



**WILLIAM H. PICKERING (II)**  
**(1910–2004)**

**INTERVIEWED BY**  
**SHIRLEY K. COHEN**

**April 22 and 29, 2003**

**ARCHIVES**  
**CALIFORNIA INSTITUTE OF TECHNOLOGY**  
**Pasadena, California**



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**Subject area**

Engineering, physics, administration, Jet Propulsion Laboratory, space flight

**Abstract**

This 2003 interview with William H. Pickering, in two sessions, contains his further recollections of the Jet Propulsion Laboratory's early involvement with the US Army and missile development, followed by JPL's transformation into a NASA laboratory with a focus on exploration of the solar system. The interview begins with an account of his return to the small town in New Zealand where he grew up, to attend dedication of a memorial to himself and Ernest Rutherford, who attended the same primary school; he is also honored at Christchurch and Auckland. Additional recollections of JPL's collaboration with Wernher von Braun; of the first flight of *Sputnik*; Caltech's early work in rocketry; development and production of the Corporal missile. Awarded the National Medal of Science in 1975. Trip to Japan in 1994 to receive the Japan Prize. Further discussion of his work establishing an applied research institute in Saudi Arabia in the late 1970s; his later relationship with it. Establishment of Pickering Research, a consulting business, after retiring as director of JPL in 1976; consulting for the Electrical Power Research Institute after Three-Mile Island incident in 1979; contract in 1980s to help mainland China set up computer systems for its satellite program. The interview concludes with an account of his recent involvement in the sawdust-pellet (alternative fuels) business.

## **Administrative information**

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### **Preferred citation**

Pickering, William H. (II). Interview by Shirley K. Cohen. Pasadena, California, April 22 and 29, 2003. Oral History Project, California Institute of Technology Archives. Retrieved [supply date of retrieval] from the World Wide Web: [http://resolver.caltech.edu/CaltechOH:OH\\_Pickering\\_2](http://resolver.caltech.edu/CaltechOH:OH_Pickering_2)

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**CALIFORNIA INSTITUTE OF TECHNOLOGY**

**ORAL HISTORY PROJECT**

**INTERVIEW WITH WILLIAM H. PICKERING (II)**

**BY SHIRLEY COHEN**

**PASADENA, CALIFORNIA**

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## TABLE OF CONTENTS

### INTERVIEW WITH WILLIAM H. PICKERING

#### *Session 1*

1-7

Recent trip to his native New Zealand to be honored by his old elementary school, which E. Rutherford also attended. Early history of the Jet Propulsion Laboratory's postwar work on the *Explorer* Earth-orbiting satellite. President Eisenhower's attitude toward rocketry work. Competition between the army and the Naval Research Laboratory. Work for the army on the intermediate-range ballistic missile (IRBM); collaboration with W. von Braun.

7-10

Launching of *Sputnik*, 1957. Establishment of NASA. JPL moves from missile work under contract to the army to satellite and space work under contract to NASA.

10-16

Earlier work on rockets for the army, particularly the Corporal. NASA awards JPL the deep space program for exploration of the solar system. As JPL director, he presides over changes in methods occasioned by switchover to satellite and spacecraft work. *Ranger*, *Surveyor*, Deep Space Network.

#### *Session 2*

17-20

Awarded National Medal of Science at White House ceremony, 1975. Awarded Japan Prize, 1994; his trip to Japan to receive it.

21-28

Becomes an advisor to the University of Petroleum and Minerals in Dhahran, Saudi Arabia. Cultural conditions in Saudi Arabia, and his experiences there.

28-33

Sets up Pickering Research, consulting firm. Works as a consultant on safety issues in nuclear power plants; Three Mile Island. Works on Landsat photography of the Earth and consults with Chinese on their comparable program. Participates in manufacture of sawdust pellets as an alternative source of fuel.

**CALIFORNIA INSTITUTE OF TECHNOLOGY**  
**ORAL HISTORY PROJECT**

**Interview with William H. Pickering**  
**Pasadena, California**

**By Shirley Cohen**

Session 1                      April 22, 2003

Session 2                      April 29, 2003

**Begin Tape 1, Side 1**

COHEN: Welcome to the Archives here at Caltech. Why don't we start with your more recent stuff, and then we'll get back to JPL [Jet Propulsion Laboratory]. It looks like you were much honored in New Zealand this year.

PICKERING: Indeed. I was in New Zealand for a couple of weeks in March. In fact, we got back on March 23<sup>rd</sup>, just a month ago. The reason for the trip down there was that I *was* being honored. First of all, I was brought up in a very small town there—about 200 to 300 people—and brought up by my grandparents. I went to primary school in a little two-room schoolhouse. It turns out that a man by the name of Ernest Rutherford, who is a very well-known atomic physicist, also went to that same school. He was probably twenty or thirty years before my time; in fact, he got a Nobel Prize in the early 1900s.

COHEN: He did his work in England, though—right?

PICKERING: Yes, he did his work in England, but he attended this little two-room school. And so the little village decided that if Rutherford and I both went through that little school, they should have something in the town to recognize this fact. So they decided to make a memorial to honor both Rutherford and myself. And this has been built—it's right in the middle of town, and I think it's quite attractive. They wanted me to come over and cut the ribbon, as it were.

COHEN: For both of you.

PICKERING: For both of us, yes, and I did that. So that was the first motivation for going over there this year. And the second one was that I had spent a year at the University of Canterbury [then Canterbury College], before I came over here to Caltech, and the university decided they'd like to give me an honorary degree. So we had a little graduation ceremony down there in town. I was the only graduate, of course. [Laughter] That went over nicely—it was in Christchurch. And then on the way home we stopped in Auckland, and there a local high school—Westlake High School—had decided to name their science building after me. They did this maybe about a year ago, but when they heard I was in town, they wanted me to come over and have a look at the building, and I did. So I had three stops—one in Havelock for the memorial, one in Christchurch for the degree, and one up in Auckland to look at the building.

COHEN: It sounds like a nice trip.

PICKERING: It was a nice trip. But we didn't do any sightseeing [laughter], although we did do a lot of meeting with relatives, because of course I was on the local TV and radio, and anybody who considered himself to belong to the family turned up at one or another of these affairs. So I saw a lot of people who said they were my relatives, whom I'd never seen before.

There was one other thing that was kind of fun, down in Christchurch. We had a couple of days down there, where we were relaxing. On one of these days, they asked me if I would like to be on a TV program at a local TV station. They had a cooking program. And I said, "Cooking! What do you mean?" And they said, "Well, there's a man who runs this program who likes to have guests, and he invites the guests to partake in the meal."

COHEN: Does he cook?

PICKERING: No, he doesn't cook, he's got a chef, but he runs the program—a rather unusual way of handling the emceeing of a program. But anyway, so I did that, and it was sort of amusing. First of all, I did get a very nice lunch out of it. [Laughter] And he was amusing—at least some of the time. This was the first and only time I've ever been on a cooking program. [Laughter]

COHEN: Could you get a copy of it?

PICKERING: Yes, I have a copy of it.

COHEN: You say somebody is writing a biography of you?

PICKERING: Yes, a man by the name of Douglas Mudgway. He's an ex-JPLer and also an ex-New Zealander. He has written a couple of technical books about work at JPL, and he decided he'd like to try and do a biography of me. So I suspect he'll be down here [in the Archives] to talk to you about this. He moved up to Sonoma County somewhere.

COHEN: When did he start doing this?

PICKERING: Just a few months ago. So we're just starting. See, [when] I was down in New Zealand just the past month, he came down, too. I was getting various honors, and he wanted to get in on it, so he went down there, too.

COHEN: Of course, you have been well recognized for the work you did at JPL. So let me get back to some of this. I've read your oral history [1978], which is really wonderful. Along the line, there were big decisions that were made that established how JPL was going to go. It would be interesting to hear a little bit about how some of these decisions were made. I know it was a long time ago, but I'm sure you do remember. The first one I'm thinking of was *Explorer*. Now, when you did *Explorer*, was JPL still working with the army?

PICKERING: With the army. NASA had not been formed yet; we were working for the army. The history goes—I think it was in 1955 that [President Dwight David] Eisenhower announced that as part of the International Geophysical Year [IGY] activities, the US would launch a small scientific satellite, and the Russians said, "Me, too," very shortly afterwards. So we had a couple of years to develop it. Now, Eisenhower also said that he did not want to get mixed up with the development of the intercontinental [ballistic] missile or any other big military rocket program.

So he wanted [the scientific satellite] kept out of the military's hands, and the Naval Research Lab [NRL] in Washington, DC, was chosen. The reason for choosing them was that they had been doing quite a lot of upper-atmosphere research using rockets. See, back before the days of satellites, we used to send rockets vertically upwards, and they would make measurements at high altitudes, and then they would fall down again, of course. So you could get only a few minutes of measurement. The NRL had done quite a lot of work in the upper-atmosphere research, so it was a fairly logical choice.

On the other hand, there were those of us on the fringes of this who felt, "Gee, you asked me to develop the whole thing—brand new rockets and all the rest of it—and here we could use some of the stuff we have on hand and get through this a lot easier." At the lab [JPL], there were several people who said, "We ought to be in on this." Actually, the development of [the *Explorer*] program was under a committee [the Ad Hoc Advisory Group on Special Capabilities] chaired by Homer Joe Stewart.

COHEN: And people from different institutions were members of this committee?

PICKERING: Yes. So they were watching the development of [the satellite program], and as time went on, we felt that the NRL was having troubles. It was a bigger problem than the NRL thought it was, and we really ought to be in on it.

COHEN: Now when you say "we," who do you mean?

PICKERING: I mean the army. Actually, there were a few meetings in Washington where the army made a presentation to Stewart's committee—basically saying that if you get in trouble, this is what you can do. I remember being at one of those meetings when a navy admiral—who I guess probably had responsibility for NRL—stood up and said, "I don't believe a word of it," and stomped out. [Laughter]

COHEN: Meaning...?

PICKERING: The idea that the army could end-run the navy, as it were.

COHEN: Oh, I see. This was a matter of pecking order.

PICKERING: Yes, army versus navy, you see. Here was a bunch of characters from the army who were telling him they knew his business better than he did, so he just said flat out, “It’s a bunch of lies; I don’t believe it,” when we told him we could do it. As a matter of fact, we—myself and one or two others—went around to the secretary of the army and said we thought this called for an official apology on the part of the navy. [Laughter] And by golly, they did. They got the admiral to come in and apologize.

COHEN: And they also gave you the program.

PICKERING: Well, not yet. At that time, the large long-range rocket work was divided between the army and the air force. The army felt it should have been theirs entirely. In fact, General [John B.] Medaris, who was running the army program out of Huntsville, Alabama, being an old artillery man, said, “Look, this business of delivering a payload across the other side of the ocean, this is just an artillery job, and we’re the artillery, and we know how to do this. Of course, I’ll admit that the airplane was rather useful in World War II, but it was just an interim solution. The real solution is the artillery.” [Laughter] He was talking like this, and he was told to shut up.

Anyway, they did end up by assigning the army what they called the IRBM, instead of the ICBM. The IC was the intercontinental ballistic missile and the IR was the intermediate-range ballistic missile—which was a 2,000-mile range rocket. So the army facility at Huntsville was assigned that responsibility, and that included [Wernher] von Braun and his people, who had been brought over here after World War II and eventually ended up at Huntsville.

Von Braun was very sensitive to the fact that one of the real technical problems you’ve got to solve is that if you’ve got a high-speed rocket coming back into the atmosphere, the friction of the atmosphere makes everything very hot. And he lost a lot of V-2s, which blew up because they had some residual fuel in them and the heat from reentry blew them up. So when he was faced with the problem of a 2,000-mile missile—as against a 200-mile missile—it’s going to be a lot worse. The question of how you solve this reentry problem bothered him quite

a bit, so he came to us at JPL. In fact, General Medaris came to us at the lab and said that he would like to have JPL work with von Braun's people on this whole problem. Medaris basically put his hands on the table and said, "OK, this is what I want you guys to do." And I looked at him and I said, "We're a contractor. We're not going to do that." [Laughter] I kind of surprised him. I said, "Look, we'll work with you, but it will be on our terms. You're not going to dictate to us what we're going to do."

When von Braun came up with this reentry problem, we said, "OK, we'll help you with that. What we'll help you with is that we will build some solid-propellant rockets to put on top of your Redstone rocket and shoot it up to higher speeds so that you can get the equivalent of the 2,000-mile rocket. And you build your reentry whatever-you-want, and we'll put some radio on it to communicate with it and find out what happens, and we'll do the experiment for you."

This was what we did. We had about a half a dozen of these reentry test vehicles, as we called them, shooting out into the middle of the Atlantic Ocean. But with the reentry test vehicle, we had two problems. One was to build the solid-propellant rockets to go on top of the Redstone and the second was to build a communications system to get the data back. We did both of those things. The design we came up with used a rocket we had developed as part of the development for the Sergeant missile, which we were working on for the army. It was a six-inch-diameter rocket about *yay* long [showing the length].

COHEN: Five feet?

PICKERING: Yes. Actually, what we had was a ring of eleven of these rockets in a circle. They were fired together and constituted, as it were, the second stage after the Redstone. Inside that ring was a ring of three rockets, which then were the final ones to deliver the payload. The payload was mounted really on essentially an empty third-stage rocket; we used the same structure because it was convenient; we just didn't have propellant in it. And the engineers, of course, very quickly said, "Look, if we want to go into orbit, all we have to do is make that third stage a live stage, and then we can kick something into orbit."

COHEN: So you were already thinking about that.

PICKERING: Yes, we were thinking about that. And it was General Medaris who said to us once, “I don’t want to hear by accident that you guys happened to put in a live third stage.” [Laughter] Because he had gotten very definite orders that he was to stay out of the satellite business.

COHEN: Who was in the satellite business at that time?

PICKERING: Just the navy.

COHEN: So this was still an army-navy competition.

PICKERING: Yes. All right. So then it goes along until the Soviets launch their *Sputnik* [October 4, 1957].... After that, of course, my people got more anxious about putting up a satellite, because they said, “Look, the *Vanguard* satellite”—the navy one—“is having troubles, and we ought to have a crack at it.”

Well, nothing happened until the second *Sputnik*, which was a month later, in November. When that was sent up, then the army was asked, “OK, what can you guys do?” And Medaris told them—we told him what to say—Medaris said, “We can do it in ninety days.” And we got the go-ahead....

COHEN: And you did launch *Explorer I* successfully [January 31, 1958], and that was a big success.

PICKERING: Yes. And of course the other thing I think was interesting was that this is the 1<sup>st</sup> of February, essentially, and by the 1<sup>st</sup> of June the Congress had passed the act that set up NASA. If you think about Congress doing something as complicated as setting up a new agency between February and June, that’s pretty good. By October, NASA was in business, and by December 1958 we [JPL] were part of NASA.

COHEN: Did you personally—or did [Caltech president Lee A.] DuBridge—think it was good for you to go from the army to NASA? How did that happen?



**Fig. 1.** Shortly after its successful flight in February 1958, Lee DuBridge, Vice-President Richard Nixon and William Pickering proudly display a replica of Explorer 1. Courtesy of JPL.

PICKERING: Oh, we were delighted about the whole development, because there was a feeling here at Caltech that it wasn't really appropriate for us to be working on a classified project up there at JPL....From our point of view, we were very happy to welcome NASA, or to join NASA, pretty much on their terms.

COHEN: Now, why was it that NASA was happy to let you stay an independent contractor, while places like Goddard and Ames and others were government laboratories.

PICKERING: Yes, I know. But on the other hand, Los Alamos, for example, is run by the University of California. So the fact that Caltech was running JPL—the precedent had been set for that.

They also wanted von Braun's people in, too, and the army cried on their shoulder about that—the army didn't want to lose all of their rocket capability. But eventually, of course, the Huntsville group became part of NASA as well.

COHEN: And you also kept JPL from turning into a civil service organization.

PICKERING: That's right.

COHEN: That's a lot of maneuvering.

PICKERING: Well, as a matter of fact, it caused some problems in NASA, because if you look at the laboratory structure of NASA, it was primarily the old NACA—the National Advisory Committee for Aeronautics—which owned a bunch of labs around the country and was transferred *in toto* into NASA. And then NASA set up Goddard, and eventually Houston [the Johnson Space Center]. As far as NASA was concerned, those were all civil service labs, and they didn't realize that they had to treat us differently from the civil service people. That caused some tension between JPL and NASA.

COHEN: Differently in the sense that they could not tell you who to hire or make you put them through their security system? I mean, what was different about it?

PICKERING: Well, the civil service system required—or at least expected—tighter control from Washington. And we didn't. [Laughter] We wanted to do things our way. In fact, one of my big arguments with the NASA management in the early days was that they wanted to put a number maximum on the lab—that we couldn't have more than 2,000 people, or whatever it was. And I said, "Look, you give us a job and we agree to do it, and we agree on costs and so forth, and the hiring of people is my problem—not yours." But since in the civil service situation they are very tightly controlled on numbers, they wanted to do the same thing with us.

COHEN: And you did win. But, you know, they were footing the bill.

PICKERING: That's right. One other thing that we argued about was that we said we would select the projects we'd work on and then tell NASA what it was going to cost. And they said, "Oh, no! We will tell *you* what to do." We argued about that quite a lot. And the way the contract is now written, NASA did win on that.

COHEN: So they determine the projects?

PICKERING: They determine the projects. But there's some sort of a mutuality clause in there. I don't know what the wording of the contract is now—see, the contract gets rewritten every few years....

COHEN: Now, I have a point here about [the] Corporal [missile].

PICKERING: Corporal. Yes, we made actually two missile developments. The history of that goes something like this. The initial graduate student project was to learn about rocket motors. And they learned how to make a rocket motor—both solid-propellant and liquid-propellant motors. They learned how to keep them from blowing up unexpectedly. And the initial application of these was the JATO—Jet-Assisted Take-Off aircraft. This was because in the late thirties, early forties, the army was very conscious of the fact that they had to work from airfields that were too short for what they would like to have had, and therefore they needed something to get an airplane up in the air quickly. And the idea of putting a rocket under there and giving it a push was the solution. This was demonstrated for the army out at March Field, and then demonstrated for the navy up at Edwards [Air Force Base]. And both the army and the navy were delighted with the idea of getting this extra push, and they wanted lots of rockets.

At that time, [Theodore] von Kármán said, “OK, we don't want to do this. We don't want to go into production of rockets.” So they set up the Aerojet Corporation—von Kármán and a few others. I wasn't involved in that—unfortunately, because I think a lot of them made a lot of money out of that. [Laughter]

COHEN: So they went instead to Aerojet to build those rockets.

PICKERING: That's right. Now, what happened at the lab was that after this first research effort to make a good rocket motor, the army then came to us and said, “Look, the Germans have this V-2 contraption, and we really ought to be doing some research to try to understand how those things work. So what about it?” So we said, “OK, we'd like to do that.” So we started out on a

research program to learn how to build stuff that would fly—also guidance systems and communications and all the rest of it. We started that in about 1944 or '45, toward the end of the war. Incidentally, one of the interesting things, which we had nothing to do with, was the fact that as the postwar thinking was developing, Vannevar Bush—who had been running the science program for the military during the war—stated that in order to develop a system to deliver an atomic bomb across the ocean, a rocket is not the way to go, because a rocket would have to be too big and you can't build one that big. Certainly you can't guide it accurately enough. Therefore, the way to go is to have an unmanned airplane do it. And the US started on a program they called the Navajo program, which was to develop an unmanned aircraft for this purpose. And it wasn't until about the early 1950s that the US discovered that the Russians were happily working on big rockets. See, both the Russians and ourselves had grabbed a bunch of the Germans. [Laughter] The Germans they took into Russia, the Russians had them working right away on improving the V-2 and making bigger ones, and the word got out that that's what they were doing. So in this country we did a quick turnaround, because by then we'd learned more about rockets and guidance and we realized that we *could* do it. So the country then did embark on what was essentially a fresh program, making ICBMs.

COHEN: But not at JPL.

PICKERING: No, we had nothing to do with that. Our objective was to build something not too different from the V-2, something definitely more accurate. We started out on a research program, trying to learn about the problems. And after a few years the army came to us and said, "Hey, we like what you're doing. We'd like you to make it into a production device." And they picked two firms for us to work with—Firestone, the tire company, and Gilfillan, an electronics company down here—and put the Corporal into production. We said, "Well, this is the research program and it's not really designed to go into production." They said, "Well, that's all right; do it anyway." So we did.

COHEN: So you did the production part of it.

PICKERING: Well, the two big companies did the actual production, but it was our responsibility. We told them what to do, and they did it. The result was that—although, let's see, I don't know how many of the Corporals were manufactured, maybe on the order of 100 or so. And the army did learn how to fire them. I remember that it happened that as a tourist in Italy I was sitting in a bus, and the bus had to wait at a road intersection while the Corporal battalion went across the road. [Laughter] So we waited and waited and waited for that long group of vehicles and people and so forth.

From the military point of view, [the Corporal] wasn't really a success. And the army realized this, because even before they—

COHEN: But let me go back. How did you get the name "Corporal" for this thing?

PICKERING: Oh, yes. When we started out, we said first of all we'd do the Private, then we'd do the Corporal, and then we'd do the Sergeant, and maybe get up to the General. [Laughter] The Private was a little solid-propellant contraption that didn't have any guidance or anything on it and went about ten miles. In fact, we had the WAC Corporal, too—Woman's Army Corps.

COHEN: WAC Corporal? How was it different from the other?

PICKERING: Well, it was a little one. [Laughter] It was smaller. It was just designed to go straight up in the air.

COHEN: I'm getting to the point where you're out of the army. What made you decide to leave the rockets and go to the planets?

PICKERING: Well, wait a minute. Let me continue on with the rockets. Actually putting the Corporal into production and seeing some of them get built and seeing the army trying to shoot them, the army decided that they would want an improved version of the thing. Possibly the same thing, but "Let's have a good one!" They put out a request for a proposal. So at the lab we said, "Hey, we're not industry, but we could propose on this, too." So we did, and we got the contract. We beat out General Electric, who was our biggest competitor. This time we said,

“OK, let’s make something that is really a good, usable weapon.” And that was obviously the Sergeant.

So at the time the satellite business began—that would be about 1955, ’56—we were still working on the Sergeant. When NASA came in, I said, “Well, I think we ought to finish what we’re doing on Sergeant, then phase out as quickly as we can, but not have a sudden cut-off.” And the army and NASA, everybody agreed, and so that’s what we did. So for a year or two, we still had a little bit of Sergeant work, but there wasn’t much left.

COHEN: Was this because you saw there was more future in satellites?

PICKERING: Well, it was because we wanted to get out of the classified stuff and into the unclassified. The Sergeant basically was the last thing we did for the army.

Then we went off on a program for NASA....I didn’t want to get into the manned program. I said, “That’s too big and expensive, and it’s not appropriate for JPL.” Or for Caltech. And likewise the near-Earth satellite program. That was all right, but not as much fun as the deep space. So they gave us the deep space program.

COHEN: Sometimes you wonder how decisions are made, and sometimes it’s just as simple as that. And DuBridge, of course, must have agreed with you, up and down the line.

PICKERING: Yes, indeed.

COHEN: Did you do a lot of discussing of this with DuBridge?

PICKERING: Quite a bit.

COHEN: So it was the two of you together, you put your heads together and made the decisions.

PICKERING: That’s right.

COHEN: As simple as that! [Laughter] No board of directors.

PICKERING: That's right. I had the best possible contract—to go out and explore the solar system. That was a very nice contract to have. Well, we started out by sending some stuff to the moon—the *Ranger* program and the *Surveyor* program. And then to Venus, and then to Mars, and so forth.

COHEN: What was your relationship with some of these other NASA labs, like Goddard and Ames? Did you have much to do with them?

PICKERING: Not too much. Goddard took on the near-Earth satellites. One of the interesting things, of course, is what you do about the science in all of this. When we first started this, I think I said it, but certainly people at the lab said it: “Look, we’ll decide who the scientists are going to be and what experiments we’re going to fly.” And NASA said, “No.” And after a while, I realized that they were right—that this was a national program, and NASA, representing the federal government, would clearly make the choice of what experiments were going to be carried. It was up to us to figure out how to get them to fit into the spacecraft.

Now, in the case of Goddard, Goddard did more scientific experiments than we did, I guess, because these small satellites in Earth orbit—there were quite a lot of them and each one of them carried several experiments. So Goddard was closer to the science, I think, than we were.

### **Begin Tape 1, Side 2**

COHEN: And Ames?

PICKERING: Well, Ames was one of the old NACA labs. The NACA was a very successful organization. They did basic research, underlying the whole development of aircraft in this country—or in the world, really. The NACA had some very good people. They had an office in Washington that was staffed by PhDs, who were thoroughly familiar with the research programs and worked closely with the people in the research programs. NASA pointed out to me that when I had gone to Washington I had talked to some colonel at the Pentagon [laughter] who didn't know beans about what I was talking about. And furthermore, they knew darn well that

we were basically setting our own program; the colonels were just asking us how much money we wanted. [Laughter]

COHEN: OK. And of course the Deep Space Network [DSN]—very successful.

PICKERING: Very successful. Yes, that was something I was very interested in, because when I was in the electrical engineering department here, my interest was not in power engineering, which was Royal Sorensen's specialty. Sorensen was running the department then. My interest had gotten into the electronics field. In fact, I used to have arguments with Sorensen as to how much electronics we ought to be teaching, and by the end of World War II we had developed quite a lot of electronics. In fact, that was the reason they got me up to JPL in the first place. And so my interest in the radio end of it, was, again, a natural interest and went way back.

One of the things I remember: Back in New Zealand days, when I was in high school, another fellow and I put together a local amateur radio club. In those days, we built our transmitters by winding our own transformers and doing everything, from the ground up. [Laughter] So the DSN was something I liked very much also. The man who was running it, Eberhardt [Eberhardt] Reichtin, had been one of my best students. He did very well.

COHEN: OK. So tell me about the *Ranger* program. How did that change how you thought and planned? Did that entail major changes?

PICKERING: No. NASA, in fact, insisted [after the *Ranger* program] that we had to learn to do things differently than we'd been doing. They said, "Look, you guys are brought up by the artillery people." And the way the artillery people develop a gun, or a set of shells, is that they end up shooting a lot of them and eventually they get what they want. And now we were going to launch one satellite, and that one satellite has got to work. You don't get the option of doing a lot of testing. And NASA was quite right, because when we lost the first half dozen *Rangers*, most of those were engineering tests of various things. It's true that many of them completely satisfied their initial requirement. But we sort of had the philosophy that you were expected to launch a lot of them.

Speaking of Corporal, we actually got around to launching about 100 Corporals. And in fact, when we got to around to number 100, I said, "I will push the firing button." [Laughter] So I pushed the firing button, and instead of going north it went east. [Laughter] And that was very embarrassing, because we had decided to—this was down in White Sands Proving Ground, of course—have a big party afterwards. [Laughter]

COHEN: So what did you do? You tightened up the program, then?

PICKERING: Well, you have to learn to test and develop things differently and to be very conscious of every little thing in the process of new development. In other words, basically you've got to say that anytime you do a test on equipment that you think you're going to fly, and it doesn't do exactly what you wanted it to do or something strange happens, you have to completely explain that and correct it before you can do anything else. And we got this psychology of looking for any kind of irregularities and doing something about them.

COHEN: What you're saying is you really had to be very, very careful. I mean, everything had to be accounted for.

PICKERING: That's right. In fact we had to learn that the only time you ever test the whole contraption is the time you push launch the button. And then it's too late.

COHEN: So those were the major changes from the *Ranger* program. You really had to change the way you were thinking about things.

PICKERING: Yes.

**WILLIAM H. PICKERING****SESSION 2****April 29, 2003****Begin Tape 2, Side 1**

COHEN: Good afternoon, Dr. Pickering. Here we are again at the Archives to continue our conversation. I see here, looking over your curriculum vitae, that you got many awards. But two of them that I'd like to talk about—could you say something about getting the National Medal of Science?

PICKERING: Yes. This was awarded, of course, at the White House, actually by President [Gerald R.] Ford. It was just a quiet little ceremony there in the White House—if you can have a quiet little ceremony in the White House. [Laughter] Guy Stever, who at that time was national science advisor, introduced me to the President, and the President gave me the award. This was done downstairs in the White House, not in the Oval Office, and I was the only one, in this case. The whole thing was over in a half an hour, I suppose. [Laughter]



**Fig. 2.** President Gerald Ford bestows the National Medal of Science upon Pickering in 1975. Courtesy of JPL.

COHEN: So there was no dinner that went with it or anything?

PICKERING: No.

COHEN: The President came down, gave you the award, and that was it?

PICKERING: That was it.

COHEN: He said “Good work.”

PICKERING: Yes. And I have a piece of paper to prove it. [Laughter]

COHEN: But you were the only one there? Because I think now when I see these announced, there seem to be a half a dozen or so.

PICKERING: Yes. Incidentally, it's interesting that the very first one of those awards was given to von Kármán. I'm not sure whether they called it the Medal of Science or Medal of Engineering at that time. But anyway, that started the whole series.

COHEN: Well, quite a few Caltech people have won this over the years, but it's still a great honor. Now, the Japan Prize is relatively new, and I see that you got that in '94. So that was among the first.

PICKERING: Yes, '94. Actually, that was the tenth year they'd given it. The first one was given to a Caltech alumnus, and that was John Pierce. This was a lot more elaborate, of course; it involved going over to Japan. We were there for about a week. There were various events going on. The actual awarding of the prize was done at the National Theatre, by the emperor. Two prizes were given—one to a man from Sweden, Arvid Carlsson, who got it basically for the discovery of dopamine. So the two of us and our wives were on the stage, and the Emperor and Empress and one or two officials were on the other side of the stage, with a podium in between. There was a certain amount of speechmaking, and of course the awardees had to make some short acceptance speeches. The audience, I would guess, was several hundred. I don't know how they were selected, but anyway it was very nice, a very nice affair. After the actual awarding of the prizes, we were invited to go upstairs, and we ended up sitting in the balcony of the theatre, with the Emperor, in the front row of the balcony, and the local symphony orchestra and some opera singers put on a concert for us.

COHEN: Just for you people sitting up there?

PICKERING: Yes.

COHEN: There was nobody downstairs in the seats or anything?

PICKERING: No, I don't think so. Well, maybe the ones who were there earlier stayed. And there we were. As I told my wife, it's not very often that you get to sit with the Emperor and have the orchestra playing for you. [Laughter]

COHEN: Well, why not. Of course, there was a generous amount of money that came with that award.

PICKERING: Yes. In US terms it was around \$400,000. Anyway, after the concert we went back to the hotel and Inez complained that she had only half an hour to change. We had to change and go to a dinner at the hotel. And that was very interesting, because there were several hundred people at that dinner and it was entirely western—it was not a Japanese dinner in any sense. The service and the food were all western.

The Emperor was across the table from me and Inez was sitting next to him, and the U.S. ambassador was sitting next to her. And I was across the table, with the Empress sitting next to me—and I've forgotten who was on my other side. But anyway, it was pretty impressive to walk in as part of the Emperor's party. They had a children's concert—a children's choir—singing and they also had some piano playing.

COHEN: So it sounds like a lot more stuff went on than at the White House.

PICKERING: Yes. And then after the dinner, we retired to a smaller room where there were maybe twenty or thirty people, including the Emperor, and we had an after-dinner highball.

And then after that—the next day, I guess it was—we went down to Kyoto and had a couple of days there, which involved a little sightseeing. There we had the Japanese-type banquet, where we sat on the floor—well, a few inches above it, not quite on the cold floor. That was fun, because they had geisha girls waiting on us, and the girls did some singing and dancing afterward. Also, the ride down to Kyoto is on the high-speed train. One of the things that fascinated me about that was when we were on the platform to get back to Tokyo, on the timetable, up there in lights, it said that these high-speed trains would go by about every fifteen

minutes. A couple of them went by before we boarded our train. I don't know how many stops there were between Kyoto and Tokyo; in our case, there was only one—Nagoya. So that was very exciting.

COHEN: Those were nice awards to wind up your career at JPL.

PICKERING: Yes. One of the things I did, having gotten a big chunk of money that I didn't expect to get, was to set up a scholarship, a fellowship, here at Caltech for New Zealand students. I have one a year—graduate students.

COHEN: That would be the Pickering Fellowship?

PICKERING: Pickering Fellowship.

COHEN: Well, OK, Japanese money paying for a New Zealander—why not. [Laughter] That's very nice.

PICKERING: The Japanese have sort of taken over the tourist industry in New Zealand. The first time I took Inez down there, after we got married, we had a leisurely trip. We went to Honolulu for a couple of days and then Fiji for a couple of days. And in Fiji we got on this Air New Zealand plane, which had started in Japan, and we were the only white people on the plane. [Laughter] The plane was loaded to the gills with Japanese tourists.

COHEN: Well, I think some years ago that was all you saw no matter where you went. I don't think it's true anymore.

PICKERING: [Laughter] That's right, no. No, it's not true anymore. We just got back from New Zealand and there were a few Japanese tourists, but not like it used to be.

COHEN: There's another question I wanted to ask you, and then we'll leave it. In looking back at all the good years at JPL that were so successful, is there anything that you wish you had done differently?

PICKERING: That's an interesting question, and I haven't really thought about it. No, I don't think there's anything, short of a real sea change.

COHEN: The big decisions we talked about—where you decided to do the deep space program. And that certainly was a good decision.

PICKERING: Yes, the shaping of the overall program at JPL. Of course the question is: Should we have done it differently? No, I don't think so, because we got into the space program as soon as we could, and that was the thing to do. There wasn't any point in just continuing to make missiles for the army. So we did that when we should have. No, I don't think I have any real second thoughts.

COHEN: Well, that's good. OK. So you finished up [your directorship] there [1976]. And then almost immediately you were approached by the people from Saudi Arabia? Or had you known them before?

PICKERING: No. It turned out that what had happened in Saudi Arabia was that the oil minister, Ahmed Zaki Yamani, had decided that he needed to start training some Saudis for his business in the oil industry and that he was not going to get these people out of the conventional, old-fashioned university system. So he said he wanted to set up his own university, a technical school. And what he did was take a man who was an American who had been running the training program for Aramco. He got this man from Aramco and asked him to set up a school. And he quite naturally said OK, he'd set it up, modeled on an American engineering college, and he did, requiring that all the instruction be in English. Because, he said, "All our textbooks are in English, and you guys are going to have to learn English if you're going to take engineering."

So he had set the school up [the University of Petroleum and Minerals]—and it was located right next door to Aramco, in Dhahran. As a part of that program, he wanted to set up a

research institute—something like the Stanford Research Institute—attached to the university but serving industry. In setting up the SRI equivalent, he came over to this country himself and was looking around at places.

COHEN: Where had he been educated?

PICKERING: That's a good question. I ought to know, but I'm afraid I don't.

COHEN: But it must have been in the west, some place.

PICKERING: Yes, he had a good background. Anyway, he was visiting various schools to set up something more or less equivalent to this. So obviously he came to Caltech and he ended up going to JPL—actually came up and talked to me. He discovered that I was about to retire and said, "Well, if you're about to retire, why don't you come over to Saudi Arabia and set this thing up?" And I said, "OK, I'll do it for two years." I didn't want to make a career out of it, but for a couple of years it was all right.

COHEN: He was rather lucky; he found someone who was used to traveling. [Laughter]

PICKERING: Yes. So that's how I got started. And it's quite a good engineering school, in the sense that many of their graduates, of course, come over here for postgraduate work. I remember they had a graduate student at the University of Oklahoma, or something like that. Anyway, this student was considered the best graduate student they'd seen for quite a long time.

COHEN: In Oklahoma?

PICKERING: In Oklahoma, yes. Most of the kids who came over here did all right.

COHEN: This would have been in the late seventies?

PICKERING: Yes, the late seventies. Let's see—what else about that? The problem I had then was to try to set up this research institute, as to how it might work. They had made a tentative plan for a building for this place, and that building got built just about the time I left. The institute was turned over to a young Saudi when I left.

COHEN: Now, what did you do there?

PICKERING: I did the planning.

COHEN: Did you just model it after Caltech?

PICKERING: Yes, that's right. Actually, I told them, "Look, if this is a planning function, I don't have to live in Saudi Arabia to do that." I wanted an office in Pasadena—OK, no problem.

COHEN: And that was even before e-mail. [Laughter]

PICKERING: [Laughter] Yes, before the days of e-mail. I had a place down there at the Huntington—what's now the Ritz Carlton—one of the cottages behind the hotel.

COHEN: I see. You didn't keep your offices here or at JPL—this was completely separate.

PICKERING: Completely separate. And I used to have Saudis come over there to stay at the Huntington and work with me for a while. And conversely, I would get people usually from JPL who wanted to help me. Hire them as consultants and send them over there to Saudi Arabia for a couple of months.

COHEN: I gather you just had a blank check or something. I mean, there was never a problem?

PICKERING: There was never a problem, no. But while I was over there, I had a heart problem. I'd had sort of an angina problem for maybe five or six years before, but it had never been very serious—but there, it was. When I was over there in 1976 or '77, I remember one day I was

sitting at my desk about nine o'clock in the morning. I wasn't running around or anything, but I had quite a bad angina attack. So a doctor over there took an EKG of me and put me in the hospital at Aramco. Aramco had a good, modern hospital. They kept me there for a couple of weeks, and then they basically said, "OK, we've done all we can." They gave me a pat on the shoulder and said, "Good luck." But they recommended that I go either to England or to this country and have it looked at. So I said all right, I'd go.

COHEN: So they really didn't do anything for you; they just watched you for a couple of weeks.

PICKERING: Yes. Well, they gave me some shots and some pills, but that was it. I came back over here to the Huntington Hospital, and the Huntington did a bypass on me. This was back in the days when bypasses were not that common, really. But it fixed me up and I've been in great shape ever since.

What brought this to mind was your comment about money. Because when I was ready to go back to Saudi Arabia, I said to the Saudis, "Look, I'm just out of the hospital, so I'm just recovering from this. So I think I ought to come on the Concorde instead of on an ordinary airplane." And they said, "No problem." [Laughter]

COHEN: So how long were you at this?

PICKERING: Well, it essentially was a couple of years. Actually, at the end of the first year, I was talking to the head of the university—they call it the rector, over there. We were reflecting a bit, and he said, "You know, this year, to be perfectly frank, you lived in Pasadena and commuted to Saudi Arabia. I think for the second year you ought to live in Saudi Arabia and commute to Pasadena." [Laughter]

COHEN: Did you do that?

PICKERING: I ended up spending a little more time there, but I never did spend a full summer there.

COHEN: Oh, the weather must have been terrible!

PICKERING: Well, the winters are fine; it's not too different from what it is over here. In fact, in that particular year the rainfall in Saudi Arabia, in Dhahran, was greater than the rainfall in Pasadena.

COHEN: So tell me, does that university function now?

PICKERING: Oh, yes. I haven't had any direct contact with it lately, but the last time I talked to the man who was running it was during the Gulf War. I remember some of us sitting here and philosophizing a bit and wondering what had happened to the place. So somebody said, "Why don't you call him up and talk to him?" So we did. And the thing that fascinated me was that I just dialed the number here in Pasadena, and I got him, sitting in the middle of the war, over there in Dhahran. The university is next door to the airport, which is a combined military and civilian airport, and the university housing is spread around in that same area. So here he was; he was sitting right next to the airport. "What about Scuds?" "Oh, we haven't had any today."  
[Laughter]

COHEN: So when you worked in Saudi Arabia, it was not politicized yet, at that point? I mean, as it is now.

PICKERING: No. There was a little bit of anti-American feeling, but not very much. Because actually there was quite a large American contingent at this airport. Air force people—I don't know what they were doing, but they were there.

COHEN: Now, this building that got bombed some years ago in Saudi Arabia.

PICKERING: Oh, that was a housing development down there on the shore. That happened seven years after I left. At the time we were there, going downtown was not a problem. Women were not allowed to drive cars. One of the Saudis told me that if some of the Saudi men saw women driving cars, they would probably cause a collision, push them off the road in some way.

The other thing about that that I remember—I was again talking to the rector of the university. He said, “The place is going to the dogs. When I go downtown and park my car, I have to take the keys out nowadays. I don’t trust them. Too many foreigners down there.”

[Laughter]

COHEN: So you didn’t see anything.... I mean, all we read about is that it’s a repressive place.

PICKERING: They told us a story about when miniskirts first appeared. There were quite a few English girls working in Aramco and in the hospital, and so forth. There was at least one occasion when a bunch of these girls turned up down in Khobar in their miniskirts. And some of the vigilantes down there spray-painted them with black paint. [Laughter]

COHEN: So that was really a good experience, this work you were doing.

PICKERING: Oh, it was a very interesting experience, yes. Of course, as I said, on the university grounds it was pretty much an international university, but not entirely. There were still places where the women—well, in fact, women were not supposed to walk around the campus unless they were accompanied by their husbands.

COHEN: There were no women in attendance at this school?

PICKERING: No, although there was discussion about it, and I don’t know whether they ever got around to it or not. But if it had materialized, those women would have been put in separate classes. Thinking about the way the university operated, the recreation area was pretty much where the foreign faculty lived, and that was just like a university most anywhere.

COHEN: So they brought in people to teach, by and large?

PICKERING: Yes.

COHEN: And those people brought their families with them.

PICKERING: Yes, they brought their families with them. One or two incidents which sort of illustrate the differences in culture: There was one case where a Saudi had married an American woman and she'd converted to Islam. And like most converts, of course, they get very involved. And she discovered that in the library in the recreation center they had a copy of the Koran in English which was not the approved English version. And she got very indignant about this and made them take it out.

COHEN: So you came back here after that, and that was the end of your involvement with them. And since then you've just been involved with this business of yours.

PICKERING: I might say that when I came back here, the university had set up a sort of advisory council—an American group that met about once or twice a year—and I was on that for a few years.

COHEN: So they graduated their own people to go into the oil industry there, in Saudi Arabia.

PICKERING: Yes, the purpose was really to train their own people. As I said, the university had good standards. As a matter of fact, on at least two occasions I know they invited the group that does the accreditation of engineering schools in this country to come over and look them over. And the one that I was involved in gave us a good report. They found a few things to nit-pick—of course, they always do.

COHEN: We won't talk too much about your present endeavor, but you're running a few factories here and there—is that correct?

PICKERING: You mean the sawdust pellets?

COHEN: Yes. What made you go into that? Where did that idea come from?

PICKERING: Well, when I came back from Saudi Arabia, the question was: What was I going to do now? What did I do? I set up Pickering Research—a little consulting venture. I had two fairly large things come out of that. One came from the Electrical Power Research Institute, which was set up by the industry quite a number of years ago and is headquartered up around Stanford. Right after Three Mile Island [March 28, 1979], they came to me and said, “Look, you guys in the space business have a good record of safety and reliability. How do you go about doing it?” And I said, “All right, we’ll do a study for you and document it.” So we ran that for them, and I got both the military and the civilian space business to contribute to it. We wrote a pretty good report on what we did and how we did things differently. They thought it was a good report, and they said, “Now look, now that you guys have done this, it would be an interesting case for you to have a look at one of the nuclear power plants and see what you think about it, in terms of safety and reliability. And the obvious one to do is Diablo Canyon, up the road here, because the plant is being built but they haven’t got their operating license yet, so it’s sitting there idle, and it would be easy to run tests and so forth.”

So another guy and I went up to San Francisco to PG&E [Pacific Gas & Electric] to talk to them about this, and of course they just threw us out of the office. “Who are you? You bunch of space cadets, get out of here! We know what we’re doing.” [Laughter] And the sequel to that is that about a week later the Atomic Energy Commission jumped on them for something they had done wrong. They had done some extra seismic bracing of some sort as part of spiffing up the station, and they had done it incorrectly, and the AEC jumped on them. However, we never did get the chance to show what we could do. As a matter of fact, I was at a conference back east, put on, I guess, by the AIAA [American Institute of Aeronautics and Astronautics]. Anyway, it involved the power industry and some of the younger generation talking about safety problems, and one of the younger engineers working in the power industry told me, “The trouble is that these things are run by a bunch of old-timers, and until they die you’re never going to correct these things.” He was right, because as a part of this I had to look at Three Mile Island, for example, and went over things in there. And by space standards, they were terrible. In fact, I heard some more stories about other things happening at other plants and it just scared the daylights out of me—these guys were telling me, “None of your business.” They just don’t have an appreciation for how they should do things. For example, at Three Mile Island, the basic problem was that when they had the incident that shut the thing down, they ended up with a pipe

with 500° water. Now, 500° water means it's under very high pressure—very high-pressure water in this pipe. And the valve at the end here, which is an electrically operated valve. And the whole incident happened because that valve didn't operate properly. Now, it took them several days to discover this. In the meantime, there was radioactive water going through here and dumping into the reservoir down in the basement. And the only way they discovered it was that—not in the control room, but around the back somewhere—they had a recorder that was recording the level of the water in this basement reservoir. And they said, “Oh, my gosh!” They realized the water was coming up in the reservoir, so this valve must be open. And they got the valve shut down and that saved the problem.

I looked into the question of this valve. Now, as it turns out, this valve was used on about fifty reactors in this country, and secondly there was no facility in this country where you could test it.

COHEN: You mean, they just bought these valves and put them in?

PICKERING: Yes. Well, it's sort of a safety valve, and when you put a safety valve in a boiler, you just expect it to open. You don't test it.

COHEN: That's scary. So did they correct that one?

PICKERING: No. But the AEC said, “Look, we've got to do something about this. You guys don't have this wired up so that you've got any indication in the control room as to what's going on.” “Well, what can we do?” And they said, “Put a microphone in the same room with that valve. When the water's going through that valve, it makes one hell of a racket. So you'll know it in the control room.” So I worked on that for a bit.

I also worked a little bit, back in the space business, on the Landsat photography of the earth and the ways in which you can get information out of that. In fact, that ended by my taking a contract from mainland China to help them set up some computing systems to do this. This was quite interesting, because the first reaction was: “Working with mainland China? Are you really serious about this? You really want to tell them how to do this?”

COHEN: Was this before relations were established?

PICKERING: No, this was in the early eighties. We already had some contact with them. As a matter of fact, we found out that the kind of computers we were talking about they had already gotten from America. They had them over there. Anyway, it ended up that I went over to China to negotiate a contract with them. We spent a couple of weeks there, and the negotiator on the Chinese side was a woman. We were talking about a timetable—I forget what we said, but anyway she looked at the timetable and laughed and said, “You’re never going to get Washington’s approval that fast.” [Laughter] And she was right.

COHEN: You had to get Washington’s approval to do this kind of technology?

PICKERING: Yes. She knew that. And we got approval.

The other thing that was interesting was that once the contract got going, we had no trouble with the Chinese. In other words, they paid up; we got our money right on time.

Another interesting thing regarding the cultural difference: When we negotiated the contract, at the end of the contract you end up with a disputes clause that says what you do in case of a dispute. And this clause basically said, “Neither side will have any recourse to a court of law. You will have an arbitrator to do this.” And I said, “Oh, yes, you’ll get your own arbitrator!” But it went on to say, “And the arbitrator will be So-and-so in Switzerland.” So I said, “OK, in that case I’ll sign the contract.” We didn’t have any arguments, so we didn’t have to check out this arbitrator. But it turned out that the Chinese just didn’t like lawyers. In fact, we had somebody from IBM involved in this, and when we told the IBM people how we were going to negotiate this thing, their reaction was, “You’ve got to take along a gang of lawyers with you to do this, and you’re never going to do it in two weeks like you say you’re going to do.” And we went without the lawyers and did it in two weeks.

After that, the next thing I got involved with had to do with the problem of renewable energy. We’re talking now about the early eighties, and the energy problem was getting to be an increasing problem. Up at the lab, we had done a lot of work with solar energy, so I thought maybe we could find something in solar energy that I wanted to work on. I had one or two ideas that I thought might be interesting to work on, but it really wasn’t going anywhere when, through

another JPL-er, I met a man who had a patent on how to make wood pellets. I talked to this man and got kind of interested in what he was doing. And he got interested in me, because it turned out that he was trying to commercialize this and was having awful trouble trying to work with business on it, not getting anywhere. He felt that having some technical advisor helping him might help this. So I said, "All right." Well, this went on for about a year or so, and he still wasn't getting anywhere. Finally he basically said, "Oh, the hell with it," and went back to South Africa, where he'd come from.

COHEN: He gave up the idea.

PICKERING: He gave it to me and said, "OK, you can have it." [Laughter] Well, it turned out that the patent he had really wasn't worth much, if anything. When I had first started working with this man, I expected that I would be his technical advisor and from time to time I'd exercise myself by going to the bank. Well, when he went off, I realized that I really didn't know anything much about this business, about how to make pellets. And it turned out that another man had had a patent on how to make these things, a few years before this man. And the first man was a real promoter, and he had actually sold franchises, or licenses, to about a dozen people in this country, and they promptly proceeded to build plants, and all of them went bankrupt. And this man had the good sense to disappear to Hong Kong. [Laughter] One of the plants that went through this exercise was up in Sandpoint, Idaho, and the man who owned the plant got hold of me and decided he wanted to talk to me, because he thought maybe I would finance him and help him get started. Well, I didn't have any money, so *he* went bankrupt.

Then I talked to the bank that foreclosed on him and worked out a deal with the bank whereby we would work on the plant and put it into good working condition and take an option to buy it, and the bank would help by giving us some money to help us do this. The bank agreed that they would do it, because we told them they should let us put it into condition: "Then you've got something to sell. Right now, all you've got is a pile of junk." So they said OK. So we did this, and at the end of the period we said, "OK, we'd like to exercise our option and buy it from you and go into business." Because we had learned enough about the business end to know, first of all, how to make wood pellets. And we believed that the pellet industry was a niche industry that could very well grow. Also because Jerry Whitfield, who happened to be an ex-Boeing

engineer, had decided he wanted to make a good stove for burning these things. Jerry's stove and my pellets sort of arrived at the same time. I had good pellets and he had a good stove. So that sort of started the industry. His plant is up in the Seattle area. The plant is still making them, although he sold the plant recently.

But anyhow, we had some discussion about joining forces in some way. But I said, "No. If you think about the automobile business, I'm like Chevron and you're like General Motors. And General Motors doesn't own Chevron." [Laughter] "And our firm is in the fuel business. But a few years from now, I don't know whether your stove is going to be the best one or not, but I still want to make good fuel." So I ended up in the fuel business.

COHEN: So that's been successful?

PICKERING: Yes. We have this plant in Idaho, and we have a second plant in West Virginia, and they each make about between 50,000 and 100,000 tons a year, which is an awful lot of sawdust. The location of plants are out in the boonies, where there are a lot of lumber mills around, so you can get the sawdust from these lumber mills, because lumber mills have a problem getting rid of their sawdust.

COHEN: So you make your pellets out of their sawdust.

PICKERING: We told the lumber mills we wanted clean sawdust, and by clean sawdust, I mean no dirt and no bark, just wood. They grumbled about that, but we finally got them to realize that we were serious about it.

I'm sort of phasing myself out of the business. I obviously was very active in it when we started it, but now I call myself chairman of the board. The chairman of the board doesn't have to do anything he doesn't want to.

COHEN: So it has good people running it?

PICKERING: Yes, it's still running along very nicely.

COHEN: You've done so many interesting things.

PICKERING: We, of course, sweated through learning the space business. In the early days, when we had the *Ranger* missions to the moon, none of the first six *Rangers* worked properly. My goodness, we had the Congress and NASA both glaring at us, both wondering how they were going to cancel the contract. But we talked our way out of it. We learned.