in a way I have enough interaction with a lot of people. But still, if I could have, it would have been better if I had spent some time—

COHEN: Had gone away?

KANAMORI: Yes.

COHEN: And refreshed yourself a little bit?

KANAMORI: Yes, but I just didn't have a chance to do that.

COHEN: Well, maybe you will do that now.

KANAMORI: I don't have any plans right now. I'm still involved in TriNet, and I have some specific responsibilities.

COHEN: OK. I think we've covered almost everything. Is there anything you would like to add?

KANAMORI: The really good thing here, I think, is that we always have very strong intellectual stimulus. Not only from colleagues but also from students. Some students are [laughter] sort of frighteningly bright.

COHEN: Very good students.

KANAMORI: Yes. So we need to work really hard to keep them happy.

COHEN: And you would not want to see Caltech get bigger?

KANAMORI: I think one real benefit of Caltech is the smallness. I worked with Paul Jennings in Engineering. I worked with Brad [Bradford] Sturtevant in Aeronautics. It's very easy to work with people outside your own department here. And I worked with Andy [Andrew Perry] Ingersoll in Planetary Science—of course, that's part of our own division. I really think that small size is very important for an academic institution.

COHEN: So you've enjoyed your own division here?

KANAMORI: Oh, yes.

COHEN: It's like a family. I've heard people say that about Geology—that it's just like a family.

KANAMORI: It's a very nice place, with good people.

COHEN: OK. [Tape is turned off.]