CHEMICAL HERITAGE FOUNDATION

JOHN R. FERRARO

Transcript of Interview
Conducted by

Michael A. Grayson

at

Ferraro's home
Elmhurst, Illinois

on

9 May 2011

(With Subsequent Corrections and Additions)

ACKNOWLEDGMENT

This oral history is one in a series initiated by the Chemical Heritage Foundation on behalf of the American Society for Mass Spectrometry. The series documents the personal perspectives of individuals related to the advancement of mass spectrometric instrumentation, and records the human dimensions of the growth of mass spectrometry in academic, industrial, and governmental laboratories during the twentieth century.

This project is made possible through the generous support of the

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

JOHN R. FERRARO

1918 Born in Chicago, Illinois, on 27 January

Education

1941 B.S., Chemistry, Illinois Institute of Technology
1948 M.S., Chemistry, Northwestern University
1954 Ph.D., Physical Chemistry, Illinois Institute of Technology

Professional Experience

United States Army
1941-1942 Analytical Chemist, Kankakee Arsenal

Argonne National Laboratory, Lemont, Illinois
1948-1980 Senior Scientist
1986-2005 Consultant

Loyola University, Chicago, Illinois
1980-1985 Searle Professor Chemistry

Honors

1973 Outstanding Achievements in Spectroscopy Award, New York Section of Society of Applied Spectroscopy
1973 Distinguished Scientist Award, Argonne Universities Association
1973-1974 Appointee, Hasler Award in Spectroscopy
1974 Honorary Member, Society of Applied Spectroscopy
1975 Meggers Award, Society of Applied Spectroscopy
1975 Achievement in Spectroscopy Award, Chicago Section of Society of Applied Spectroscopy
1986 Distinguished Service Award, Society of Applied Spectroscopy
1990 Honorary Member, Coblentz Society
1991 Emeritus Fellow, Italian Chemical Society
1996 50 Years of Infrared Spectroscopy Symposium Honoring John R. Ferraro, Eastern Analytical Symposium
1996 Editor Appreciation Award, *Journal of Applied Spectroscopy*
2004 Fellow of the Society of Applied Spectroscopy

ABSTRACT

John R. Ferraro was born and grew up in Chicago, Illinois, one of two children of Sicilian immigrants. His father was a tool and die maker, his mother a seamstress in a coat factory. His parents had little education themselves but valued it highly for their children. Ferraro attended Richard T. Crane Technical High School, where Francis Coulson fostered his interest in chemistry. Though the Great Depression continued, Ferraro found a job at General Motors, where he worked for three years before entering Illinois Institute of Technology, majoring in chemistry, working with Norman Kharasch.

After graduation Ferraro entered the U.S. Army and was sent to Grand Rapids, Michigan, for training in meteorology. He met his future wife there. He spent the remaining three and a half years of World War II in the Burma-China-India theater and another six months awaiting a ship home.

Finally back home, Ferraro received a master's degree from Northwestern University, working under Charles Hurd and leaving organic chemistry behind for good. Next he accepted a junior scientist position at Argonne National Laboratory, working in solvent extraction. He became interested in infrared spectroscopy, then far-infrared (FIR). Ferraro wrote what others have considered to be the seminal work on far-infrared spectroscopy and bought the first dedicated FIR instruments from Beckman Instruments and PerkinElmer. He taught at Loyola University in Chicago for five years, leaving there as professor emeritus. He spent a year at the Lunar Planetary Laboratory at the University of Arizona, learning Fourier transform (FTIR) spectroscopy. Ferraro then moved back to Argonne, where he spent a total of fifty-seven years.

Ferraro discusses his students; his theory about innovation; his travels and interactions with colleagues around the world; his publications; his interest in history and his genealogy; and his continuing affiliation with three museums. He talks about instrumentation and the nexus between technique and equipment; what he sees as the enormous improvements in instruments; the serendipity of Fourier transform and what it has made possible; and miniaturization.

Ferraro summarizes his own contributions to the field, particularly Raman, infrared, and far-infrared spectroscopy. Pointing out that his predictions of 1967 have come true, he theorizes about the future, discussing an expansion of ultraviolet Raman; terahertz spectroscopy; improved fiber optics; and greater importance of Raman to medicine. At the end of the interview, Ferraro talks in greater detail about his book *Vibrational Spectroscopy at High External Pressures: The Diamond Anvil Cell* and an article, "Recent Trends and Developments in Inorganic Far Infrared Spectroscopy," in *Analytical Chemistry*, as well as his publishing history and the number of awards he received for his work in the field of spectroscopy.

INTERVIEWER

Michael A. Grayson retired from the Mass Spectrometry Research Resource at Washington University in St Louis in 2006. He received his B.S. degree in physics from St. Louis University in 1963 and his M.S. in physics from the University of Missouri at Rolla in 1965. He is the author of over forty-five papers in the scientific literature dealing with mass spectrometry. Before joining the Research Resource, he was a staff scientist at McDonnell Douglas Research Laboratory. While completing his undergraduate and graduate education, he worked at Monsanto Company in St. Louis, where he learned the art and science of mass spectrometry under O. P. Tanner. Grayson is a member of the American Society for Mass Spectrometry (ASMS), and currently is the Archivist for that Society. He has served many different positions within ASMS. He has served on the Board of Trustees of CHF and is currently a member of CHF's Heritage Council. He continues to pursue his interest in the history of mass spectrometry by recording oral histories, assisting in the collection of papers, researching the early history of the field, and preparing posters recounting historic developments in the field.

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INTERVIEWER: **Michael A. Grayson**

LOCATION: **Elmhurst, Illinois**

DATE: **9 May 2011**

GRAYSON: We should be recording at this point in time. What I'm going to start to do, while you are signing that, is to say that this is May 9, 2011. I'm at John Ferraro's home […]. We're going to do an oral history interview of John Ferraro. So with that taken care of, I think we can start. Did you want to say something before we really get into it?

FERRARO: Well, presumably, we're going to go where this list here that you provided.

GRAYSON: Right.

FERRARO: I'm all ready to go. The first indication here is the "childhood, parents and education."

GRAYSON: Can you speak up a little bit more?

FERRARO: Louder.

GRAYSON: Yeah.

FERRARO: You want me to repeat that?

GRAYSON: Yeah. Why don't we go ahead and repeat that, if you…

FERRARO: The first thing on the list here is, childhood, and parents, and their education. I was born January 27, 1918, in Chicago, [Illinois], of immigrant parents from Italy. Actually, I was born on 721 South State Street, which is very interesting, because it's the great street of Chicago, and only about a block away from [the southern "loop" of the elevated train]. We

lived in a tenement building, three stories. And we were in a community, which I think was probably the first settlement of Italian immigrants in Chicago. Most people here are from Taylor Street, but Taylor Street came later. […] The central part was Polk and Dearborn, and that was a three-story. We lived on the third floor. […] The interesting part about that is that we had a central church, which you might expect, because the immigrants from Italy were Italian—were Catholic, excuse me. They had a little grocery store where they could buy their salami or what have you. My first six years were in that neighborhood. My grandfather, who had come here with his two boys, my father being one of the boys, was ten years old when he came here; [he] used to take me to school when we started school. I went to Old St. Peter's. They call it Old St. Peter's. It was demolished, and I spent kindergarten there and first grade. It was a small school. All grades were in one room, one classroom. We're talking about 1905, 1906, now. My grandfather…

GRAYSON: I'm sorry, 19…

FERRARO: 1906.

GRAYSON: But that was before you were…you were born in 1918.

FERRARO: Yeah. I was born in 1918.

GRAYSON: Okay. But this school had been there…

FERRARO: From before.

GRAYSON: From before.

FERRARO: I was just going to point out my grandfather and two boys came here in 1900, so that's a long time ago.

GRAYSON: What part of Italy did they come from?

FERRARO: Sicily.

GRAYSON: Oh, okay. And Sicily is fairly sized…is this Agrigento, [Sicily] or Palermo, [Sicily], or…?

FERRARO: Well, right in the center. It's a little town which is called Calascibetta. It's in the center, precise center of Sicily, right there.

GRAYSON: Ah, very good.

FERRARO: And it's a history that I wrote for my family. I was there for two years, and being a religious family, I became an altar boy as well. But then we left and we moved west to about, I would say about three miles west. Then from there on for a long while, we went from flat to flat to flat. I went to a grammar school which was called King Grammar School. It was on Harrison Street and Western Avenue, in that vicinity. Then from there, I went to Manley Junior High, which was a little further west. Then, [I] ended up at Crane Tech, a technical school. At that time, it was all boys, and got my diploma in <**T: 05 min**> 1935.

GRAYSON: So let me get a little bit more information before we go forward. One is the name of your mom and dad.

FERRARO: Yes. My mother's name was Jenny—actually in Italian, Giovanna, but they…and my father was Carmelo, but he changed it to Charles. Now, they didn't know each other until they met here. The two families did; the two grandparents of mine knew each other, and it was a […], what do you call it—a planned marriage. My mother was only sixteen when she married my father. But they [were married] for sixty-two years, so I guess it worked out all right. Sometimes these things work out.

GRAYSON: What kind of work did your dad do?

FERRARO: All right. When my end of the family, my grandfather's two boys, they came by ship, of course. They landed in New Orleans, [Louisiana]. So, that was a different place, but this was the 1900s, you understand. All of the ports were active at that time that take immigrants. Later on, of course, it was Ellis Island. But you got off the ship, but didn't know the language, no money, and somebody came to them and said, "Do you want a job?" He said, "Yeah, I need a job." So, he says, "Well, get on that vehicle." Over there was a truck, and it took them out into the country at a cotton field. He worked sun up/sun down for thirty-five cents a day. I got this directly from him, so it's true. It's not anything that's conceived. And the boys, of course—this is located maybe thirty, forty miles away from any large civilization, the farm—they couldn't go to school, too far away. So, they were the water boys, because it was

awfully hot, and provided water for all the workers. They must have worked out there for about three years.

Then, they decided that they were going to come to Chicago, because they heard Chicago was a good place for work, and which they did. Now, that part I'm not sure whether they slipped on a train, a boxcar or whether they saved their pennies and made it on the train legally. So anyway, they got to Chicago, and the work. Okay. The west was building up at that time. I would say that this has got to be about 1905, approximately. They're building the railroads to the west. The Chinese were building the railroads to the east, and they were going to meet somewhere in [between]. Anyway, this is what they did. They worked on the railroads, laborers, more or less. When that ran out, they came back out to Chicago, and I would say this is about maybe 1910. My father, of course, I asked him. He must have had about three years' education in Italy, and that's about all, spoke with an accent. My mother […] came here when she was five, and did have some education here to twelve. So, she spoke with no accent.

GRAYSON: So, when did your dad come to America? At what age was he…?

FERRARO: […] Ten. My mother was five. From there my father went to work for a machine shop, learned a trade. He became a tool and die maker. The uncle, of course, [worked] in the machine shop too, and he became a screw machine operator. So, they had trades, real trades. […] We're talking now about, oh, I would say, 1916, 1917, 1918, and they [had a] planned marriage. They were married, and a year later, I came. I always look at myself as a World War I baby. I was born in January, and then of course, the Armistice was signed later that year, in November.

GRAYSON: Now, and both of your parents, did they become citizens eventually?

FERRARO: Oh, yes.

GRAYSON: Okay. So was that fairly early in their time here?

FERRARO: Quite early, yeah, right. As a matter of fact, my father during World War II got an award from the government. I forget the name of the department. I think it was the Department of…not Interior, Department of War, that's what it was. I don't know if they called it Department of War at that time.

GRAYSON: I think maybe, they did.

FERRARO: Yeah. <**T: 10 min**> He got an award because of some of the work he was doing for the government.

GRAYSON: I'm going to stop here just a second. I want to take a sound check and make sure that we're getting…

FERRARO: The sound right.

GRAYSON: Getting […] it down, because we don't want to go too far, and find…

[END OF AUDIO, FILE 1.1]

FERRARO: Pre-college education.

GRAYSON: Well, we were kind of finishing off information about your parents and basically they both became citizens. They were both…really neither one had much education, but your mom had more than your dad.

FERRARO: That's correct.

GRAYSON: And they ended up with having trades after they…

FERRARO: Except for my mother. She went into the…well, she started to work at twelve. The legal limits were fourteen, but my maternal grandfather, of course, wanted her to go to work, so […] she could bring home a check, money, the old-school idea. But she went to work for a candy factory first, and then, the grandfather and grandmother had both gotten into—her mother and father—had gotten into the trades here in the clothing industry, which was quite big in Chicago at that time. They got her in there too, and so she worked the rest of her career in the trade industry, mending suits. She worked on the lining of the coats of men, until she finished and retired.

GRAYSON: Oh, wow. So she worked her whole life.

FERRARO: Her whole life.

GRAYSON: Wow.

FERRARO: Right, yeah. So, and that brings us to a point that I think is pre-college education. I've already said I graduated from Crane Tech [Richard T. Crane Technical Preparatory High School]. […] The thing about that was, that here I am in 1935. I'm in the middle of the Depression, and there's no fun. My father worked for maybe one or two days a week, got about seventeen dollars a week out of that. He was lucky […] he was able to do that. We never went on charity.

GRAYSON: So they basically just cut back on the amount of work; that was kind of like furloughing. They didn't lay people off. They tried to keep them employed.

FERRARO: Yes, that's right. Of course, we had to cut back on a lot of things, food and so forth. We never got essentially meat. That was unheard of. But I still attribute that we got through this because my mother was a pretty good cook. Of course, the primary thing was pasta, but you wanted to do something with the pasta, so she would always mix the pasta with either beans or peas, cauliflower, whatever she could come up with in the vegetable region. So, we got by. We got by.

So here I am in the middle of 1935, what do I do? It's hard to find a job. I managed to find one finally, and I worked for three years, saved my money. In 1938, I went to college. I went to Illinois Institute of Technology.

GRAYSON: Okay. What was the job that you got [when] you were [there]?

FERRARO: I worked in the stockroom, which was a machine parts place for GM [General Motors]. We made parts there, and stocked them and so forth and so on, and shipped them for the manufacturers of cars. Most of the stuff we were doing was side view mirrors, and small stuff.

GRAYSON: So, there was still manufacturing in automobiles going on, [it's just] probably…the amount was not that significant.

FERRARO: That's right. It wasn't large, no. Trickle, if you want to use that.

GRAYSON: Then you went to the school, at IIT. That was 1938.

FERRARO: 1938. Yes. There was the possibility you could take Saturday courses. You can take evening courses, which was almost unheard of, but I was able to do that. I finished in three years. So, I'm out in 1941, June. Unfortunately, every time I come out with some degree that there's no jobs.

GRAYSON: Yeah. So what did you study at IIT?

FERRARO: I went into the science program, majored in chemistry.

GRAYSON: Chemistry.

FERRARO: Right, yeah. I start looking for work, and I interviewed and I got a good interview with the United States Army. They were building plants here outside of Chicago, about twenty-five miles, thirty miles. One was going to be a plant which would make the chemicals that go into a bomb, and the other one was going to be where they would load them into shells. So, they finally convinced DuPont [E. I. du Pont de Nemours and Company] to make the chemicals <**T: 05 min**>. They were making trinitrotoluene [TNT] and lead tetryl. They were making mercury fulminate with azide as detonators. So, I was hired to work with the chemicals, the ingredients of the bombs. One of the things that was major for the army was the fact that as you made two thousand pound amounts at a time, in the case of TNT and tetryl, [coupling became a problem].

GRAYSON: Now that last one, tetryl, what's…?

FERRARO: It's got several nitrate groups on the rings, [2,4,6-trinitrophenylmethylnitramine].

GRAYSON: Okay.

FERRARO: A little different, [but similar].

GRAYSON: […] So, it's kind of like a derivative […]?

FERRARO: Well, it's an offspring of it, yeah, right. They made them in two-thousand-pound amounts. And the question comes up; they had to wash them very well with water, for the simple reason that if you didn't wash them with water, the alkaline material in there—there'd always be the possibility of pre-detonation. Kill your own people. So that was a big task for us, our lab there, to do that. Now sampling a two thousand pound model is not easy. I mean, you just pick a small sample, and there were times of course, that stuff got through with the alkaline. Then you had a battle in your hands with DuPont, because they didn't want to wash it again. One time, a kind of interesting offshoot of this was that I did the alkalinity test, and they didn't believe it, said we didn't know what we were doing. So, they shipped it to Northwestern University, and there—and he became a very famous scientist, Dr. Pearson, Ralph Pearson. […] He did the alkalinity on it and verified what I had found. So, anyway, they had to wash it again.

GRAYSON: But let me get…I don't understand. I understand the importance of getting the tests right, but so the alkalinity test was done after the reaction vessel for this large thing…

FERRARO: After they condensed down to solids.

GRAYSON: And then washed and it was ready for the next batch.

FERRARO: Well, we had to have another wash.

GRAYSON: Okay. And if there was any alkaline material in there, then the next batch was the danger of going off in the process of preparing it, is that…

FERRARO: No. Well, we always got the implication it wouldn't happen until you poured it into a bomb, and that's when it might happen; or in a cannon, where your own people are shooting. […] It wasn't in the vessel.

GRAYSON: Okay. So, if there's any excess alkalinity in the charge that you were preparing, and that was put in your weapon, then there's a chance it could pre-detonate, and that would be definitely not good.

FERRARO: That's entirely right.

GRAYSON: Okay. So, […] your analysis was borne out by the…

FERRARO: In that one case, yeah. Most of the time, they washed it all adequately, and we had no problem.

GRAYSON: Now, were you working for a company that was working for DuPont? Or were you…

FERRARO: No. I was working for the U.S. government.

GRAYSON: Oh, U.S. government.

FERRARO: U.S. Army, actually.

GRAYSON: I see.

FERRARO: Right. So that continued for about a year and a half, and…[let's see, where are we]? 1942. It was almost the end of 1942, when I had trouble with my Selective Service Board. They wanted to draft me. I said, "But, I'm working with explosives. I'm working for the government, for the war." But, you know, they didn't believe this, right. Well, didn't react to it. So, I decided, well, I better do something about it. I have a degree in science, and said, "I've got to look to see what I can find." Of course, they were doing all [the nuclear] work at Stagg Field, [University of Chicago]; I could have fit in the program there. But knowing what the Army knows and the military did, and at that time, the Air Force was part of the Army, that they decided that I was pretty close to being drafted.

I decided I'm going to interview. So, I did. I interviewed the Army. And I interviewed the Navy, and I pointed out to them, you know, I'd like to go into something science, because it's my background. I have a degree already. Well <**T: 10 min**>, the closest they told me I could come was to have a big meteorology program. They need a thousand meteorologists to follow weather for the aircraft, the Air Force being part of the Army at that time. I had no choice. So, they enlisted me as a private first—no first class, they didn't have first class, just private—and I went off to military training exercise and so forth in Florida. Then the big school was going to be in Grand Rapids, Michigan. They had a big auditorium, the biggest in the United States. They could provide seating for a thousand kids, and we'd go through these courses, a full program you know from 8:00 a.m. in the morning and 8:00 p.m. at night. Get up at 6:00 a.m. and go a couple of miles exercise, and go climbing hills, and coming down.

Anyway, we got to go to Grand Rapids, and the interesting part about that is […] that's where I met my wife, Mary. So, there's some good and bad all the time, right, the law of compensation.

GRAYSON: Yeah. So they wanted a bunch of meteorologists there.

FERRARO: Yes. Well, the interesting thing, of course, is what I'm going to tell you now. A thousand meteorologists, okay. All day long, the same raw benches, you know, until you get a thousand guys in there, one course after another, very, very tough program. I mean, you're in there for that many hours, and the lights go out, and the slides come on, how do you keep your eyes open? Oh, my god, even though you're interested in the subject matter. But anyway, we're about, I would say, a quarter through, and they determined that they didn't need any more meteorologists, not that many. So they start washing them out, I'm telling you. It's disgraceful the way they did it. They give you a test from one…you maybe had about twenty-five in this row. The paper, by the time you got it, if you were in the middle, it was okay. But by the time the guy on the other end got it, they were collecting them.

GRAYSON: Oh, no.

FERRARO: They washed them out. They didn't care if it was good or bad. Anyway, we're down to about six hundred now and halfway through the program. They then put us in the airfield here in Illinois. So [we] moved there. The point was that if you successfully go through this course, you're really a cadet at the beginning. You get all this [United States Military Academy], West Point stuff, you know, square meals, which chicken shit stuff, you know. But you had to do it. […] We were living in a hotel there, in the Pantlind Hotel in Grand Rapids, and a guy would come in with white gloves, you know, go on top of the different things and see the dust on the…if you had dust, then [on] the Sunday morning, which is the only time off, you had to go out and march back and forth on the grounds. So you lost your time off. But, anyway […] So, then we were at this airfield here in Illinois, and we finished up in the early part of November, get our second degree bar, second lieutenant. But now what do you do with six hundred guys? You don't want them in the meteorology program anymore. So what did they do? [They said,] "You go to communications; you go to Air Force Intelligence [U.S. Army Air Forces]; and you go for engineering." Different courses, different places. I got stuck in the Air Force Intelligence for six weeks of more training. This is 1942, November, and then December, coming toward Christmas. I got through the course, which as far as I was concerned was kind of simple, if you had a background in science, or mathematics, whatever, you know.

Then you had to join an outfit, be part of a squadron or whatever. Temporarily I got put in one squadron there, and then finally they decided that they were going to have an air force in China-Burma-India. They formulated a group, <**T: 15 min**> which had the bombers, the

fighters, gliders, and carriers—you know, carriers which would carry different materials and so forth, troops and so forth.

GRAYSON: [These are the] aircraft…I mean, airplanes that would carry materials. Those are all in air…

FERRARO: Yes, cargo ships. […] Arnold, at the time, General [Henry H.] Arnold, couldn't make a big aircraft group, in a sense. Well, I don't know what you call it, but it's like they had thirteen Air Force units in England and so forth. […] The first group that went through was the First Air Commando Group. They went ahead of us, and then we went later, Second Commando Group.

GRAYSON: This is in India?

FERRARO: Yeah, China, Burma, India. Well, we started in Burma, because that's where the Japs had come up from Rangoon, [Burma], up the peninsula of Burma. They had taken all of northern Burma, which was really forested, and they were in Myitkyina, [Burma], […] in the foothills of the mountains there. And there was another sister city there called Bhamo, [Burma]. I joined them in Myitkyina. But they had sent the cargo ships ahead of time, and so we had to go by boat. The cargo ships were already there, and they were shifting the material over the hump, as we call it. […] I would be briefing them, actually, on the intelligence. As it turns out because we were so short-handed with people there that I had to brief them also in the weather. So I had two functions, which kept me pretty busy. One of the things that disturbed me was the fact that when our guys took off to go to China the first morning, there was only a window that you…you had to go up to an altitude of thirteen thousand feet and then, head east over the mountains. There was an opening there in the mountains you could get through, because it was always [overcast], the monsoons and so forth.

The interview was…the interrogation, not the interrogation, but the people that talked to them before, and gave them the details, didn't emphasize it; had to get up to thirteen thousand feet and some of our kids just took off from the airfield and went straight up, and hit mountains and never got to the altitude. We lost two ships in the first day, that wasn't because there wasn't the proper intelligence, but some of those that were briefing them were…they'd been doing this for several months, and got a little lackadaisical. I think everybody that was there […] had flown the path before. But anyway, we finally got there and settled that problem.

GRAYSON: So the China/Burma, that just refers to the fact that this was a theater of operations that you were actually located in India.

FERRARO: Well, I was actually located in India, correct. Yeah. Well, for a while there, we were in Myitkyina, Burma.

GRAYSON: Oh, okay.

FERRARO: But what happened then, you see, they had all of the north. These were the last villages that had to be conquered, and then we would push them down south. There the land war would begin, because the forest trees were no longer there. But Burma's funny, because the northern part is all vegetation, and then you get into flat plateau <**T: 20 min**> that's…

GRAYSON: Is that at altitude or at lower plateau?

FERRARO: Lower plateau.

GRAYSON: Lower, okay, lowlands.

FERRARO: And slowly the British troops—but they were headed by the West African black people, and the Gurkhas—they pushed them out.

GRAYSON: […] These were allies with the British.

FERRARO: Yeah.

GRAYSON: Okay.

FERRARO: They were their troops, you know. So, we're there now because of the situation. A lot of people thought that this was a forgotten war, and in way it was, because what these kids were doing is flying that hump every day and coming back the next day. Later on the large bombers were—the B-29s—were flying one mission and back on the same day to bomb Japan. They were doing it on a daily [basis]. There were two different groups; one group would go one day, and the next group would go the next day.

GRAYSON: So this was from a location in India…

FERRARO: Yes.

GRAYSON: …that they would fly all the…

FERRARO: They […] were flying out of Calcutta, [India] actually. Yes, an air base in Calcutta.

GRAYSON: […] Do you have any idea what the nautical miles is? That's a pretty good haul.

FERRARO: That's a big plane, but I don't know the nautical miles.

GRAYSON: Yeah. I mean, that's a pretty far away…

FERRARO: It is, yes. Yes, they dropped their bombs there, and then they'd come back, again. So, that's…

GRAYSON: Yeah. […] I was not aware of this action at all, but, I mean, I'm not a World War II buff or anything; but it's just complete news to me. Obviously, it was an important part of the World War II outcome.

FERRARO: Yeah. Well, and the other part of that is that […] we had to supply these people, and we did it by sometimes by dropping the different instruments or whatever, bombs—not bombs, but guns and so forth—in order to keep them, so they could move with the Japs, and fish them out, which eventually they did. They moved them all the way down to Rangoon, and the Japs surrendered there. But the other part of that mission was going over the hump, which was kind of extremely dangerous, because, like I said, the mountains there are always non-visible, and I went on several missions with them, just as a passenger, more or less, to make observations for my briefings, and so forth. But we lost a lot of planes out there and they're still out there.

GRAYSON: Just from running into the mountains.

FERRARO: Yeah, covered with snow, bad weather. One time, well, I briefed this pilot after the mission from China, he came back. […] I said, "You just got off about an hour ago, what

are you coming back for? What happened? You got mechanical problems?" [He said], "No." He said, "I was looking at the ground. We had an open space, so we could see, and I'm still seeing the same ground." He says, "I'm going hundred-eighty miles an hour." He says, "There's wind there a hundred-eight miles in my face. We weren't going anywhere. We were going to run out of fuel, so I come back." In fact, that day two of them came back. Kind of interesting little sideline […] to have that occur.

GRAYSON: Couldn't make any headway.

FERRARO: No […].

GRAYSON: Good thing they could look down and see what was going on; otherwise you might have run out of gas.

FERRARO: Yeah.

GRAYSON: I'm going to have to back up a little bit. How did you get interested in chemistry? I think we kind of slipped past that.

FERRARO: Okay. Okay. I'm from a neighborhood with a lot of Italian kids, immigrant families, and all wanted to be M.D.s.

GRAYSON: Oh, okay.

FERRARO: I mean, that's great, because we wanted to be something, instead of gangsters. So, we're all going to college and took pre-med stuff and so forth.

GRAYSON: Were you one of these guys?

FERRARO: Yeah […] I was interested in medicine, yeah. So, but what happened then, of course, was that I take fourth year chemistry, with Professor [Francis C.] Coulson […] and I'm doing very well. You know, I'll probably find it later. He wrote a manuscript […], a course manuscript. I got very interested in it. He got interested, and I was doing pretty well. So, that's how it happened.

GRAYSON: So you actually became interested in <**T: 25 min**> the chemistry, for its own sake.

FERRARO: Yeah.

GRAYSON: So I mean, there's a lot of this thing nowadays where, I know my son teaches chemistry at Tulane [University], and they have a lot of pre-med students. His sense is that mostly they're all in it for the grade, and that's it. They don't really say…occasionally someone will get interested in chemistry, to do this, get the science out of it. So, when your class […] did they have the same attitude that, chemistry was…they just wanted a grade, so they could move on to their M.D.?

FERRARO: Most of them, yeah. Yeah, of course, that's typical of the pre-med people. I mean, they just want to get through it and take chemistry or whatever, and want to go on. They're not interested in chemistry per se.

So, here we are. I decided I was going to go into science and chemistry. That's what my biggest motivation—of course, far superior to that motivation of this college or high school teacher was the fact that I came from a family […], immigrants that they were, [who] recognized, because they never had it, education, the importance of education. I can still remember to this day that my father stimulated me when he said, "I never had the opportunity to go to college and become something." He said, "But you are going to go to school, and you're going to become somebody." It was a stimulation, of course.

GRAYSON: So […] did you have any brothers and sisters?

FERRARO: One sister. She was married about eight, nine years after I was, later on, probably after I was. So we were close. But I had no brothers or anything, just the two, very small family. So, that's where we're at. I'm still in…

GRAYSON: This is at IIT, the …

FERRARO: No, no, no. He was at Crane Tech. Fourth year of high school teacher.

GRAYSON: Oh, oh, okay, so it was in high school. Okay.

FERRARO: Yeah.

GRAYSON: Okay. So he kind of got you switched around, and …

FERRARO: Yeah, he did. Kind of interesting. There were two teachers that would teach fourth-year chemistry that time, and one everybody had. He's easy. Everybody could take him. This one was tough. So, by the time I got to get a teacher there, I didn't know him from Adam. I got the tough one. It helped me tremendously. But there were other motivations as I progressed in science, and the people that helped.

GRAYSON: […] What did he do to turn you on? […] Obviously, he was able to connect with you, and …

FERRARO: Yeah, yeah. Well, it's hard to say. It's just that I performed so well, and he was always encouraging me to continue. As the course progressed, he said to continue it further, go to graduate school and so forth, and so on. You know, and the right kind of information that you should give students to encourage them and so forth, and that's what happened.

GRAYSON: So were your classes very big, large at that time?

FERRARO: Yeah. It was pretty good-sized classes, I would say, better than thirty, yeah. Except it was a pre-med school, and then they started bringing in girls, and then you got pre-nursing. That was rough, because all they wanted to do was get a passing grade, you know. Always arguing with the professor, because, you know…I deserve better than that, and so forth. So, you know that.

GRAYSON: Yes, the same old, same old.

FERRARO: Yeah. [laughter]

GRAYSON: So, I kind of backed up on the…but I guess we're back in the [time] you're finishing up your tour of duty in India. So, actually that meteorological training came in handy, after all.

FERRARO: Yeah. Well, actually, it's such a severe course, I mean, that we were told that if we went…after the war was over, we wanted to go to grad school, that we had done all the preliminary scholarship work, that all we had to do was write a thesis. But I never did that. I wanted to get back to civilian life. I had gone there, and got stuck for three and a half years, in China, Burma, India. Took a good chunk out of my whole life. So I didn't get back until 1946, Easter. In fact, I was waiting for a ship for almost four months <**T: 30 min**>, and finally got one to come back. And I got here of course, and wouldn't you know, I'm in the middle of the Depression. Everywhere I went there's no work. No work, G.I. Bill of Rights, all right, I'll go back to school. This time I went to Northwestern…and worked for Dr. [Charles D.] Hurd in 1946 September; 1948 June I got my master's degree. Okay.

GRAYSON: By this time, you began to specialize in a different kind of chemistry?

FERRARO: Well, I made a switch, you know, unbeknownst to a lot of people, but Hurd was an organic man, very famous.

GRAYSON: Inorganic.

FERRARO: Organic.

GRAYSON: He was…Hurd, okay. Hurd was organic.

FERRARO: Yeah, right. So by the time I got out, I figured there's too much memorizing. You have to memorize all this organic stuff. I didn't like that. I wanted to figure out results without using my memory all the time, so I chose to go into physical chemistry. But I couldn't do that until I got a job or whatever, so after the master's degree, I interviewed for…I got [an interview with] a national lab, of course, and got a job with them, a junior chemist, more or less, starting from the bottom of the ring. It was 1948, in the fall of 1948. Then, spent the better part of [fifty-seven] years at Argonne National Laboratory in one capacity or another […].

GRAYSON: Well, if there's anything that we want to cover previous…you know, previous to getting into your career activities. I think we've gotten a pretty good sense of the flavor of your war service, which…now, the war actually kind of ended while you were still in…

FERRARO: Oh, yeah. It ended September of 1945.

GRAYSON: Yeah. So you had to skate around…

FERRARO: Well, what happened was—I neglected to tell you that—I was with a cargo squadron. You had to have certain representation. There were four units. They put me in the cargo squadron unit, and that's where I was the TO, Technical Order. Okay. So, we got the cargo ships. We got to go to China now, after the war is over. I thought we were coming home, well, we have to go to China, because we got the CIA [U.S. Central Intelligence Agency] guys, which were the…there was another designation, acronym, for them,. They were scattered all over China, you know, just like you might have spies here and there, and we had to get them back home. Well, to get them back home, we had to go to different airfields—some of them, airfields—and then the different cities […] and one flight we had to go to land in Mongolia. There was no airfield, so how do you get a C-47 plane on a rocky field or whatever? I don't know how that ship got in and got out, but he got out. We bring them back to [Kunming, China], and then they flew home. So, we're stuck there for about three or four months, and we came back and turned in our planes, and [flew to] Calcutta to wait for a ship to come.

The thing about the way the Air Force did it [was] if you were a pilot, every flight you took, every mission you went on, you got points, certain number of points to go home. Ground officers didn't get anything, anyway. We're back in [Calcutta] and spending the time there doing this, you know. Well, they had a horse track there, racing horse, go out there Sunday afternoon, betting on horses, and trying to kill the time that way. But finally got on the ship and came home.

GRAYSON: Now, you were saying, CIA guys you picked up in various stations, but you said you picked up some from [Beijing, China]? CIA?

FERRARO: Yeah. They come back. In fact, when we were…I flew in the plane that went to [Beijing] to get these guys.

GRAYSON: No, but I mean, were you saying that they actually had…CIA had people in [Beijing] during the war?

FERRARO: Oh, yeah, during the war. They were there.

GRAYSON: So, they were […] providing intelligence on…

FERRARO: Of course, most of them were Oriental, so.

GRAYSON: Yeah, yeah. Yeah, yeah <**T: 35 min**>, wow. That's got to be…

FERRARO: Well, when we came into the airfield at [Beijing Airport], we see the Japanese soldiers still there with their guns and so forth, and saluting us, you know. When you got off the plane, what…these guys with guns and I don't have one. I'm…you know what I mean. [laughter] So anyway…

GRAYSON: So, okay. That's pretty interesting for a guy to do CIA duty in [Beijing] when you're fighting the Japanese. That's got to be tough duty.

FERRARO: I was in China, but they're fighting Japanese—no, no, Tokyo—Beijing.

GRAYSON: Oh, Beijing, okay.

FERRARO: In Beijing, China.

GRAYSON: Okay, China. Okay.

FERRARO: Yeah. So, but anyway…

GRAYSON: So you have to fly all over the Far East then.

FERRARO: Yeah.

GRAYSON: Finally you got home.

FERRARO: Finally I got home.

GRAYSON: And no job.

FERRARO: No job. Then, as I say, with the GI Bill of Rights there, and I took advantage of it. Went to Northwestern, got my master's, then started looking for a job. Got hooked on with Argonne and had a good program there. You could go back to IIT and take coursework and do your research work at Argonne, and eventually you come upon a degree. Well, again, back to IIT, where you could work on Saturdays, Sundays, evenings and so forth, and so on, and it took me about, almost five years in [1954]…

GRAYSON: In the early 1950s?

FERRARO: Yeah, 1954, I finally got my Ph.D. I worked with the chemistry of thorium nitrate. So that's where I'm at then.

GRAYSON: So, what kind of operations did Argonne have at the time? […] Did they have a fairly large chemistry operation with different, say, like, analytical and inorganic, organic, and physical…

FERRARO: Physical, yeah, some. Well, we had different buildings. We had physics, engineering, chemistry…

GRAYSON: Okay. And Argonne, their primary charter was what…were they…

FERRARO: Research on nuclear developments and nuclear energy. We did all the work on the reactors, initial work.

GRAYSON: Okay. So that was their primary focus.

FERRARO: That's right. No military. We prided ourselves at that time that, we didn't have…the national lab didn't do military work. There were others that were doing it, so.

GRAYSON: Okay, and that was located where they are currently?

FERRARO: Well, we first started at Stagg Field, you know. That was in 1948, 1949. Then we moved to the new place in 1951, I think it was. Yeah, and I joined a group there. They put me in this group, and it was the solvent extraction group. The idea there was, of course, to separate the different nuclides from one another. One would have, you know, decayed in

thousands of years, the other was less, and you [had] to separate [them]. So you had to do it by solvent extraction.

GRAYSON: So these were isotopes of the same element, or are they…

FERRARO: They had germanium…

GRAYSON: Okay, but they are different elements.

FERRARO: Yeah, different elements. Yeah. The way that was started was we had to synthesize new extractants. We found the best ones were organophosphorus acids, which had a functional group of phosphate P-double bond-O, where the metal would latch onto it and be pulled out of the solution that way.

GRAYSON: How do you spell phosphero…what?

FERRARO: Organo…

GRAYSON: I got your organophosphorus.

FERRARO: Organophosphoric acid…

GRAYSON: It was phosphoric acids. Yeah, that's an important distinction.

FERRARO: Of course, you could put anything you want in the organic group, you know, which will give you a whole new slew of more compounds.

GRAYSON: Sure, okay. So they had the property of latching onto […] specific elements in the…

FERRARO: Yeah, separating them.

GRAYSON: So the material that you got came from a mining operation or…it came as a mixture of elements and the radioactives. You ran <**T: 40 min**>…what, you ran part of the periodic table.

FERRARO: Yeah, right.

GRAYSON: And they were all kind of like mixed together.

FERRARO: Well, you had a semblance of what you would find in nuclear waste, that type of stuff. So, what I'd do…I went into trying to determine the chemistry of these organophosphorus compounds and then, that's where you had to know what the molecular weights of things were in the solution, where there were monomers, dimers, and so forth. The thing I did was first started out with freezing point measurements to determine molecular weights in various solvents. Then, I branched off into isopiestic methods, which were the more accurate, and these were more or less, depending on the…

GRAYSON: This…?

FERRARO: Yes, isopiestic.

GRAYSON: What does that mean? That's a word I'm not familiar with.

FERRARO: Well, it's just a word for looking at the vapor pressures of the materials in a solution and equilibrating at a certain temperature, and you had two arms, and then you would have a transfer of one material to the other, that is the solvent. Then, it comes to some kind of equilibrium, and then there are times that you can measure the volume and so forth. It's kind of a volume template.

GRAYSON: Volumetric kind of [thing].

FERRARO: Volumetrically, yeah.

GRAYSON: Yeah. I've heard a lot of "iso" things, and isopiestic…

FERRARO: So we did a lot of that to get molecular weights in different solids, and so forth and so on. Then, I knew that there was a phosphoryl group, which was the functional group, and so I decided to go into infrared and find out—this was 1948, 1949, that period of time. We wanted to see what the effect on the phosphoryl group was with the different ligands and isotopes, different metals. Of course, the way we worked […] we were working with lanthanides, because it was a family that would be similar to the uranium family, you know, germanium. So, we studied the effect the…of course, once you bond on the P-O, you make it a more single bond type of thing. You stretch the P-O bond out, so it's a…

GRAYSON: So, it's phosphorus-organic bond.

FERRARO: Yeah. So you shift it to the lower frequency, and we could get a comparison of different elements in their basic combination there. But then we realized that this didn't really do the trick either, because we wanted to know not necessarily the P-O function, and what it did when we made a compound with an element. But we wanted to know what the bond that the metal had to the oxygen, and how it changed. Well, then you ran into a situation where you had to go into lower frequency. That was far-infrared [spectroscopy].

GRAYSON: Okay.

FERRARO: And that's how I got into that. Later on, when you ask for some…

GRAYSON: So, at this point, when you decide to use infrared, because of your background in the business, in the science, that you knew that the infrared would provide information that was useful.

FERRARO: Yeah, right.

GRAYSON: And what type of infrared equipment did you have to work with at the time?

FERRARO: Well, with the phosphoryl group—the P-O group, we worked with it in infrared. Then, when we decided we wanted to look at the oxygen bonding with the metal, the metal to oxygen […] we had to go to far-infrared. There you ran into a situation which most instruments cut off at 650 wave numbers. Then you found that these vibrations were down to 400 wave numbers or less, 400 reciprocal centimeters or less. It was a chore to try to do anything down there, because you had to change [many] of the parameters in order to get down there. You know, you couldn't <**T: 45 min**> use KBr prism anymore, you had to go to cesium iodide, and

that wasn't very good [instrumentally]. But we started doing a lot of work in the far-infrared with lanthanides and coordination compounds.

One of the theories that they had…somebody came out with a stipulation that, group frequencies are not possible in the far-infrared. By doing more of this kind of research, which was really fundamental at this stage, I determined that, yes, you could do far-infrared work with these compounds, because they do have group frequencies. You can assign group frequencies to the various vibrations in the far-infrared, relative to the metal and so forth.

GRAYSON: Okay. So there was a little bit of controversy about the whole spectroscopic area that you were investigating. So now, the equipment that you used was this…this would have been fairly primitive instruments at this time?

FERRARO: Yeah…

GRAYSON: 1950s?

FERRARO: I would say so, something like that, the early type of infrared instruments that were commercially provided. But this is not to say that—I don't hold generally, but fact of the matter is that I did a heck of a lot of work down there, and there is a question to have here significant things that you—publications or other things that I was involved in. Well, the paper that did it, was this *Analytical Chemistry*, value. It opened up far-infrared [and showed the value of FIR].[1]

How do I mean by opening it up? Well, more people got into it, but there was no commercially made standard far-infrared instrument that would just be for the far-infrared, because I think it was work, and then, later on, I wrote a book.[2] This one of course is with high external pressures. But it opened up the far-infrared to the point how…Beckman [Instruments] provided a far-infrared instrument just for the far-infrared, the IR-11. Then, PerkinElmer came out with the 301. So, then you could go down to maybe as low as 50 wave numbers, 50 or [lower]. We [now] got clear past the metal oxygen [using commercial FIR instrumentation].

GRAYSON: Yeah, sure.

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[1] John R. Ferraro, "Recent Trends and Developments in Inorganic Far Infrared Spectroscopy," *Analytical Chemistry* 24a (1968).
[2] John R. Ferraro, *Low Frequency Vibrations of Inorganic and Coordination Compounds* (New York: Plenum Press, 1971).

FERRARO: So this work here that I did, I was put for an award for the Pittsburgh Group, which I never got, but it was for the far-infrared work that I had done. But that's in that area.

GRAYSON: So basically, well my understanding…my sense is that infrared had a lot of application initially for the […] organicers. What I see from looking at the publication record is that, you know, you're doing all this infrared work in the inorganic.

FERRARO: That's right.

GRAYSON: So. basically, in order to be successful, you needed to go down into the far IR, and so there you went and explored it and essentially developed it to the point where instrument companies actually made equipment to work in that area.

FERRARO: Right, right. In fact, we bought the first IR-11, and then the 301 [which were the first dedicated FIR instruments].

GRAYSON: So that made it more accessible to more people, and then…you know, which is then an important development in the whole infrared story.

FERRARO: Right. Of course, from that the diamond anvil cells, which could give you spectroscopic work in the far-infrared or emitted-infrared under high pressure.

GRAYSON: All right. Now, yeah, I was looking at that. What's with this pressure business? […] Why do you want to squeeze these things?

FERRARO: Well, number one, high-pressure spectroscopy had not been developed, again, that was one reason. Then, the curiosity: what happens when you put something under pressure? This was the motivation that we did it, and we had the diamond <**T: 50 min**> anvil cell, which we bought when they first developed it. So, we had to interface it with the instruments. In the far-infrared […], you had to use a beam condenser, and the commercial beam condensers were not suitable. So we had to take a six-time beam condenser and redo the optics on it in order to make it so that it can interface with the diamond anvil cell and the far-infrared region. […] That's how that developed.

GRAYSON: So all this for the purpose of understanding what's going on in these…or you still were working in the lanthanides then.

FERRARO: Yeah, but…

GRAYSON: This was kind of like a model system for the transuranic elements.

FERRARO: Yeah. We, of course, applied it to some of those compounds too. Yeah. But basically, this was kind of a spinoff of what I was doing before. I mean, but I had the opportunity to do this, and then the question comes up, why did you do it? Well, I worked for a laboratory which allowed you to do basic work of this type, if you wished, if they wanted you to. The way you got your monetary budget every year was that they looked at your research and then gave you an allotment, if they thought what you were doing was okay, and useful. Then, that's how it worked out for me. I was quite fortunate that I was able to do this, since I…

GRAYSON: Yeah, I see…

FERRARO: Get away from the [routine].

GRAYSON: …here that you have an *Analytical Chemistry* paper, I can make a note of it in my publication list.[3] Yeah. So, in the meantime now, you say you started out as a lab…a peon in the Argonne structure there. But obviously, you promoted […] yourself past that…

FERRARO: Well, I became a senior scientist, in which case I could formulate my own research, which was an advantage, of course.

GRAYSON: So, at the time this work was done, where were you in your career, in 1958?

FERRARO: I was still in the solvent inspection group.

GRAYSON: Okay. So you were still a…

FERRARO: Let's see.

[3] Ferraro, "Recent Trends."

GRAYSON: You haven't gotten your…

FERRARO: My senior scientist yet. I think I can tell you when I got it here. Exactly, I don't know. Here it is. But it was after this sort of thing.

GRAYSON: After this…

FERRARO: Course in…let's see, when was this published?

GRAYSON: This was April 1958, I have the book. Okay. I'm trying to find this *Analytical Chemistry* paper in here. […] You're the sole author on it.

FERRARO: Yeah. This was published [1967], the pressure…

GRAYSON: Okay. Did you get a chance to look over this publication list?

FERRARO: Well, I did skim through it.

GRAYSON: Okay. […] I did reorganize one…it's ordered by year. But I don't see that…this paper in that [list].

FERRARO: One of the things that you could see the value of going over to far-infrared, here is a spectra of these particular complexes, mercury, cadmium, zinc. They're identical, and then…you're only looking at the organic expression, but when you go to far-infrared, then you can identify them. Here they are [different].

GRAYSON: Ah, yes.

FERRARO: They're different, because your metal to the bond there to the organic ligands is different. So, the theory there was that if you want to look at inorganic compounds and coordination compounds, you'd better go into far-infrared. I could identify them, but if you want to use infrared or other things you could do, of course, but… <**T: 55 min**>

GRAYSON: So then, in addition to kind of motivating the development of instrumentation for covering this group […] of frequencies, you also work with this diamond anvil business, where you were looking at these things, how they behaved under pressure.

FERRARO: That's right.

GRAYSON: And so, under pressure these bands would shift?

FERRARO: [Correct].

GRAYSON: And what information were you able to extract from the band shift […] when they were under pressure?

FERRARO: Well, they [would] always shift to higher frequency, because you're tightening up the bond. That was of significance, because before this work, I didn't know what would happen. So, that's one of the major things that came out of that.

GRAYSON: But that did require some instrumentation development on your part, because…

FERRARO: Yeah. We had to modify and change the optics of the beam condenser. Otherwise, we wouldn't be able to […] get the thing in the path of light…

GRAYSON: Yeah, because I guess the examples are fairly small…

FERRARO: Very small, yes. Depending on size is how much pressure you get, the smaller the size to the area of the pressure.

GRAYSON: So you're talking millimeters, or…?

FERRARO: You want to measure it that way, yeah, that's possible. We were able to reach 100,000 atmospheres on a lot of these things.

GRAYSON: Wow.

FERRARO: And provided that they were in good alignment with one another, you didn't crack them, but diamonds could crack.

GRAYSON: Oh, yeah, yeah.

FERRARO: But there were a lot of applications of this sort of thing, and so I'm studying the earth and a lot of the materials that are under pressure in the bowels of the earth and so forth. It was a lot of practical […work]. One nice thing is that I understand it, see basic subject matter, and a lot of laboratories did not stand behind you to do it. I was lucky to understand that.

GRAYSON: Well, I mean, I guess you got a little bit more freedom than you would have had in an industrial lab.

FERRARO: Yeah, right, exactly. It was a wonderful place to work from that point of view.

GRAYSON: Yeah. How is that…

FERRARO: Almost pseudo-academic in a sense, you know.

GRAYSON: Is that still that way now, or has that evolved with time?

FERRARO: Well, they've changed their functions so much now that they're going in for more practical things, batteries and things like that. I've been away now for six years. Actually, I took an early retirement in 1980 and went for five years to the University of Loyola in Chicago, Searle Professor of Chemistry in physical chemistry.

Then I came back to Argonne […] in 1986 as a…more or less like a consultant; there wasn't terminology for what you were. But anyway.

GRAYSON: Now, did they ask you to come back, or did you show up at their doorstep? Or how did that work?

FERRARO: No, but actually when I went to Loyola, I still had connections doing basic work with other people in there.

GRAYSON: Okay. Well, I don't know…

FERRARO: […That] type of work.

GRAYSON: Yeah, okay. Well, I'd like to explore some of these other things, but why don't we continue with Argonne, since […] finally, I guess you kind of went up through the ranks in a fairly steady fashion there. Probably…

FERRARO: Oh, yeah.

GRAYSON: …starting out, and eventually you made senior scientist, which gives you the freedom to do more than…

FERRARO: That's right. You set your own program, your own research program.

GRAYSON: Yeah. Did you have any people working for you at the time?

FERRARO: Oh, yeah, sure. Well, and the other thing that we always had is students coming in working, either for their graduate degree or we had undergraduate kids come in, and it was an idea of sprinkling of what research would be like. I had quite a few of those.

GRAYSON: So when did that program start, when you brought in undergraduates? That was not something that was done…you know, […] until more recently, right, bringing undergraduate kids?

FERRARO: Well, I would say about in the 1980s, probably, or even earlier. It was <**T: 60 min**>…

GRAYSON: So this was people that had an interest in science, and you want to kind of give them a little tweak in it.

FERRARO: Right, right, give them a little research project, and they had all the capabilities of using the equipment. So, if I show them how to use it, bup, bup. It worked out real well. At the end of that period of time, I had to write a summary of what they did, and it worked nice. They gained great experience.

GRAYSON: Yeah. Do you know what happened to some of these kids? Did they go on to…?

FERRARO: Yeah. I still keep track of one of them that's working in some chemistry laboratory in Detroit, [Michigan]. Yeah, the rest I've lost track of.

GRAYSON: Sure, sure.

FERRARO: Then you have a lot of college teachers that come in and take the courses too. See, we had an educational division. We had these people on Saturdays and gave lectures on different topics [that] we were …

GRAYSON: So did you have to kind of maybe keep them current with what's going on in the science and give them some exposure to the laboratory environment, and […] research, cutting edge of the research, so they see where the field is headed. So you also had students in colleges; anyone in particular or just all over the area? I know there's a ton of…

FERRARO: Usually we had what they call an Argonne National Laboratory University Association. There are about a dozen of these, and they would come from those […] schools […].

GRAYSON: Because there's a lot of schools in this area, I mean, just driving around town …

FERRARO: Yeah, I know.

GRAYSON: It's amazing.

FERRARO: Pretty […]—what would you say?

GRAYSON: Saturated.

FERRARO: Pretty loaded.

GRAYSON: Yeah, yeah. So you had people working for you during this period. […] How big a group did you end up running at one time?

FERRARO: Well, I think if you excluded the students, I'd say about five or six full-time, yeah.

GRAYSON: So what other significant developments did you work on during this period when…now, you have this diamond anvil thing, you know, you have the far-infrared technology to take advantage of what was going on there […].

FERRARO: Well, when I went back to Argonne after Loyola, I got associated with [the] superconductor group [directed by] Dr. [Jack] Williams, and I was doing the molecular spectroscopy on these [molecules]. But it was a little different, because I was working for somebody who was, you know, in the…doing sort of technician type of thing. But we were doing spectroscopy on some of the superconductors. That was another fallacy; that people said at one time you couldn't get a superconductor that wouldn't conduct […] greater than 26°, 24° Fahrenheit. But that wasn't true, and we found out differently. […] Williams wanted to look at some of the organic type of materials, […] which…the other were well-known by this time, the inorganic. So, that's one of the things we did. Now, then I went back to the…I left Jack Williams, and went back to the chemistry group, nuclear chemistry group. I got involved in that just up to the time I left, went to third phases. Are you familiar with those?

GRAYSON: No.

FERRARO: Well, if you take an inorganic salt, like, say, cadmium nitrate and dissolve it in water. You hit it with nitric acid, and…let's see, I can't remember what I would do with that. The organic solvent, providing you had the nitric acid in there, you would separate into three phases.

GRAYSON: […] We've got, the three phases we know about, gas, liquid, and solid. So, you're talking about another phase?

FERRARO: I'm talking about three liquid phases.

GRAYSON: Three liquid phases.

FERRARO: Yeah. You've got the sheet here, it'll show you a <**T: 65 min**> picture of it, if I can find it. Anyway, the three phases, the original phase which is, the aqueous, has a higher density. It's in the bottom. Then, there's an organic phase, which is, from a volume point of view, the smallest, in the middle. That has all of the thorium nitrate in the majority of it, and the nitric acid that's in there. Then, you have the other organic phase, which is the light phase, which has some thorium nitrate in it, but most of the stuff is in the third phase. We want to know what the third phase is constituted…what the species was in the third phase.

GRAYSON: The third phase being the one on top.

FERRARO: Middle.

GRAYSON: Middle.

FERRARO: That's why I wanted to see.

GRAYSON: Oh, okay.

FERRARO: I'll show you, because it's kind of vivid. Well, can't find it. But anyway, we'll find it before the day's over.

GRAYSON: Okay. So, this was a development that came about because you were using this particular way of separating these…dissolving these compounds.

FERRARO: Yeah, right. It came because of that, and when they put the thorium and the nitric acid in there, then you got the third phase, which gums up everything, if you're going to do separations.

GRAYSON: Well, yeah.

FERRARO: And you could avoid it by throwing in a polar solvent, like acetone or ethanol, and then, the third phase would never appear. But there was a danger here, because you could have an accumulation of a phase that contained a considerable quantity of actinide, let's say. It could probably get you in some trouble, as far as exploding. So that's another area that I went into, and up to the end of the time that I spent with [Williams].

So, my career has been, as far as research is concerned, it's been very diverse. I've worked with separation chemistry, also high pressure, far-infrared and near-infrared, low-temperature superconductors, spectra. Oh, I won the Argonne award one year there, for my research in...you were allowed to go to spend a sabbatical somewhere.

GRAYSON: Oh, great.

FERRARO: It was at the infancy of FT-IR, Fourier Transfer stuff, infrared and I wanted to know more about this. The observatory over there was usually where you transform methods. So, I went to the University of Arizona, the Lunar Planetary Lab. I was heralded with open arms [by Professor Kuiper…]. But he said, "My God, a chemist. We don't have a chemist here." I'll tell you what I did there. I went there to…

GRAYSON: This is Arizona.

FERRARO: University of Arizona at…

GRAYSON: Flagstaff?

FERRARO: No, not…

GRAYSON: Tempe?

FERRARO: Tucson. Yeah. So what I worked on, they were observing these outer planets, and the different [ices] in the outer planet, of the planet itself, and had no way to compare the spectrum they were getting infrared with known materials. So, he wanted me to go ahead and start looking at ammonia, ammonia sulfide, H_2S, methane, carbon dioxide [at] low temperatures and usually before you transfer to spectroscopy, and which I did. By the time I left—I only spent a year there—I had formulated a compendium of these laboratory [ices] that could

possibly be materials that <**T: 70 min**> were on the outer surface of these planets. A very productive year, and good experience.

GRAYSON: So this was based on…he came out with the compounds based on your suspicions of what was there? You came up with…

FERRARO: Possible…possible materials…

GRAYSON: You came up with the spectra of these various compounds you wouldn't normally be looking at, using Fourier transform technique, so I guess for astronomical purposes, before you transform, is it a better method of exploring spectra than the conditional…

FERRARO: Method, yeah.

GRAYSON: …method, and so that's…yeah. Was this at a time when Fourier transform was…

FERRARO: Just starting.

GRAYSON: Just starting, I guess, and it started with the astronomers, wasn't it?

FERRARO: Right. I had gone to the astronomy department first. I think being a chemist there was foreign, so we didn't hit it off.

GRAYSON: This was the astronomy department in…

FERRARO: Tucson.

GRAYSON: In Tucson.

FERRARO: At the University of Arizona. When I got to the Lunar Planetary Lab, [Professor Kuiper] was looking for somebody that could do this kind of work, and so I did. Of course, then the other thing is, all this diverse career, the importance of far-infrared. I actually did some

work with immune stimulator drugs on a consultant basis. I was working with a guy that was making these things, and we were studying them and so forth, and got some good results. The unfortunate thing about that was he died in the middle of all this, and it went down the drain. But that was okay.

GRAYSON: So sometimes people want to suppress the immune system, because it gets kind of wacky. But these were actually drugs to stimulate it.

FERRARO: Like my wife, her immune system is shot, and she has trouble with infections, particularly in the urinary canal.

GRAYSON: Oh, my.

FERRARO: In December, I almost lost her. She had an infection in her urinary canal, and there's no manifestation, except all of a sudden, her temperature shoots up. But she became a little incoherent. Then I took her temperature, and by the time I got her to the hospital, it was 104.5 [degrees], knocked the hell out of her heart rate and everything. Then, we have continued series of these, but the first one was the worst, because it was *E coli*. I always thought *E coli* was associated with the digestive tract, never with the urinary tract. To this, I don't know enough about the anatomy, but the fact is, I tried to get this out of her experts and doctors, and […] the specialists, they couldn't tell me what the path might be to go from one [tract] to the other. But be that as it may, that's what happened. Anyway, back to business.

GRAYSON: Okay. So, when you decided to go to college, your selections were just based on your previous experience or were you given recommendations from people? […] How did you decide that you wanted to go to IIT?

FERRARO: Well, one, it was local. When I first went to IIT to get my bachelor's…the thing there was I didn't have the monetary funds to go anywhere else.

GRAYSON: Okay. So, in those days, what…I mean, college education nowadays is getting a little pricey. What did they used to…what were they charging you then?

FERRARO: I don't remember. [laughter]

GRAYSON: Okay. But it was something that you felt you could afford, and…

FERRARO: Well, I had saved for three years from the job I had during the Depression, and it was enough to do it.

GRAYSON: So, this convenience of it, and obviously the price was right.

FERRARO: Yeah. The economy and so forth, the situation, yeah. There was no choice that I could say I could go to Harvard [University] or Princeton [University], or whatever.

GRAYSON: So were there any particular teachers in that environment at IIT that struck you?

FERRARO: Yeah. There were.

GRAYSON: And helped you along in you… and kept you interested in chemistry and your scientific…

FERRARO: No. In the undergrad, it was a man by the name of [Norman] Kharasch, and he was the nephew of another Kharasch [Morris S. Kharasch] that worked in [chemistry and] was from the University of Chicago. <**T: 75 min**> […] Norman is his first name. He went to work as a professor at the University of Chicago, but I don't know what his first name was.

GRAYSON: And he was teaching…

FERRARO: He was teaching chemistry, various courses in chemistry…

GRAYSON: Okay, you said general curriculum…

FERRARO: Yeah, right. And he encouraged me, saw my potential, I suppose, and that's what happens.

GRAYSON: So obviously, the education you got there was… put you in good stead, in terms of doing graduate work and also…

FERRARO: Very good, because I get back to Norman…to Ralph Pearson, I said before. Went to Northwestern, he was a year ahead of me. We both were at IIT at the same time. So, he turned out to be quite a good scientist, got many awards and so forth. Fundamentally it was a good place: it was a good school, you got good training, good coursework and so forth.

GRAYSON: […] So it's basically, a science pure…was it fairly pure science? I mean, they'd have to have some English and all that kind of stuff.

FERRARO: Oh, yeah. We had all that stuff, you know, that goes with it, of course.

GRAYSON: […] Do you recall size of the school at that time, was it fairly large? It was probably dominated primarily by local students?

FERRARO: That's probably the truth, yeah. Kids that couldn't make it anywhere else, financially or whatever. But that's what it was, local, you know. When I went to Northwestern, same thing, although it was on a GI Bill of Rights, I didn't have a car. I used to ride the streetcar to go to [anywhere] on campus or anything else.

GRAYSON: Yeah. That's a bit of a haul from where you…you were living down in this part?

FERRARO: I was living in the…I would say, I don't know if you know Chicago.

GRAYSON: A little bit. I'm learning more about it.

FERRARO: Fullerton [Avenue] and Austin [Avenue]. So I had to get down to the "El" by bus, and then catch the bus and go.

GRAYSON: That's one thing I appreciate coming here is the transit system. You know, the local transit system is very, very good.

FERRARO: Very good.

GRAYSON: It's very good. […] I have a son who is on the faculty out at Northwestern, and so I'm out here regularly to visit him, and so I'm becoming much more familiar with the Chicago area.

FERRARO: Well, I have a grandson that lives in St. Louis, [Missouri].

GRAYSON: Oh, okay.

FERRARO: So, we haven't gotten out there. He wants us to come out because we have a great-granddaughter there, she's going to be three. We want to get out there, except that I don't drive on the highways anymore, have to take a train, but…

GRAYSON: Well, they're improving that. A lot of times, my wife and I'll take a train up from St. Louis, because it's very inexpensive, and plus the hassle and the flying.

FERRARO: Yeah. That's the trouble with the train is you have to catch it in Chicago. […] If you're going to go for a few days, you have trouble with a bag, and go to Chicago. It gets to be a little awkward.

GRAYSON: Schlep a bag around, yeah.

Okay. So, I think we kind of moved through a lot of the career stuff here, and so, I mean, did you apply to any other position, places when you finally got on with Argonne […]? Did you apply to a bunch of other places, or were you just…Argonne came through? How did that work?

FERRARO: I think I applied at Abbott [Laboratories] and Argonne, was the only two. In fact, I was offered one at Abbott too, but I decided to go to Argonne.

GRAYSON: So finally, you got the position of your career where there were jobs available, finally.

FERRARO: Yeah. Well, during the course of time that you're at Argonne all these years, there were times where I paced presumably, out of curiosity, I suppose…I did look around to see whether I could do any better. But I always came to the conclusion that **<T: 80 min>** I

was…where I was at, was the best. I was offered a chairmanship of chemistry at University of Missouri.

GRAYSON: Oh, okay.

FERRARO: What's the name of that town?

GRAYSON: Columbia, [Missouri].

FERRARO: Columbia, yeah, right. I didn't accept it though. But…

GRAYSON: Well, I mean, you know, these are…

FERRARO: You make your choice, you make […] the right one, make the wrong one, so…

GRAYSON: Yeah, yeah. You know, these decisions that come along, and…but do you recall what year…what part of the time of your career that offer came along, came up? […] You'd been at Argonne for a [little] while.

FERRARO: Later on, I think it came. I think…

GRAYSON: Mid 1980s, 1980s?

FERRARO: Yeah.

GRAYSON: Somewhere in there.

FERRARO: Because in the 1980s, I retired from Argonne.

GRAYSON: Oh, okay.

FERRARO: That would be in the 1970s.

GRAYSON: Okay, 1970s.

FERRARO: Late 1970s or something like that.

GRAYSON: So, okay. So you worked there…you say you worked there from 1965…

FERRARO: Well, including my consultantship…

GRAYSON: Coming back, okay.

FERRARO: Yeah, right.

GRAYSON: That would be an interesting offer to just come out of the clear blue sky, or was it…did they call you up, or send you a letter, or…?

FERRARO: I saw an ad for it, responded Sometimes you just throw out the hook.

GRAYSON: Yeah, well.

FERRARO: See what happens.

GRAYSON: Sure, yeah. Why not? So you kind of basically ended up working in government, but it was not […]…it wasn't any…just that they looked like they had a better offer, better job for the thing you wanted to do.

FERRARO: Yeah. Well, you couldn't beat the fact that they could go basic, too. I was intrigued by that.

GRAYSON: Yeah. And as time has progressed, it's harder and harder to find places that …

FERRARO: Will do that.

GRAYSON: …will do that, yeah.

FERRARO: Right, right.

GRAYSON: So what…I've got a thing here about challenges in general during your early career. Did you like…

FERRARO: Well, yeah. It was a challenge. I bring it up, but not because of something that bothers me anymore, but when I came out of the War in 1946, I interviewed a number of places. One of the places was in Argo, [Illinois], which was the starch company there. Forget the name of it. The man in charge was Dr. [Albert L.] Elder, who eventually became president of the ACS [American Chemical Society], several years down the road. I had just finished working for Dr. Hurd, and he knew Dr. Hurd very well. So, I had a foot in the door, as it were.

He got to cogitating like I'm sitting with you, and telling me, "Ferraro, is that Spanish?" I said, "No, it's Italian-American." [He said], "Oh, so Italian. We have a lot of Dagos out here, loading boxcars and so on." So I just got through three and a half years in the war. I'm going to take this kind of shit from him? I got up and walked off. But the point I'm making here is that I was going to override these things. I could have taken another avenue, but I said no, I'm going to show these people what I can do, what I can't do.

GRAYSON: Yeah.

FERRARO: Even previously to that, just recalled it now, I came out with my bachelor's and interviewed a bunch of people, you know, what you do when you're coming out. One of them was Bartlesville, Oklahoma, the oil company there. It was, oh, melting point of this, and freezing point of that, and melting point of that—common stuff, but I did all right, and I get the same damn question finally: is Ferraro Spanish? I said, "No, it's Italian." He says, "Oh, we chase Italians out of town." Okay, fine. Then, I'm chased, and I left. Should have punched him in the nose.

GRAYSON: Yeah. No, but…

FERRARO: But you see, my career has spanned so much, that I've actually gone over to the point <**T: 85 min**> where there's prejudice still existed. Now, I think it's over with, now. I hope, sometimes I wonder. Because based on [Barack H.] Obama, I mean, there's a lot of people don't like him because he's black. Yeah. I mean, so forget it.

GRAYSON: Yeah. I think that is a large part of the…I don't know what you want to call it, but politics and whatever that's going on, surrounding Obama and his […]…I believe that there is some slightly undercover prejudice.

FERRARO: Sure.

GRAYSON: It's not as broad-based or as wide-open as it would have been twenty years ago, but I think it's still there.

FERRARO: I think so, yeah. It hasn't eradicated itself, even after all these years. It's too bad, but, I mean, on the other hand, they got the fallacy of being black, too. So, it always appears, this prejudice. You know, in my case, well, I'm white.

GRAYSON: Unless they ask, whether you're Spanish or Italian, they don't know whether to insult you or not.

FERRARO: Well, it's pretty stupid on their part. They don't know that Ferraro is Italian. You got the Ferrari car, for crying out loud.

GRAYSON: Yeah, right. That's what I was thinking. I was like, this is Ferrari.

FERRARO: You know, I mean, how stupid can you get.

GRAYSON: So, I mean, did these people, were they surprised that you just walked out on them?

FERRARO: I don't think so. I don't think so.

GRAYSON: So that's interesting.

FERRARO: Maybe he wanted me to walk out, I don't doubt…

GRAYSON: Yeah. Yeah, it was a pretty crude thing. Figure a guy that ends up president of ACS, you'd think he'd have a little more…

FERRARO: Yeah, he became president of ACS.

GRAYSON: A little more…

FERRARO: When I got the first thing, the Bartlesville thing, well, I was just a kid, you know. So, I don't know anymore. But the other thing, that really offended me, because I'd just come out of the service.

GRAYSON: Yeah, yeah. It's amazing. Well…

FERRARO: These things happen.

GRAYSON: Yeah. I think that every…I'm sure, I don't know if you call it ethnic group or not, is this country is, it's tradition of being, you know, looked down on for some period of time.

FERRARO: Well, every one of these, you know…

GRAYSON: The Irish.

FERRARO: The Germans first, the Irish, then the Italians, and now the Latinos and so forth and so on. It goes through pecking order, I guess. You've got to have a pecking order that you can look at, and say, look, I'm on top.

GRAYSON: Yeah. Well, that's what a lot of it's about is, you know, I'm on top and you're not.

FERRARO: Yeah, right, and I want to stay that way.

GRAYSON: Yeah. So that was one challenge, that was kind of interesting. What about scientifically, when you were involved in your job? Were there any situations where you were…well, we know that you challenged early on about the alkalinity thing, but that was way back in the beginning.

FERRARO: Well, there's always good parts of my career, and I was rewarded and awarded a number of medals and plaques and whatever. But the bad events, I would say the only bad event I probably had is that, I was exposed to organophosphorus poisoning. Of course, the group, everybody was.

GRAYSON: Now, you know, those are…the organophosphorus compounds end up being insecticides.

FERRARO: Sure, sure, exactly.

GRAYSON: Yeah. So, I was thinking that, what's he doing with insecticides?

FERRARO: So, the bad part about that was, the fact that we should have been taking periodic exams for liver function, and never did until I got sick. Then they brought everybody in from the group. I wasn't alone. I was not in my group then. It was earlier. We all had some problems with [the] liver.

GRAYSON: So did they know at the time that these things were insecticides?

FERRARO: They knew, sure. They knew.

GRAYSON: But they didn't […] put two and two together, and nobody thought about the fact that you're dealing with things that are poisonous.

FERRARO: Nobody probably thought about it, problems in oversight I think. When we got the exam, you know, they kept us off organophosphorus stuff for several months. Then, by that time, I got out of the organophosphorus stuff.

GRAYSON: So what happens to the liver then? It's probably trying to dispose of this compound, and it's being poisoned.

FERRARO: Being poisoned, yeah. Later on, I took another liver exam at the University of Chicago. It wasn't top rung, if you know what I mean.

GRAYSON: Mm-hmm.

FERRARO: But superimposed on that, three and a half years in China <**T: 90 min**>-Burma-India theater, I had to take Atabrine for malaria.

GRAYSON: Now, wait. What's that called?

FERRARO: Atabrine […].

GRAYSON: Atabrine.

FERRARO: One a day and your skin turns yellow, which, you know, it's affected your liver, for three and a half years. Even when I got home, I had to take these pills one a day for six weeks. Between the two, I don't know what my state of my liver is. The fact that I've lived as long as I have, I mean, that's super…

GRAYSON: Yeah. It's still working. So, yeah, they were on a high preventive maintenance program for malaria then.

FERRARO: Oh, yeah.

GRAYSON: Sure, because they…

FERRARO: They don't use Atabrine anymore, because [I have a] granddaughter who is going to go to Zambia this summer, a six-week course. They're using other things now, one-a-week pill.

GRAYSON: Oh, wow, okay.

FERRARO: It's not too bad.

GRAYSON: So, I guess, did people suffer? Did […] any Americans end up getting malaria, or did this particular…

FERRARO: Some of them did, because they failed to take their pill, and coming back on the ship, I think six guys got malaria. They just didn't want to take their pill anymore. It was, kind of, as far as the your surface of your skin is concerned, not only were you yellow, but you kept a tan too, so a hell of a color that you had your face when you came home, oh, boy.

GRAYSON: People didn't know…didn't recognize.

FERRARO: Who is this guy?

GRAYSON: Yeah.

FERRARO: Mosaic of colors.

GRAYSON: So that's pretty scary stuff, but I guess the disease is a lot worse.

FERRARO: Yes, of course it is.

GRAYSON: So, I guess, living in that part of the world…

FERRARO: Well, that part of the country. I mean, it's horrific. We had malaria. We had all kinds of skin-borne diseases that knock you off.

GRAYSON: Yeah. Things were a little scary.

FERRARO: I only got sick in…one day, one night in China/Burma. But I took all kinds of precautions. Of course, at night, we had the cots with the four poles and you put the [mosquito nets] around [it]. And before you went to bed, a couple hours before, you sprayed it with…what was the name of that stuff they banned? I can't think of it—[DDT]. But I avoided it, and I'm here.

GRAYSON: Yeah. So, mature careers…if you're assessing your career direction, it looks like you kind of just followed the signs, pretty much.

FERRARO: Yeah. Never went into the managerial or stuff like that. I wouldn't be interested in that. It wasn't interesting to me.

GRAYSON: Was that a possibility?

FERRARO: Oh, yeah. It was a possibility.

GRAYSON: In that environment.

FERRARO: Oh, yeah. You know, in the case of chemistry, there was director; could have been director of the chemistry division.

GRAYSON: So how large was the chemistry division, all together?

FERRARO: We had a maximum probably of about two hundred.

GRAYSON: Okay.

FERRARO: Yeah. It's very much diminished now. Last I heard, they were still discharging people, cutting down size. Finances, you know, be what they are, not good.

GRAYSON: No, the economy's getting pretty tough.

FERRARO: Yes.

GRAYSON: So during your career there, were there other cutbacks as well and financial issues?

FERRARO: Yes. We went through a period, I would say about almost 50 percent of my career there that were beautiful; money, all you want before the year ended, you know, there was money left over. I think the office people would come around and say, "Here. Here's some money, if you want to spend it. If you don't spend it, […] we're going to take it back." You know, that sort of stuff. But the last half, it was different, always cutting down, cutting down, cutting down.

GRAYSON: So, what did they do when they come up with a pile money to spend at three weeks? I mean, you can't hire anybody.

FERRARO: Maybe can get some equipment.

GRAYSON: Yeah. I mean, that seems to be about the only thing…

FERRARO: That seemed the only…well, that size money, anyway.

GRAYSON: Yeah. But you just kind of <**T: 95 min**> like…you want to use it for something, so you just say probably, get their equipment or supplies or what have you, and stock up on stuff you know you're going to use in a year, whatever. Yeah, I'm not sure the budgeting process they use is all that efficient, but…

FERRARO: Yeah, I know that. But you have to live with it, I guess. You know what I mean. We always used to say, "Here come the bean counters." Now, what you have over there is, not only the bean counters, but they have the safety people. Now you've got to do everything according to safety, and to hell with the research. I don't know. There's no perfection, I suppose.

GRAYSON: Well, a friend of mine is in research work. When I was in McDonnell-Douglas Research Labs, his comment on retirement was he thinks, seeing his career retrospective, it was coming. He said that he thinks that he lived through the Golden Age of research and industry. And, you know, that's just the way…

FERRARO: Not any more.

GRAYSON: Yeah. He had the funds to do what he wanted. He had the resources to get it done. He had the ability to direct it in the way he wanted. So your financial support was always kind of there, but I mean …

FERRARO: The first part, let's say the first part of my career was…there were no problems. You submit your program you're going to work on, and it was generally accepted.

GRAYSON: Who looked at the…

FERRARO: It went back to Washington, [D.C.].

GRAYSON: It went back to D.C.

FERRARO: Yeah. They had people over there that would give you the rundown, and whether this is agreeable or not.

GRAYSON: Okay. So, like project managers or what not?

FERRARO: Yeah. That's what they were, yeah.

GRAYSON: See, when I was at McDonnell-Douglas, we had this research and development program. There, basically you…I think it's kind of similar. You presented the work that you'd done at the end of the year, and they looked at that. The way that worked is, the government, since we can…McDonnell-Douglas had so much government contract work, there was a specification in the contract that a certain amount be spent for research and development. So, what would happen at the end of the year, they'd look at what the company had spent that year, and say, oh, we're going to pay you for 90 percent of that or 85 percent, or 90. So, that was kind of a…

FERRARO: Well, that seemed to be pretty reasonable

GRAYSON: Yeah. So that was the way it worked. So, obviously, your research had to be relevant enough to get that chunk paid off.

FERRARO: To do that, sure. Yeah, right.

GRAYSON: Then the bean counters, well, the M.B.A.'s moved in, and said, "Well, we're giving you this money, and you're supposed to return 25 percent of it. […] We're not even getting it all back. You know, we have to spend 15 percent or 10 percent for you to do this research." Oh, this is not the way it works.

FERRARO: That's right. I want to show you [how the three phases separate, and that the third phase is in the center]. This is the third phase.

GRAYSON: Oh, okay.

FERRARO: The black one in the middle of the third phase. I couldn't find that, because the paper clip around…

GRAYSON: Oh, okay. This is, like, a poster. Okay.

FERRARO: Yeah.

GRAYSON: So, how did you resolve this third phase as being…it looks like it's some kind of a…

FERRARO: Well, we…in the case of thorium, you had thorium nitrate and three TBPs would hook on. In the case of uranium, uranium nitrate, two TBPs, and the nitrate would not hook on, in the species, for major species, anyway. All done by spectroscopy. Well, we also did x-ray, and what else? Full neutron scattering and so forth…

GRAYSON: Okay.

FERRARO: But a lot of looking at these solutions and…

GRAYSON: So this looks like some kind of an aggregate of the…

FERRARO: Yeah. The overall thing is an aggregate, very complex, yeah.

GRAYSON: I guess it'd probably be nice if I could get a copy of that, or make a copy and send it back to…

FERRARO: Well, we could do that.

GRAYSON: So we can improve this …

FERRARO: Yeah, because not many people know about this. They know…

GRAYSON: So you had plenty of interactions with other academic, [industrial], and government organizations <**T: 100 min**>. Your environment there…you're always getting graduate students in, and undergraduates as well. So that is really, you had a broad interaction with the scientific community. You weren't kind of cloistered away in Argonne there.

FERRARO: Yeah. The nice thing going to Loyola is you've got to get point of contact with students that were full-time students, not just visiting us in some sense. That gave me another avenue, another outlook.

GRAYSON: Yeah. Now, when you were at Loyola, you were teaching. How many hours would you carry? What…

FERRARO: Well, I went there, and stipulated—maybe that's not the right word—that I didn't want to teach any basic chemistry, because they get all the pre-med, pre-nursing. I didn't want that. I figured, too late in my life to start doing this sort of stuff.

GRAYSON: Well, the…

FERRARO: I taught advanced physical chemistry. There were different topics that I could choose from, and over the course of five years, we chose a number of them, you know. What made it nice, I only got a handful of students too, to work with.

GRAYSON: So it was, kind of…these were primarily graduate students.

FERRARO: Right. Yeah, graduate students.

GRAYSON: And so, you had full faculty privileges and all that?

FERRARO: Well, sure.

GRAYSON: And you were…

FERRARO: Yeah. I ended up with a…what do you call it? Oh, yeah. I was […] emeritus professor, right.

GRAYSON: Oh, okay.

FERRARO: Which maybe is not justified, since I was only with them five years, but anyway. They gave it. I took it. [laughter]

GRAYSON: Yeah, sure. Why not? So, basically then, you were interacting primarily with graduate students now.

FERRARO: That's true. Yeah, yeah.

GRAYSON: Well, it's a good school. It's…

FERRARO: Yeah.

GRAYSON: So how did you come upon this position? Did they…

FERRARO: Well, the Society of Applied Spectroscopy had monthly meetings. Dr. Moore, very good friend of mine, was the chairman, Carl Moore, at the time. […] At one of the monthly meetings, I was telling him […] "It's just, I'll try to devote my life to something else." Oh, he says, "You know what?" He says, "We've got a"—well, what did he call that thing—"program," and he said, "With Searle, and they're offering a five-year professorship in physical chemistry, and right down your alley." He says, "How would you like to come?" That's how it happened.

GRAYSON: Wow, that was nice, kind of like good connection at the right time and place.

FERRARO: A break, whatever you want to call it.

GRAYSON: So, you say you took early retirement from Argonne. Is that…were you feeling like you finally…things were getting nasty? You didn't want to put up with it anymore?

FERRARO: Well, that was one of the reasons. I mean, it was becoming tougher to guard our money. They take people away from you. That went on constantly. Got down to where it's one [scientist] besides myself, it gets…kind of [irritating] you after a while.

GRAYSON: Oh, yeah. No, I understand. I've been there.

FERRARO: So, I just decided, well, what the heck. I've had thirty-two years here, so. And then, when you consider my background in the war and so forth, and you get, kind of…

GRAYSON: Yeah, yeah. So…

FERRARO: But then I went, and then found out that, you know, it was great to be at a university, too. I mean, especially the contact, one-to-one, with full-time students. But then I found out it was a Jesuit school, you know.

GRAYSON: Oh, yeah.

FERRARO: I found out that the politics at an Argonne National Laboratory, which is government-supported, and one [at] a university, and I found out that the politics were worse in a university. [laughter]

GRAYSON: Yes. I think that is…I think most <**T: 105 min**> people would concede that without too much of an argument.

FERRARO: Right, right.

GRAYSON: So, you had contact with the students. But were you also…did you do any lab work, or have any lab…

FERRARO: Oh, yeah. We had lab work, sure.

GRAYSON: You had your own lab?

FERRARO: I had something. I was able to get myself an FT-IR. We did research and carried over a lot of the pressure measurements with the diamond anvil cell. We did work on lattice vibrations of […] solids, but low frequency, way down, 30 degree—33 wave number and so forth. There was a particular lattice mode that could not be done by infrared directly going through the solid. You had to do it by reflecting method. So, we had to design some kind of a unit that we could do in the diamond anvil cell, a reflectant type of measurement. Then the lattice mode would show up in the spectrum. So that was presumably a contribution, to an extent, you know.

GRAYSON: So you're looking at a very fundamental property of…I guess these are…

FERRARO: Alkaline metal solids.

GRAYSON: Yeah. These would be crystalline.

FERRARO: Crystalline.

GRAYSON: Yeah. They had to be crystalline, right, to…

FERRARO: Yeah. Oh, yeah, right. Now, the young lady who was in my lab who—I call her my last resource—she is now working for that company with the microscope [McCrone Associates…]. Right here in one of the suburbs. Excellent student. She was one of the brilliant kind of girls that…it's kind of interesting, because I must have had about, I would say about ten Ph.D. students, between Argonne and…and nine of them were women. Figure that one out. I never asked for it.

GRAYSON: Yeah. Well, I was kind of curious, because I looked through…I don't know. I did an analysis of your publication writing. I noticed a couple of things. It's kind of a…

FERRARO: Oh, mm-hmm, interesting.

GRAYSON: …a peak in the, what is that, 1970s, and you were putting out a significant number of publications per year.

FERRARO: Yeah.

GRAYSON: That's…I mean, that's a lot of work, sixteen…

FERRARO: Yeah. But at that time, I was maximum-size group, too, four [to six] people.

GRAYSON: So when you were you were doing this…you can keep that.

FERRARO: Yeah, it was interesting.

GRAYSON: When you were supervising these people in your group, they were […] you were really more directing a research, instead of […being] involved hands-on with it?

FERRARO: Well, I was always hands-on too.

GRAYSON: Okay. So they were leading the research, but you were close to keep tabs on what was going on, and…

FERRARO: Yeah, sure, sure.

GRAYSON: …and making contributions with regard to how you should proceed and so on, so forth. Yeah. Well, that's…yeah, I've got that on, you know, computer files, so…

FERRARO: It's interesting when people with the…list the publication.

GRAYSON: Yeah. Well, when I was looking through this list, I noticed that that's one thing I noticed. I looked at the authors.

FERRARO: Female, huh.

GRAYSON: And there were a lot of authors, female authors. I just, kind of…this just shows that your publications…

FERRARO: Yeah. Some of these are the students.

GRAYSON: Yeah.

FERRARO: Undergrad.

GRAYSON: Yeah, I was wondering about how that came about.

FERRARO: Right, right.

GRAYSON: These first few pages are ones where there's multiple papers. The rest of these were all just a single paper. So, I don't know how…a lot of those probably, you know, you were included on it, as an author. But you can have those too, if you want. It shows…the number there refers to number of papers published with that author, with the person as a coauthor. I had to go through those. The problem is they, you know, there's G. Smith, and there's George Smith. There's G. A. Smith. So, I had to condense those down to the one that…so you knew that they were all the same person, with all the same publications. But I was

just struck by the fact that, yeah, there's a lot of female coauthors. Like, what's John up to <**T: 110 min**> here.

FERRARO: Just, you know…

GRAYSON: Luck of the draw.

FERRARO: … I had circumstances develop, you know.

GRAYSON: Now, I guess with that, a good question would be, at what point in your career did you start to see more women in the sciences or interact more with women in the field that you were in? Was there much…did you have many women working at Argonne with you?

FERRARO: No, [there were] not as many as you might think. See where I can maybe give you a date here. Yeah, okay. Interesting, because my first student, Priscilla Walling [LaBonville], she retired from her job, and invited me to the party they had. I said, "Gee, I don't know how I feel." I said, "Here, it's a student retiring, and I'm still active." Poor woman died in Florida [shortly thereafter].

GRAYSON: Oh, my.

FERRARO: She retired and she died. So, my first student's dead. Whatever that means, I don't know.

GRAYSON: So she would have been pretty early on, and that would have been…

FERRARO: I think she…

GRAYSON: When she first…

FERRARO: Would be, when she first came in here, one of the early publications, probably. I don't know.

GRAYSON: What's the last name?

FERRARO: Her last name may appear as LaBonville. She later got married. She has eleven publications with me.[4]

GRAYSON: Oh, okay. But that would have been fairly early on in your career […], that she showed up in the lab. So she worked with you at Argonne.

FERRARO: At Argonne. Yeah, right. Detroit University [University of Detroit], she did all her subject matter there, and then did her Ph.D. here. Yeah. I got her thesis here that can give you the date, if you want.

GRAYSON: Okay.

FERRARO: Another thing about predictions and things like that that the rare gases don't react. We did a lot of work here on some of the compounds. I mean our gas compounds. But did she have a date in there or something, 1970.

GRAYSON: 1970.

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[4] John R. Ferraro and Patricia LaBonville, *Space-Group Selection Rules* (Lemont: Argonne National Laboratory, 1971; Patricia LaBonville, John R. Ferraro, and T. M. Spittler, "Vibrational investigations of several alkali metal haloxenates," *Journal of Chemical Physics* 55 (1971): 631-640; Patricia LaBonville, John R. Ferraro, M.C. Wall, and Louis J. Basile, "Force fields for octahedral hexahalogen molecules," *Coordination Chemistry Reviews* 7 (1972): 257-287; Louis J. Basile, John R. Ferraro, Patricia LaBonville, and M. C. Wall, "Force fields for tetrahedral molecules and ions," *Coordination Chemistry Reviews* 11 (1973): 21-69; Louis J. Basile, Patricia LaBonville, John R. Ferraro, and J. M. Williams, "Hydrated proton H+(H_2O)n. II. Spectroscopic study and normal coordinate treatment of the oxonium and oxonium-d3 ions," *Journal of Chemical Physics* 60 (1974): 1981-1987; Louis J. Basile, J. C. Sullivan, John R. Ferraro, and Patricia LaBonville, "Raman scattering of uranyl and transuranium V, VI, and VII ions," *Applied Spectroscopy* 28 (1974): 142-145; John R. Ferraro, J. M. Williams, and Patricia LaBonville, "Modified Urey-Bradley force field for the normal coordinate treatment of oxonium ions H_3O^+ and D_3O^+," *Applied Spectroscopy* 28 (1974): 379-380; R. D. Willet, Patricia LaBonville, and John R. Ferraro, "Normal coordinate treatment of xenon fluoride oxide (XeO_2F_2)," *Journal of Chemical Physics* 63 (1975): 1474-1478; Patricia LaBonville, R. Kugel, and John R. Ferraro, "Normal coordinate analyses of the neutrol carbon oxide (CO_3) and sulfur oxide (SO_4) molecules," *Journal of Chemical Physics* 67 (1977): 1477-1481; John R. Ferraro, Patricia LaBonville Walling, and Anne T. Sherren, "Some new solid electrolytes: substituted organic ammonium silver iodides," *Applied Spectroscopy* 34 (1980): 570-575; J. I McOmber, D. F. Shriver, M. A. Ratner, John R. Ferraro, and Patricia LaBonville Walling, "Pressure dependent Raman, and conductivity studies of the fast ion conductors dicopper mercury tetraiodide, disilver mercury tetraiodide, and dithallium zinc tetraiodide," *Journal of Physics and Chemistry of Solids* 43 (1982): 903-909.

FERRARO: Yeah. So, I would say from then on, we got more and more students. It probably happened slightly before 1970, but you know. Let's see how this corresponds here. Yeah. Well, see. Right on […] one of the bigger peaks here on publications. But of course, it was quite active from then on till I retired. This was her thesis. Yeah.

GRAYSON: Sorry, transcriptionist, didn't mean to do that. Oh, okay, so you're looking at xenon trioxide. That's pretty clever. So, why did we…I mean, I say most of the noble gases are pretty unreactive.

FERRARO: Right, they are, but the indication was that they didn't react.

GRAYSON: They can be made to.

FERRARO: Sure. I think it was [Dr. Neil] Bartlett in Canada [at the University of British Columbia] was the first one that did it <**T: 115 min**>.

GRAYSON: Yeah. This is interesting too. Your old theses that are typed out, obviously, were typed out by…

FERRARO: Were typed out. Yeah.

GRAYSON: …typewriter, as opposed to word processing.

FERRARO: Yeah, so was mine.

GRAYSON: Yeah.

FERRARO: Yeah. Anyway.

GRAYSON: Get back to where we…so, yeah, there were. Did you do any patent work or anything…

FERRARO: Yeah. […] I got paid twenty-five dollars for a patent about…we didn't really do anything of that nature that allowed us to get a patent. So, I only had one.

GRAYSON: And it wasn't something that was…

FERRARO: No, no, no.

GRAYSON: …promoted or anything. Didn't want to mess with that.

FERRARO: That's right.

GRAYSON: And so, obviously, you didn't get anything worth…

FERRARO: No, no.

GRAYSON: Yes. Patents [are] kind of like a…they're not what some people think they are. What about with regard to publications. I mean, organizations like yours probably had some kind of an approval process that you had to go through before you could put it in a literature.

FERRARO: It was preapproved. But then it was submitted to the journal.

GRAYSON: Yeah. So, but I mean, were they looking for, like, material that they didn't think they wanted to have out in the literature, or were they just making sure that they looked like the science is good? Or, you know…

FERRARO: I think they…I don't know if the people who were looking at them, knew anything about scientific practice to be able to judge. But they would kind of look to see if there was anything that shouldn't be disclosed or whatever, that type of thing.

GRAYSON: Were you involved in what we call secret or top-secret type of work in your career there?

FERRARO: No.

GRAYSON: Although, I would imagine they were doing some things…

FERRARO: Oh, they always were doing some things like that, yes, sure.

GRAYSON: So basically, getting stuff published wasn't an issue in terms of…a lot of places can make it a pain in the can. But I know in some industrial labs, it's hard to get publications out.

FERRARO: Yeah, they're always worrying about patents and so forth, and so on.

GRAYSON: Patenting their trade secret type information …

FERRARO: Secrets, yeah. Right.

GRAYSON: Where they didn't want…

FERRARO: The thing…in the solvent extraction group I worked for, down at the - Don Peppard, was a student at Baylor, at the University of Illinois. He was at IIT when I was at IIT, so we had a long friendship. But, Peppard was always worried about somebody scooping him. For some reason, I never had that worry. I always thought, look. I mean, two guys can come. He'll put out a paper. You put out one. They're going to be different, because the direction that he's going and you're going, cannot be the same; I thought, anyway. It never bothered me, but him, it did. He was always worried about whether he was going to get scooped.

GRAYSON: Well, I guess in certain areas, things can be pretty competitive, you know.

FERRARO: Well, what do they say about competition? It's supposed to be good.

GRAYSON: Yeah.

FERRARO: Financially it is supposed to be…

GRAYSON: Yeah, yeah.

FERRARO: As opposed to scientific structure. I don't know. I don't think so.

GRAYSON: So, it's kind of scientific innovation. What does it mean to you?

FERRARO: Well, that's kind of an interesting…I looked at that. I said to myself, "You know, if you just look at the word innovation, and you say to yourself…does it have any connotation in terms of just looking at the word, innovation, that something develops from it. You know what I mean, that that's the end product, presumably. I always thought that, well, innovation means that something good came out of it. But that doesn't have that connotation. It really doesn't. I looked it up in a dictionary and it just says, "a new idea." Well, all my life I've worked on innovations, and since they haven't been world-shaking presumably, but on the other hand, they have been new ideas. What does a scientist do—scientists do—when he gets a new idea? He pursues it, presumably, you know. He doesn't know ahead of time, what's going to come. A lot of our discoveries are made that way, too. I mean, you don't know ahead of time what's going to happen. But you follow your instincts, and you think it's a good idea. It's an innovation, presumably. That's the way <**T: 120 min**> I always felt about that. Everybody probably has a different interpretation, in a sense, but…

GRAYSON: Well, I think [it's] a good point [you made] about the idea, that you have an innovative thought or approach to a problem that you want to explore, and a lot of times something happens that you didn't intend, or didn't foresee. Then, that gets you going in a direction that's totally different.

FERRARO: That's right. It happens that way, doesn't it?

GRAYSON: Yeah.

FERRARO: I mean, you think I'm going to go down this path, and all of a sudden, something happens and you go down another one.

GRAYSON: Now, if we just get the bean counters to understand that.

FERRARO: Oh, well.

GRAYSON: That'll never happen.

FERRARO: That'll never happen.

GRAYSON: So, it looks like you did a lot of professional networking with your peers, both inside and outside the company. You got some…didn't you go abroad for a while, and spend time…

FERRARO: Well, yeah. I did a lot of that.

GRAYSON: How did these things come about, visiting professor in Rome?

FERRARO: Who?

GRAYSON: It says here, "Visiting Professor at the University of Rome, 1966, 1967." Is that…

FERRARO: Oh, yeah. Well, I got that appointment with them—I'm sorry, sabbatical. I mean, we could take sabbaticals every so often. And I had been there a couple of times giving lectures, and it was kind of neat because of my background.

GRAYSON: Sure.

FERRARO: And I know the language. I could speak the language.

GRAYSON: So you could actually…so you grew up…your family spoke Italian, so you knew the…

FERRARO: Not the parents, but my grandfather.

GRAYSON: Ah, okay.

FERRARO: They would take the year, five years, six years, before I go to school. He's retired, my grandfather, who brought my father and uncle here. I'm living with him. First language I learned was not the Italian language. In a sense, it's the Sicilian dialect. But it close to the real language. It's from Florence. So, I know both of them, and that's the way I was raised, in a sense, I mean, with being able to speak the language. When I went there a couple of times, I gave lectures in Italian and they were kind of impressed—I competed with Fred Basolo. You know Fred?

GRAYSON: No.

FERRARO: He went to Northwestern. He's an inorganic chemist.

GRAYSON: How do you spell that?

FERRARO: B-A-S-O-L-O.

GRAYSON: Okay.

FERRARO: He didn't know the Italian language as well as I did. So, anyway, I was invited to go to University of Rome on my sabbatical. I got the sabbatical, and then I wrote to them, and said, "I can spend a year," and they accepted it. I went there, and it was all paid by the University of Rome. We were allowed to bring a car. My son was seventeen. My other daughter was fourteen. She graduated from grammar school there, and the little one was the seven. Interesting enough, the little one's seven, but before the year was up, she spoke precise Italian, and that window of language that you have. It was a great year. We had our car. It wasn't a small car, but we got by, and that's how that developed. Of course, I'd gone all over Italy, and then, from that time on, we've done collaborative stuff too.

GRAYSON: Was that your first trip to Italy, that when you went on sabbatical, or had you gone there previously?

FERRARO: I had gone there previously. I had gone to the University of Florence [and worked with Professor Luigi Sacconi]. But anyway, developed a lot of friendships with different universities by giving lectures. Then, they invite you back. Got to go to University of Cagliari in Sardinia. I spent a month there giving lectures on group theory.

GRAYSON: Even the Rome…one, two, three, four, four different times.

FERRARO: Yeah, right, but kept going back.

GRAYSON: Yeah. Well, it's a duty.

FERRARO: Well, in a sense, afterwards it became like a consultancy, because I sort of mentored them in their research—they were doing inorganic coordination chemistry—and helped them out as best I could <**T: 125 min**>. Yeah. I got on some of the publications. You know, sometimes only from a vertical point of view. I mean, I was just a consultant, gave them ideas on how to do some of these things.

GRAYSON: Well, that's kind of a nice duty.

FERRARO: Yeah.

GRAYSON: Then you went to Germany.

FERRARO: Germany, that's another interesting story.

GRAYSON: Was that Munich?

FERRARO: No, no.

GRAYSON: Aachen?

FERRARO: [University of] Aachen. Charlemagne's City. He developed that town. Invited by Professor Ziedler, Manfred Ziedler. It turns out that Manfred Ziedler was one of the guys from de Paul, did his undergraduate work at de Paul University, and then researched for me. So, here's the chairman of the physical department—physics department, physical chemistry department—at Aachen, and he's my former student.

GRAYSON: There you go.

FERRARO: I think that if you have an expansive career of sixty-five years, you run into these sorts of things. It's bound to happen.

GRAYSON: […] So, some of these you spent, like, a year. Others, you just were kind of like, spending a couple of weeks, a summer, or…

FERRARO: Yeah. In Sardinia, I gave a course in group theory and spent a month. The others were just around a week.

GRAYSON: I noticed also, on your publication record, you've got a lot of books.

FERRARO: Here they are.

GRAYSON: Yeah. That's quite a good collection of books.

FERRARO: Well, I didn't author them entirely, myself.

GRAYSON: No.

FERRARO: I mean, I had coauthors, coeditors, and stuff like…

GRAYSON: They're a lot of work too.

FERRARO: Yes, they are.

GRAYSON: You know, particularly in a scientific area, there's a lot of specific detail has to be done very well, and carefully.

FERRARO: Had a couple with Raman spectroscopy with [Kazuo] Nakamoto, who is a well-known spectroscopist. […] Anyway, he ended up in University of Marquette, and [lived] in Wisconsin [and now is deceased].

GRAYSON: Here in the States.

FERRARO: Here in the States, yeah.

GRAYSON: […] There's a series of books that I saw that were publications on…Volume 1, Volume 2, Volume 3…where did I see them? […] I marked them in here, when I was looking through this. Publications, right here it is. It looks like every so often, so many years, they were updated or revised.

FERRARO: Well, it might have been second editions. I don't remember.

GRAYSON: Yeah.

FERRARO: What were the titles?

GRAYSON: I could have sworn I marked them with a pen, but I can't see them now. I got to…

FERRARO: One, two, three, four in the…look up here and see them. Oh. Where are you, in transform?

GRAYSON: There's Fourier transform. I got Volume 1 on that one. Is there…or you didn't…

FERRARO: Got four volumes in this.

GRAYSON: Okay. So that was then, what I'm…so those in 1978. So you were just extending your…I mean, it's a fairly rapid development…period of development in that field.

FERRARO: Yeah.

GRAYSON: So it had to be updated on a fairly regular basis. Yeah, Volume 2, 3, okay. That makes it…yeah. So did you do any…get involved any in the organic <**T: 130 min**> side of the IR business? It seems like almost everything's inorganic.

FERRARO: No, I didn't. When I left organic, I left it for good.

GRAYSON: You didn't want to have anything else to do…

FERRARO: Do it anymore.

GRAYSON: Okay.

FERRARO: For better for worse.

GRAYSON: Well, you know.

FERRARO: Well, I'm glad somebody likes doing that sort of stuff.

GRAYSON: Yeah.

FERRARO: To each his own.

GRAYSON: Well, in inorganic, it was an area where it wasn't…were there […] many other people working in inorganic IR that you're aware of? I mean, you kind of developed the field.

FERRARO: No, not very many, frankly, when I got started. I mean, go all the way back to the 1950s. Yeah.

GRAYSON: So, it was virgin territory that could be used, you know, I mean, you were…

FERRARO: Well, it fits the idea of innovation, new ideas, whatever.

GRAYSON: Yeah.

FERRARO: But let's see. Inorganic chemistry, that's inorganic chemistry, it was thought to be a dead science, remember.

GRAYSON: Mm-hmm.

FERRARO: Until [Enrico] Fermi put it on the map. The same thing happened, which you're probably more familiar with, is analytical chemistry.

GRAYSON: Yeah.

FERRARO: Dead science, and I don't remember the year, but maybe you can help me on that. There was a one-day program on the merits of science, saying they wanted to get rid of […] analytical chemistry. They wanted to get rid of it from the curriculum of college courses. They had this program at Pittsburgh Conference, and can't ascribe that this as authentic, but I recollect that it was [M. Guy] Mellon, great analytical chemist […].

And the other was Foil Miller, the University of Pittsburgh. Foil took the part of being anti-analytical chemistry. Mellon, of course, being the great analytical chemist he was, he took the other part, and they chewed it out for a day. It ended up that analytical chemistry won out, kept it in the curriculum. Of course, now we can analyze, look how much analytic chemistry has come, when you can analyze almost a molecule or something…

GRAYSON: Yeah.

FERRARO: You know, [analytical chemistry has] come a long way. It isn't dead.

GRAYSON: Well, this isn't the topic that…I penned it in for pursuing as a kind of sub-theme, is a lot of schools don't have much in the way of analytical chemistry curriculum or research.

FERRARO: Yeah.

GRAYSON: I think, for instance, there's only two or three, or four at the most that have serious analytical chemistry research areas in mass spectrometry. It seems as though that whole area of chemistry is kind of looked down upon as a second-class science, which is just…it's kind of like the Cinderella of chemistry. The thing that I find amusing or disheartening or is that, as I've mentioned to other people in interviews, if you didn't have the capabilities that analytical chemistry provides today, a lot of these people would be in trouble. How can you show that you've made…your synthetic chemist would be in trouble, if you're going to start going there and mixing chemicals to show you that he's made this in a compound? I don't think so. There a phone buzzing there?

FERRARO: Turned that thing off, but it's still coming through.

GRAYSON: Oh, okay.

FERRARO: I should have unplugged it.

Anyway, you're right. It's almost like when you consider physical chemistry, too. I mean […], there's folks—and everything comes out of physical chemistry. I mean, you know. But the period of time, for example, that <**T: 135 min**> developed after the computer connected with the Fourier transform, the development of analytical chemistry based in the techniques that developed when they were able to get spectra out of these things in a matter of seconds.

You really developed two types of analytical chemistry, in my way of looking at it. You had the wet chemistry, where you did volumetric stuff, beakers and so forth. Then you had the dry stuff, with the spectroscopy. There's a place for both. Beck, an eminent analytical chemist, who said that, well, you could use the wet chemistry for gross analytical stuff, and the dry chemistry for the tracer stuff, for small. So, I don't know. I can't see how you cannot push analytical chemistry. I think it's very important. And what's going on today, how do you identify all…

GRAYSON: Oh, yeah.

FERRARO: Genetics, and so forth. You know…

GRAYSON: Yeah.

FERRARO: That's analytical chemistry.

GRAYSON: There's an interesting kind of anecdotal story about how it was…and Hank Fales got involved in mass spectrometry used it to…at the NIH [National Institutes of Health] labs in Bethesda, Maryland or someplace up in that whole environment. They were trying to characterize a particular alkaloid. They were using traditional wet chemical methods, combustion analysis, and they were using the infrared and UV spectroscopy. So they had those tools. But they couldn't nail the structure, because they were getting ambiguous results in the combustion analysis.

Basically, he knew that [Klaus] Biemann was working at MIT [Massachusetts Institute of Technology] with alkaloids using mass spec, so they took the sample over there. The guy had this minuscule amount of alkaloid, and he was able to get both high-resolving and low-resolving mass spectra of it, and they solved the problem like that.

FERRARO: Sure.

GRAYSON: So it's just the ability to have that extra tool, to provide information you're just not going to get from combustion analysis or any of these other…

FERRARO: Probably one or the other…

GRAYSON: Yeah. So that basically started the use of those types of mass spec initially, also magnetic resonance techniques at NIH in that lab. They essentially, after they saw how useful it was, they went ahead and bought the equipment and started developing it. Unfortunately, Hank died last year. So, that's why I became familiar with this little story about how they actually…it was the beginning of mass spectrometry at the NIH labs, was a result that they were able to get so quickly.

FERRARO: Yeah, interesting, how these things develop and change.

GRAYSON: I don't know what's going to happen with regard to…I mean, the developments in analytical chemistry keep moving along in the Pittsburgh Conference, and the instrumentation people will keep developing more powerful equipment, and it's being used. So there is…I guess there's enough innovation going on now in the physical analytical chemistry side that things are moving forward at a good clip. Anyway, even though maybe academia looks down on it as something that's not all that important, the rest of the world is…

FERRARO: Yeah. I think the real world needs it, I mean, you know. It's one of those things that…

GRAYSON: So do you […] go to Pittsburgh Conferences? Or have you…

FERRARO: From the beginning.

GRAYSON: Okay. So you're a regular attendee.

FERRARO: Yeah.

GRAYSON: Yeah, okay. You've seen a lot happen over the years in those venues, where they have, every year, somebody has something new coming out. […] I think that the PittCon has been a great promotional tool for equipment and development.

FERRARO: Sure, of course. I like to look at it from the, from <**T: 140 min**> 1940 to present time is the golden age of spectroscopy and analytical chemistry, because they worked hand-in-hand. Once the Fourier transform and the computer went into business and they were able to get spectra in seconds, this aided analytical chemistry too; because when you had it, like I said…you had dry chemistry that…but for dry and wet, of course, chemistry that helped you analyze materials and substances.

GRAYSON: I take it as, I look on it, as that there's this whole group of techniques that are based on essentially physics, physical. So, I should ask you is, physical analytical chemistry, you know all the spectroscopies basically come up from the physics department. I mean, mass spec, the NMR, EPR, all those things. You're looking at some phenomena that kind of evolved out of physics research that the chemists say, hey, […] we can use that for analytical purposes. That's the division that I make in my head.

So, how are we doing? Have we pretty much covered the topics that we're going to go over, or…?

FERRARO: Hmm.

GRAYSON: I'm not sure, if maybe in the process of going through this, if we happened to skip over some things or go past some things a little too quickly. So, this is a good time to maybe just take a good careful look and make sure that it's covered.

FERRARO: Well, one of the things that they see here is current work of interest […], and you may be interested in knowing that I am connected with three museums.

GRAYSON: Oh.

FERRARO: The one in Chemical Heritage [Foundation], I have been. I mean, I'm not doing much there now, but that was scientific of course. But based on my military career, I'm connected with the World War II Museum in New Orleans, because I've been sort of a representative of what was done there during World War II in China-Burma-India, because there are not many people in that theater that were there. I'm sort of like a correspondent. I've written stuff for them. Then I'm connected here, locally, with a museum, which is the World War II Italian-American Museum. There too I've contributed a number of things that have worked out pretty well for them.

So right now, basically, that's what I've been doing is working museum stuff with one or the other, together. So, it keeps me busy, as I want to keep.

GRAYSON: Okay, sure.

FERRARO: I don't want to keep any more, busier than that.

GRAYSON: I've been to the New Orleans, the one in New Orleans. I had a son at Tulane, so.

FERRARO: Oh, you know, I haven't been there yet.

GRAYSON: Really. It's a fantastic museum.

FERRARO: Yeah. I know it's getting better all the time…

GRAYSON: Oh, yeah. […] The first time we went there, it was good. But then, the last time we went, it was really…

FERRARO: They'd done more.

GRAYSON: …fantastic. They'd done a lot more.

FERRARO: That's right.

GRAYSON: It's really a superb museum. As I said, they're doing a very good job there. So, keep giving them good stuff, because they…

FERRARO: I was there with the Chemical Heritage Foundation, last time we were in New Orleans.

GRAYSON: Oh, okay.

FERRARO: It was a Monday. I was free, I didn't have any papers, so I went there. It was closed on Mondays. I ought to get down there and check it out.

GRAYSON: No, you should. It's really a great museum. I think you'd find it to be very well done, and definitely would recommend it. So, but it seems like I've also a certain interest in history, you know, some of the papers in here that, history of…

FERRARO: Well, here's an example of it.

GRAYSON: Yeah, that's…

FERRARO: It's not scientific, but…

GRAYSON: There's the Ferraro saga, 1820 to present. Does that mean you do a little bit of, what is that where you look at your ancestors and…?

FERRARO: Sure.

GRAYSON: I can't think of that right now.

FERRARO: That's what it's all about.

GRAYSON: Genealogical research.

FERRARO: Genealogical, yeah. It wasn't easy, because I found out that, well, my paternal grandfather came to New Orleans, no records. The <**T: 145 min**> […] people that they had interviewing these people was very crude. They couldn't write. They couldn't spell. They changed names around terribly. It's hard to get the real information, but did the best I can. I think we cornered it pretty well, the dates they came, what ships they came, and so forth, and so on.

But, yeah, I've always been a historically [oriented] person type of thing. You know, you don't know where you came from, you know where you're at now, how do you get the future? I've always had that thing in mind, you know. I'd like to know where I came from. But that's another thing that is interesting, because people seem to think, you're historically minded when you're old; it happens then. It's not true. As in my twenties, in the CBI theater, I knew the war was coming to an end, so I start working on the history of the group out there, my group.

GRAYSON: Oh, wow.

FERRARO: And [I] did a history. So, when we come back, after we raised our families and kids, we got together with an annual get-together. The first time that we got together…I don't know, a couple of the guys, maybe more, came up to me. If you hadn't written that history, we wouldn't know a damn thing, what the hell we did over there. The years have passed. You forget, you know what I mean. Yeah, you definitely write about that, and I am going to…

GRAYSON: So that history, is it in your publication record here, for that particular history? Or is that …

FERRARO: No.

GRAYSON: The CBI…

FERRARO: No. No, I never wrote that for…

GRAYSON: Publication.

FERRARO: Well, I have it here somewhere. Yeah.

GRAYSON: Yeah. Yeah, okay. So this was the…early on you had a real…

FERRARO: It's never been published, put it that way. Never published.

GRAYSON: Okay. So you had a realization that if you don't put this stuff down on paper, then…

FERRARO: Well, of course, yeah. Right.

GRAYSON: It's all going to…

FERRARO: And I was only in my twenties. It had nothing to do with old age.

GRAYSON: Hopefully not.

FERRARO: So anyway, that's where we're at. Oh, yeah.

GRAYSON: Well, I've got some specific areas here. Some of this, we've kind of covered. I think, you know, your areas of research that you chose, we've kind of gotten into that, but the impact of these various developments on analytical instrumentation, for instance, first off, I think is improvement to electronics. I guess, when you sort out everything, it was tube, tube-tied.

FERRARO: Right.

GRAYSON: So you had all those issues with it made noise, A/C hum, tubes burning out, you know.

FERRARO: Yeah, temperature.

GRAYSON: Yeah. Things were getting…your tubes made a lot of heat, lot of heat.

FERRARO: Right. Yeah. I don't know too much about the development in the sense, I never really kept on with it as, far as electronics. I did more in developments of what the computers did for analytical chemistry, spectroscopy in a sense, you know. I think if you really wanted to talk about the computers, you know, it's because of the computers that went into spectroscopy. For example, the interferometer was invented by [Albert] Michelson and [Edward] Morley in [1887]. They did it. I think they were going to measure the way it measures speed of light or something, I don't recall that too much.

GRAYSON: I think they were trying to prove there was an ether.

FERRARO: Yeah.

GRAYSON: By using which way the thing was oriented with respect to…yeah.

FERRARO: But then there was developments that took place. When you had the interferometer, what do you do with it? Then, you develop an interferogram, very crude. Then came the more resolved interferogram. Nothing really happened until [P. B.] Fellget From that, then we had a period of time when nothing was happening, because it was… until [J. W.] Cooley and [John] Tukey algorithm that they developed […]. <**T: 150 min**>

FERRARO: That was in 1966.

GRAYSON: Cooley-Tukey [FFT (fast Fourier transform)] algorithm.

FERRARO: Yeah. Then that made them process the data in seconds. […] We're talking about FT now, see.

GRAYSON: Yeah, yeah.

FERRARO: Right. Just prior to that […] in 1963 [Block] developed the FTIR [Fourier transform infrared] instrument. But it was so crude and had poor resolution that it called twenty wave numbers. The industry, of course, couldn't conceive of having an instrument to market with that sort of stuff. Then, when the Cooley-Tukey stuff came out, then they were able to get it seconds. Well, then the industry perked up their eyes, their ears, and three years later, the first Fourier transform interferometer spectrum was recorded. Interferometer was made by Bio-Rad [Laboratories]

GRAYSON: Bio-Rad.

FERRARO: Yeah. The interesting thing about this was, of course, that you…it developed a new spectroscope technique, Fourier transform spectroscopy, which created a new field of instrumentation. The spinoff from this was, if you could do all the kinds of things, that you got a computer that works with an instrument, with an interferometer, you develop all the chemimetrics, is what they call it. You know, mathematical computations of the data that would you'd all sort of things, not just what you see from the curve in the spectrum. They break it down, and then what the curve consisted of, and so forth and so on.

GRAYSON: I think it resolved itself or what not, that you wouldn't be able to…

FERRARO: Be able to do.

GRAYSON: …figure it out otherwise. Yeah.

FERRARO: And that was great. That's a contribution I think, illustrated by interferometer, the contribution of a computer with…

GRAYSON: Of course, even […] in my understanding, the original, the earliest computers were slow and didn't have much memory. So you still had, you were kind of pushing the technology, because...to get a decent spectrum, FT needs to have a fairly good sampling over the…I guess, when you think of FT spectrum in an infrared environment, what happens? How does that…you're not scanning through a series of wavelengths, right. But you're saying [you're using an infrared] interferometer, which is…these issues are not…

FERRARO: Visualize the target. You can see…

GRAYSON: Yeah. And I'm not as familiar with this as you are. So, maybe it would help to kind of explain how this all works for someone who's going to listen to this to try and understand the development of the field. You know, when they read this fifteen, twenty, or thirty, or fifty years from now. The original IRs were scanned instruments, where you would scan through wavelengths of spectra wavelengths and individually record transmittance or absorption, depending on how you want to talk about it, with some type of detector. That was just looking at each wavelength that was presented through the scanning process. But now, when you do FT, how do you do that?

FERRARO: Well, I'm not familiar with that either, because of the fact that I was always interested in the development and the use.

GRAYSON: Okay.

FERRARO: Yeah, and never got into the actual instrumentation.

GRAYSON: The instrumentation side.

FERRARO: Right, right. But it's what one can see that, of what happened when you interface the computer then with the interferometer.

GRAYSON: And somebody came up with this algorithm.

FERRARO: Yeah.

GRAYSON: Which is important.

FERRARO: We had a symposium in…I did the symposium about five years ago, I think, 1966 you said. But no, it was five years ago, at the New York Analytical <**T: 155 min**> Society meeting.

GRAYSON: Okay.

FERRARO: We did the whole day on Cooley-Tukey. Strange as it may seem, in the audience was Tukey's nephew […] showed up. It was kind of neat to have a member of the family there.

GRAYSON: Yeah. Can't say if he understood much.

FERRARO: No. No, he didn't. But he gave us a little blurb on Tukey himself, what type of person he was.

GRAYSON: So these gentlemen sound like they were Chinese or…?

FERRARO: No, I don't think so.

GRAYSON: Japanese?

FERRARO: No.

GRAYSON: Okay, Cooley, Tukey.

FERRARO: They weren't Oriental, no.

GRAYSON: Okay. The name looks kind of strange.

FERRARO: Yeah, they are strange, but.

GRAYSON: Which basically, permitted the fast, Fourier was considered the faster way to transform, is that what the…

FERRARO: That's right, fast Fourier transfer, that's the only way to do it. Yeah.

GRAYSON: Well, the whole business with Fourier transform has, I think, revolutionized a lot of analytical chemistry.

FERRARO: Well, that's science. That's not only in spectroscopy alone, you know.

GRAYSON: So, I wonder if Fourier ever could have conceived, when he did his mathematical work, what it would lead to?

FERRARO: The developments that would come out of it.

GRAYSON: Come from it, very good example of, I don't know what you want to call it.

FERRARO: Yeah.

GRAYSON: Something in one field that [has] a tremendous, unbelievable impact years later, in a completely different field. I'm sure he never, ever would have conceived of…

FERRARO: Probably not, yeah.

GRAYSON: …for what it's being used for today.

FERRARO: Well, that gives you another example of serendipity, you know. [Fourier] didn't conceive of it, when…

GRAYSON: Yeah. I'm sure most people in science probably thought it was totally useless. Who wants to do that?

FERRARO: Probably true, yeah.

GRAYSON: You know, I mean, it was kind of a mathematical exercise to show that you could create this…use math to create this shape from all these different frequencies, and so what? So the computer really helped the impact along, especially with the development of these kinds of

algorithms. But then, miniaturization comes next, and that's where we're in the middle of now. How, what do you think…

FERRARO: It's very interesting, because, you know, I sent you that stuff.

GRAYSON: Yes.

FERRARO: The early period of 2000 to 2005, did something for Jerry [Gallwas] on that. He wanted me to examine it, and see what was going on. The development of miniaturization is very interesting, because corollary with the development of the technique, there was simultaneously development in ancillary equipment of spectroscopy that industry had provided for us, because they were using it for other means, and they developed these ancillary techniques, ancillary equipment in larger quantities, and the cost came down. That's what made the people in the industry latch onto these things, because for example, the CCD […] which was a camera, detector which was used for video.

GRAYSON: Charge a couple of device things.

FERRARO: Yeah. It was developed for the camera use, but still in the video. The thing about that was, it was cheap and it was faster. So, okay, then came diode lasers, the CD players were using these kinds of new CD diodes. They had narrow line width, which provided increased resolution, comparable, almost, to the big instruments. Then, they got the holographic filters that were developed. The nice thing about them was that you could get rid of stray light and scattering. Then, of course, the fiber optics were improving right along, so they contributed. You were able to get rid of the monochromators, which took a lot of space in the bigger instruments.

That's how you got the miniatures. Now, the question about miniaturization is, while you look at a certain size and you look at a weight <**T: 160 min**>. In the article I wrote […] "Well, let's keep [the instrument] at fifteen pounds, and small size." I forgot what I put in the paper now. But what's happened there, of course, is that, they got it to handheld, and how far down is it going to go? Well, good question. How far down can you miniaturize? I mean, you're going to run out of space. So there's limitation there. The loss of limitation is the weight, if you want them not to weigh too much. Then you've got to take the other consideration about miniaturization is, certain other techniques besides spectroscopy, especially if we use large equipment like a magnet, how much miniaturization can you get? Like I mentioned in the paper there, I mean, how is this going to be in the future here, to our equipment that we have stored upstairs? If the miniatures ever take over. So I think it's been a very nice development.

GRAYSON: It seems that way, the way you're describing it. It seems like there's the confluence of three or four different developments, either at the same time or close to each other.

FERRARO: Exactly.

GRAYSON: And people, you know, being in the position where they can see, well, if we add this and this together, then…

FERRARO: Well, that's what happened, sure.

GRAYSON: Yeah.

FERRARO: Yeah. And it was…it just worked out. I mean, sometimes you can't figure out why, but that's what happens.

GRAYSON: Now, most of the miniaturization right now, I mean, I think there are a lot of areas that are going into it. But it seems like the real, true miniature instruments are in the area of the optical spectroscopy, infrared, UV, and that kind of thing. Is that…

FERRARO: Yeah. That's what it…well, Raman, too. They do miniatures in Raman.

GRAYSON: So, since you mentioned Raman, I noticed there were some papers you published on Raman.[5]

FERRARO: I've always been a pusher of Raman.

GRAYSON: Okay. So, let's talk about Raman a little bit. That development came along, in what timeframe did that…

[5] See, for example, John R. Ferraro, "Chapter 2," in *Raman Spectroscopy, Theory and Practice*, edited by John R. Ferraro and Herman A. Szymanski (New York: Plenum Press, 1967).

FERRARO: Well, when I got started, people weren't doing much Raman spectroscopy. They couldn't conceive of what…it wasn't an easy experiment to do, because it's a scattering method and so forth. The equipment was not up to par at the time. It was slow progressing. They didn't know what you could do with it. But on the other hand, if you look at the comparison of infrared and Raman, you want a total spectrum, you should do both, because selection rules are different. I kind of looked at the point of view, that eventually Raman spectroscopy is going to come into its own, and effectively I think it has now. A lot of your papers are Raman spectroscopy in the issue of *SAS* [*Society for Applied Spectroscopy*]. So, I think that there's going to be more in Raman, too, I think. They have these nonlinear techniques in Raman spectroscopy which are caustic, because they use maybe two lasers, very high-powered lasers. There again, I think that this is going to develop. The only thing holding back is the cost of the lasers. I think, again, you have the fact that some of these techniques have different selection rules. What you have in one type of Raman, you will not have in CARS [coherent anti-Stokes Raman spectroscopy] or inverse Raman techniques [and so forth].

GRAYSON: In a CAR?

FERRARO: Coherent…what the heck is it?

GRAYSON: It's an abbreviation for something.

FERRARO: Yeah, right. Well, the last part, R, is Raman, I know.

GRAYSON: Okay. Coherent something Raman.

FERRARO: Yeah. Can't think of it. No way. Sorry about that.

GRAYSON: Well, that's okay. We'll get it worked out. Spectroscopy. So that actually, there's a little aside here, is this issue with spectroscopy and spectrophotometry. So, what's technically correct, spectrophotometry or spectroscopy, or does it matter?

FERRARO: I always used spectroscopy. If you want to…

GRAYSON: Okay. Okay.

FERRARO: …make it a fine point, maybe the other one is more important. But…

GRAYSON: Okay. […] Well, probably […] spectrophotometry would imply a certain <**T: 165 min**> type of detection, which you may or may not have.

FERRARO: Yeah.

GRAYSON: Some cases, so yeah, okay. A more precise way of nailing down the estimate. So Raman is… you were an earlier, early promoter of it.

FERRARO: Yeah. That's why the last two volumes we wrote here, with Nakamoto, was all in Raman spectroscopy.

GRAYSON: Okay. So, you promoted by getting the equipment in your lab, and using it, and […] publishing on it.

FERRARO: Publishing on it. Yeah. […] I looked for Raman to push into the far ultraviolet more and more.

GRAYSON: Okay. So, yeah, as you mentioned, there's going to be these limitations to miniaturization, like in mass spec, you're going to have a vacuum system. […] It's hard to miniaturize a vacuum pump.

FERRARO: Well, that's…forgot to mention that for far infrared. They've got to have a vacuum system.

GRAYSON: Oh, okay. Okay.

FERRARO: Moisture, water.

GRAYSON: Sure, yeah. Water.

FERRARO: But anyway.

GRAYSON: Yeah. Vacuum systems actually, you know, they're kind of the bane of miniaturization. So, I don't know. Did you have personal interactions with peers and contemporaries? Any interactions with people that you found particularly fun, exciting enlightening, useful? We discussed some of them all ready.

FERRARO: Yeah, all those ones in Italy, of course, are interesting people. They're quite capable, I found them to be. They're very sincere and good scientists. They don't have the capabilities from the point of view of instrumentation or backing, scientific backing, financial terms and so forth. But I found them very good. I was impressed with the University of Aachen and their physical department. They're doing some nice work there.

GRAYSON: I was wondering if…I was interviewing a bunch of fellows in the U.K. [United Kingdom], and they indicate that the chemistry programs and their academic systems are being kind of cut back because not enough students are pursuing chemistry, so it's kind of like a demand/supply thing. If there's not a demand, [then the supply of] teachers isn't in demand. I was wondering if you've observed that type of problem going on in your other European connections, when you're going…

FERRARO: Well, definitely Italy. They're cutting back all the time, because they write to me and tell me about it. It's depressing and, you know, not very encouraging for science as a whole. I don't know about…I think Germany's in better shape, probably better shape than any of those countries out there in Europe. I think that they realize the importance of science, that this is one of the ways that you maintain your country in terms of moving forward. England, I don't know. I haven't studied, because I haven't been too involved. I've given lectures at [University of] Oxford.

But, anyway, it brings back a point that I mentioned to you. I'm not one of these guys that looks for hard areas and complains all the time. But I gave a talk at Harwell [Laboratory], the Institute for Nuclear Chemistry over there.

GRAYSON: Harwell?

FERRARO: Harwell, yeah. […] We had just found a technique, the method of extraction for some of these uranium and actinide salts that up to that time, they always thought the cadmium went up with the solution, you extract it alone. Well, I found from my infrared studies, the nitrate accompanies it, the nuclei. So the entire salt goes up, if you extract it. Well, I presented that, because that's where I just discovered this, not too long ago. Nobody had seen it before.

So <**T: 170 min**>, the guy who was in charge of Harwell, can't remember his name anymore, he pooh-poohed it all. Hell, then they got somebody over there to do it, verified it, you know, and it came out. They put out a paper, but of course, I had one out already.[6] They verified that I was the first to see this. But it's kind of interesting, how you run into things like this.

GRAYSON: Yeah. Well, you know, people have preconceived ideas of what's happening, and when you say that something different is happening, then they're going to be resistant.

FERRARO: Normal behavior, huh. [laughter]

GRAYSON: Yeah. But, I mean, you had the goods, because of the far infrared work. You knew…

FERRARO: Well, I could see the nitrate, sure, of course.

GRAYSON: There was…how interesting. So this would have been fairly early in your career, when you gave this…

FERRARO: Very early, very early. I was still in the solvent extraction business at that time, yeah.

GRAYSON: Well, maybe they thought you were too young to know what was going on.

FERRARO: Yeah, I don't know. British are funny sometimes.

GRAYSON: Yeah. [laughter] You want to take a break now, and then we can kind of…

FERRARO: […Yes]

[END OF AUDIO, FILE 1.2]

[6] John R. Ferraro, "The nature of the nitrate in the TBP solvates $M(NO_3)_3 \cdot 3TBP$, $M(NO_3)_4 \cdot 2TBP$ and $MO_2(NO_3)_2 \cdot 2TBP$," *Journal of Inorganic and Nuclear Chemistry* 10 (1959): 319-322.

GRAYSON: Yeah, Marvin [Margoshes] was up there in the foot soldier part of it, and he definitely…you know, well, he got wounded. The thing that was kind of weird, he got sent back to the hospital. I said, "Well, then you have to go home." He said, "No, they send you back to the front." There's no…

FERRARO: Well, that was rather typical over there. Unless you're a fly boy, then you got the breaks.

GRAYSON: Yeah. So let's see. I think, yeah, okay, it's working. We got that working. So we just, kind of, we stopped, we talked about miniaturization. I think we got that pretty put together. The idea that there's a whole confluence of different technological developments.

FERRARO: Kind of interesting technological developments almost came at the same time when that…well, I don't mean to say that they actually stimulated or were the catalysts in instrument part, in miniaturization, particularly, an example of that.

GRAYSON: So, and we've talked about a lot of the people you worked with. I have that list of authors that I showed you. I was just curious if you had any specific comments with regard to…

FERRARO: This one here?

GRAYSON: No, there was a list that had the number of papers that you co-published, and…

FERRARO: Oh, oh.

GRAYSON: Did we talk about mostly these Ferraro and [Louis] Basile […]?

FERRARO: Yeah.

GRAYSON: So he was with you at Argonne?

FERRARO: Yeah, right. He was permanent. He was one of the staff members in my group.

GRAYSON: Okay, so I see you published quite a bit with him…

FERRARO: Oh, yeah.

GRAYSON: Coauthor on that. Then this fellow by the name of Jack Williams…

FERRARO: That's the one with the organic superconductors and he ran that group.

GRAYSON: So that's when you went back…

FERRARO: When I went back, yeah.

GRAYSON: Okay. How did that organic superconductor thing work out? Was that…

FERRARO: Well, they never got it to…there was…[we found] organic superconductors, but not very high [critical temperatures]. So, I mean, maybe you could have predicted that.

GRAYSON: And there's this Chia…Chiariz…

FERRARO: [Renato] Chiarizia.

GRAYSON: Chiarizia, Renato.

FERRARO: There's an interesting aspect of that is that, he's a native of…born in Naples, [Italy], but was in the nuclear program in Rome and came here on a sabbatical for a year. It was at the end of 1986. Kate Martin, who was my last student, I told you about, she graduated. Then she went to work at Argonne. I recommended her, and she got a job at Argonne, and corresponded with Chiarizia. He was a divorcee. She had never married. And they got married. Now they're living outside here in…right down the street that they're fixing, further down east. Yeah. We collaborated quite a bit there, especially more recently with this three-phase system.

GRAYSON: Okay. Then we have Nakamoto.

FERRARO: Yeah. Well, with him we did some actual research in the lab. He came from Marquette. We had the system to where we could bring in professors and do some research together. Then we wrote the two books there, the first edition, second edition on Raman spectroscopy.[7]

GRAYSON: So what is the impetus for writing these books? The publisher comes to you? Did you decide something needed to be done? I mean, you know, these things don't […] fall out of the clear blue sky.

FERRARO: Well, both ways. So, we think that it was ready for something, to put something together. They did come to us too.

GRAYSON: So, I guess you'd gotten a reputation for doing this kind of stuff, because you've done a number of them now.

FERRARO: It's something like seventeen.

GRAYSON: So, there's a piece that will come to you for these things. Yeah.

FERRARO: They're looking for something to publish in a particular field, and <**T: 05 min**> they go around soliciting, essentially, that's what it's about.

GRAYSON: So how does…that's a lot of work. Do you feel that the compensation for the work is worth is it?

FERRARO: No.

[7] John R. Ferraro, Kazuo Nakamoto, and Chris W. Brown, *Introductory Raman Spectroscopy*, First and Second Editions (New York: Academic Press, 1994 and 2003).

GRAYSON: Not worth it.

FERRARO: Not worth it. I still get some now, but not worth it. I don't think you do it for monetary…

GRAYSON: No. But still that's…what you got, sixteen, seventeen…

FERRARO: Yeah.

GRAYSON: That you're editor and co-wrote…

FERRARO: Co-wrote.

GRAYSON: …co-editor or what not. That's…

FERRARO: Whatever, yeah.

GRAYSON: That's a lot of work.

FERRARO: Yeah.

GRAYSON: But so you got some recompense, compensation for it, but whether or not it's significant or worthwhile…

FERRARO: Can't make a living on it.

GRAYSON: ….doesn't make…you're not going to get rich off of it. Yeah, right. [Clarence] Postmus?

FERRARO: Postmus.

GRAYSON: Postmus.

FERRARO: Yeah. Postmus was a permanent. Then, they cut back, they let him go. He would always come to my group and let go people. But anyway, he was one of them. He was a prolific experimentalist. I mean, he would just…put him on a problem, he'd get you gobs of spectra, you know. I mean, so much that so much of it was superfluous too. But he was a good person, you know.

GRAYSON: So he's kind of like a…

FERRARO: Essentially a technician….

GRAYSON: Lab tech.

FERRARO: Yeah. He had a Ph.D., but, I mean, he never really measured to that area, that level.

GRAYSON: Okay. Then, there's a fellow by the name of [H.H.] Wang.

FERRARO: Wang was in the [organic] superconductor stuff. He did the synthesis of some of those. I worked together with him, because he would make them, and then we'd test them, infrared and so forth.

GRAYSON: What kind of materials were you…

FERRARO: These are…

GRAYSON: […] There's an organic conductor…

FERRARO: Yeah. BEDT something, something else. Went on with the amide…

GRAYSON: Okay.

FERRARO: Typically organic.

GRAYSON: These were like doped organic things or…

FERRARO: I have so much stuff here I don't know where to look for it anymore. I did put it down here. BEDT-TTF [bis(ethylenedithio) tetrathiafulvalene].

GRAYSON: BEDT-TTF.

FERRARO: Yeah.

GRAYSON: Okay. So what does that stand for? [laughter]

FERRARO: It's a while since I've worked with them.

GRAYSON: Okay.

FERRARO: Now that book was put together by eight of us members in that group at the time. So each one took a chapter.

GRAYSON: Okay. This is Organic…

FERRARO: [Organic] Superconductors.

GRAYSON: Including fluorine. Ah, yes, those wonderful, wonderful compounds. So these are condensed—semi-condensed—screening aromatic puppies.

FERRARO: Right.

GRAYSON: All right. Well, I can check that out on the web. We did a structure thing. And then, a fellow named Donald Peppard.

FERRARO: That's the one that I said was my physical chemistry teacher.

GRAYSON: Oh, yeah.

FERRARO: Yeah.

GRAYSON: But you did some publications with him in …

FERRARO: Right, at the beginning, when I first joined the group and measured molecular weight studies, and did some infrared.

GRAYSON: And then Gatson?

FERRARO: Well, he was…I worked for him for about a couple months, when I first joined the group. They didn't know where to put me then, finally got into the Peppard group. That probably came about, when they probably asked Peppard, "We got a new man here. His name's Ferraro." Oh, yeah. "Would you like to have him in the group?" He said, "Fine." So that's how it happened.

GRAYSON: Oh, okay. So you were kind of an odd man out at the beginning. But …

FERRARO: Yeah. They didn't know where to put me.

GRAYSON: Yeah <**T: 10 min**>.

FERRARO: They wanted me, but they couldn't …

GRAYSON: Yeah. What's interesting is that a lot of people I've interviewed have been hired where they were […] kind of, like, hired because they thought they were good people to have, and they kind of fell into the position. It turned out to be pretty good for them and their career. So we talked about Priscilla already.

FERRARO: Yeah. The first one, yeah.

GRAYSON: Yeah. Then, Mitra Shashanka…

FERRARO: Okay. That was collaboration with…he worked for one of the instrument makers…

GRAYSON: Oh, okay.

FERRARO: On the East Coast. We did a lot of work together…

GRAYSON: So you had some interactive…

FERRARO: Yeah.

GRAYSON: Collaborations with the instrument people…

FERRARO: With the instrument people.

GRAYSON: Oh.

FERRARO: I eventually consulted for them.

GRAYSON: Which ones were these?

FERRARO: Digilab.

GRAYSON: Okay. So that would be the Fourier transform, right. Digilab…

FERRARO: Well, afterwards, because before that…I worked with them before that.

GRAYSON: Oh, okay.

FERRARO: They wanted to know what they could do with [a technician at Digilab] in terms of applications and so forth. We actually worked with an instrument there in the Boston area and then, was able to bring this into some advertisements and so forth, and sell their instruments.

GRAYSON: Okay. So you did consulting kind of for them.

FERRARO: For them, yeah.

GRAYSON: And then, this […] worked out okay. You got a financial remuneration…

FERRARO: Yeah. I was remunerated.

GRAYSON: Okay, yeah.

FERRARO: Yeah, travel, too.

GRAYSON: That was okay with the way things were set up at the, Argonne.

FERRARO: Yeah. They allowed that too. So …

GRAYSON: But they also gave you some input into the instrument development, right.

FERRARO: That's right.

GRAYSON: So that was valuable…

FERRARO: It was worthwhile.

GRAYSON: Yeah, on both sides of it. Then you ended up, I guess, getting equipment from them that reduced their…

FERRARO: Mm.

GRAYSON: Maybe you got…what do they call the offer, the beta, a version of the equipment to checkout and use?

FERRARO: Yeah. But basically, we didn't buy too much Digilab stuff. We were more or less essentially P&E, PerkinElmer. A little of the one on the West Coast. I forget the name right now. Ones who made…

GRAYSON: Beckman [Instruments].

FERRARO: Beckman.

GRAYSON: Beckman. Yeah, yeah. PerkinElmer…so I guess Perkin-Elmer […], they had […] I mean, did they start out in the spectroscopy side primarily? I mean, they ended up going to chromatography and then mass spectrometry…

FERRARO: Oh, yeah.

GRAYSON: Everything else.

FERRARO: They got into…early in the game of commercial instrumentation. The IR-1, I think by PerkinElmer, was the first infrared. Then a couple years later, they came out with their first infrared. That was 1943, 1944, just when the War was ending, that period of time.

GRAYSON: Do you have any sense from the history or your knowledge, whether or not those early IR instruments had an impact on the scientific development, in contributing to growth, the war, in terms of …

FERRARO: Well, yeah. I mean, early they had the impact of…we were making synthetic rubber at the time. That was the Beckman instrument. I [believe] the PerkinElmer did some of that too. That was primarily the biggest contribution they made at the time, to verify [that] the synthetic rubber was just like the rubber they could get from the plantations you know, in the Pacific. So…

GRAYSON: So the objective was to essentially copy Mother Nature in the rubber business.

FERRARO: Right.

GRAYSON: And this was…the IR was a tool for …

FERRARO: One of the tools.

GRAYSON: …confirming.

FERRARO: Tools, yeah, confirming.

GRAYSON: Qua…

FERRARO: [Anthony] Quattrochi; he was just a technician.

GRAYSON: Okay. But you had ten pubs with him, so…[8]

[8] John R. Ferraro, Anthony Quattrochi, K. C. Patil, and C. N. R. Rao, "Symmetry of rare-earth carbonates," *Journal of Inorganic and Nuclear Chemistry* 31 (1969): 3667-3669; Clarence Postmus, John R. Ferraro, Anthony Quattrochi, K. Shobatake, and Kazuo Nakamoto, "Far-infrared assignments for bridging cobalt-halogen stretching vibrations in several coordination compounds," *Inorganic Chemistry* 8 (1969): 1851-1855; John R. Ferraro, J. T. Wang, C. Udovich, Kazuo Nakamoto, and Anthony Quattrochi, "Low-frequency infrared spectra of planar and tetrahedral nickel bromide complexes of diphenylalkylphosphines," *Inorganic Chemistry* 9 (1970): 2675-2678; Kazuo Nakamoto, C. Udovich, John R. Ferraro, and Anthony Quattrochi, "Metal isotope and high pressure effects on the infrared active skeletal vibrations in metal sandwich compounds," *Applied Spectroscopy* 24 (1970): 606-608; Louis J. Basile, John R. Ferraro, D. Gronert, and Anthony Quattrochi, "Infrared-active optical phonon vibrations in anhydrous lanthanide chlorides and bromides," *Journal of Chemical Physics* 55 (1971): 3729-3733; John R. Ferraro, H. Horan, and Anthony Quattrochi, "Pressure dependence of the infrared-active optical phonon modes in alkaline-earth fluorides," *Journal of Chemical Physics* 55 (1971): 664-666; John R. Ferraro, D. W. Meek, E. C. Siwiec, and Anthony Quattrochi, "Effect of pressure on the ligand-field spectra of some five-coordinate nickel(II)

FERRARO: Yeah. He was very prolific. He was a hard worker. Yeah. He didn't have a Ph.D. He didn't have an advanced degree, but …

GRAYSON: So for this, I mean, in your group, it's if you were a contributor and you did good work, then it didn't matter whether you had a degree or Ph.D. or not. You were included in the publication.

FERRARO: Well, you get one of these, even though they're not doctoral people. You give them a problem and if they're good people and <**T: 15 min**>, they can go on beyond the fact that they don't have a doctor's degree. They can do the work, and you know, we'd analyze, and publish it, and so forth.

GRAYSON: Well, let's see. That was…

FERRARO: See now, Postmus, he got a Ph.D. degree. But compared to Quattrochi, I'd sooner have Quattrochi, even though he didn't have a Ph.D.

GRAYSON: He had that, whatever you want to call it, curiosity and capability and drive to go beyond just saying, yeah, here's the problem…

FERRARO: Here's the problem.

GRAYSON: Yeah.

FERRARO: But he […] carried it on and so forth. Yeah.

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complexes," *Journal of the American Chemical Society* 93 (1971): 3862-3822; John R. Ferraro, S. S. Mitra, and Anthony Quattrochi, "Pressure dependence of infrared eigenfrequencies of potassium iodide, rubidium iodide, and their mixed crystals," *Journal of Applied Physics* 42 (1971): 3677-3681; John R. Ferraro, M. H. Manghnani, and Anthony Quattrochi, "Infrared spectra of several glasses at high pressures," *Glass Physics and Chemistry* 13 (1972): 116-121; John R. Ferraro, B. Murray, Anthon Quattrochi, and C. A. Luchetti, "Metal-isotopic substitution and high-pressure studies of zinc halide complexes of dithiodipyridine," *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 28 (1972): 817-824.

GRAYSON: Okay. So we got…that's basically what we've gone through is a list of people that we assume you have more than ten…

FERRARO: Yeah. They either worked in my group or we together before. Then there were the students there. Priscilla and later on there were others. But there was one down there, Choca, another woman.

GRAYSON: Monica.

FERRARO: Yeah. She came from Marquette University. One of Nakamoto's students, and did her thesis at Argonne.

GRAYSON: So this is a reasonably common procedure to have

FERRARO: Standards.

GRAYSON: …people come in and do research…

FERRARO: Yeah.

GRAYSON: …at Argonne for thesis Ph.D. work. [Uwe] Fink.

FERRARO: Fink, okay. I was acquainted with him in the Lunar Planetary Lab. I worked for him on the…they did the observatory spectra, and I did the laboratory spectra and collaborating in that respect.

GRAYSON: Okay. Well, I just wanted to touch base with the people with whom you had the most co-publications…

FERRARO: Yeah.

GRAYSON: Coauthors in there, get an idea of …

FERRARO: Thank you.

GRAYSON: …how they came into…

FERRARO: Yeah.

GRAYSON: Yeah. There was some […] publications I ran into here that I was curious about, and I don't know if you can remember it off the top, what they were about. But they were about one-dimensional conductors.

FERRARO: What's the full title?

GRAYSON: Well, once again I marked them, and now I've got to…I should have turned down the pages on…here we go. "Vibrational Studies of One-Dimensional Conductors, Potassium…"[9]

FERRARO: That's the conductors that were high superconductors.

GRAYSON: High-temperature superconductors.

FERRARO: Yeah, high-temperature.

GRAYSON: But they call…you refer to them here as one-dimensional.

FERRARO: Mm-hmm.

GRAYSON: What is that? One, where…

[9] John R. Ferraro, L. J. Basile, and Jack M. Williams, "Vibrational studies of one-dimensional conductors: K2Pt(CN)4Br0.3·3H2O and K2Pt(CN)4Cl0.3·3H2O," *Journal of Chemical Physics* 64 (1976): 732-736.

FERRARO: I think that referred to the conductivity in one dimension.

GRAYSON: Okay. So that's interesting. So they just, were only conductive in one of three dimensions. That's interesting. but these all look like they're crystals, right.

FERRARO: Yeah, crystals. Yeah.

GRAYSON: Interesting. So, I assume it's weird, but I don't know, maybe not. Well, that just seemed kind of an interesting concept, this one-dimensional conductivity. I just…a little background on that. All right, keep moving along here. We're doing…so we discussed the number of your coauthors and coworkers. Then, we talked about your most significant publications and scientific contributions. You might want to reiterate the ones that are…I think we talked about some of these.

FERRARO: Yeah, we did. We did, yeah.

GRAYSON: Excuse me. I don't know what…

FERRARO: I still think that the most significant publication was this one.

GRAYSON: The Analytical [paper]…

FERRARO: The far infrared. Insofar as the stuff with the high pressure, I wrote the book. A lot of the work I did is in here. So that was…

GRAYSON: Let me mark that in my publication list. That's Vibrational …

FERRARO: Spectroscopy and High External, High Pressure.[10]

GRAYSON: And this was published in …

[10] John R. Ferraro, *Vibrational Spectroscopy at High External Pressures: The Diamond Anvil Cell.* (New York: Academic Press, 1984).

FERRARO: 1984, something like that.

GRAYSON: I have date down here somewhere. 1984.

FERRARO: Right <**T: 20 min**>.

GRAYSON: And the reason that you feel that this is significant…

FERRARO: Well, I think several reasons. One, it showed the importance of the area, of the electromagnetic spectrum for organic and inorganic materials. It advanced the idea that group frequencies could be found in the far infrared, and tied in the fact that you could put materials under pressure, solids—actually you could put liquids too—and look at them in the far infrared. We developed a technique in which you could look at some lattice vibrations, which were not allowed by transmission of infrared right through the solid, and that you had to do reflective techniques. That was another area. So I don't know if I thought of all the things that I think I think are…

GRAYSON: Well, so you actually are the sole author on this book. This is a…

FERRARO: That's right.

GRAYSON: You wrote the whole thing. Then, the *Analytical Chemistry* article on the far infrared is yours.

FERRARO: Right. I keep those as the most significant actually.

GRAYSON: So, I guess you could say that if you weren't out there exploring this portion of the spectrum, maybe it wouldn't have gotten explored.

FERRARO: Well, not as soon as it did.

GRAYSON: Somebody would have explored it.

FERRARO: Yeah, I'm sure.

GRAYSON: But you got them looking there sooner.

FERRARO: Yeah. The other thing is, if this is true or not, because of the fact that you showed the importance of the region, the instrument makers came through with two dedicated far infrared instruments, vacuum type, the IR-11, 301.

GRAYSON: Yeah, I suppose that was a departure in terms of the instrumental complexity. You've got to work in a vacuum instrument.

FERRARO: That's it, yeah.

GRAYSON: Hadn't thought about that.

FERRARO: Yeah. You had to. When we first got it, we didn't have vacuum, and we had to put some kind of nitrogen envelope over it or tent, or whatever. It wasn't that good stuff, you know. It leaked all the time. But they finally came with the instruments and…

GRAYSON: So the issue is that presence of water vapor…

FERRARO: Adds vibrations in the far infrared.

GRAYSON: Right. It's got that…messed up that…

FERRARO: Cloud over everything else. The spectrum would be all over the place.

GRAYSON: Yeah.

FERRARO: You know, they're looking at that region still, and by even lower, which is terahertz. They got a new name for it, the far infrared, but it's …

GRAYSON: Terahertz.

FERRARO: Terahertz.

But they come out with equipment down there that you can get results at the very low frequencies that are much easier than we could have, even with a dedicated far infrared instrument. They go below 32 wave numbers. numbers. We went to 33, but that's about as far as we could go.

GRAYSON: So physically, 33 wave numbers is the number of waves you can put in one meter, one centimeter, one…it's reciprocal frequency, right.

FERRARO: Yeah, reciprocal frequency.

GRAYSON: So thirty-three wave numbers…I'm trying to physically visualize 33 wave numbers.

FERRARO: Well, let's see. Less than two hundred…what am I thinking of now? Two hundred…I can't think of the word. I'll think about it here.

GRAYSON: It'll probably come to you when you're…

FERRARO: Yeah, when I'm…

GRAYSON: …on a different thought that…

FERRARO: Yeah, right.

GRAYSON: So, it's kind of like just the idea people keep pushing into this region, since they're now aware that it's there, and it's valuable.

FERRARO: Right. That there are the conclusion that you can get vibrations that correlate with a particular link in the molecule.

GRAYSON: All right, well I guess we're kind of getting close to wrap up time. […] On this list of things to go through, are there any things that we talked about that you…or that we missed that you think you wanted to…

FERRARO: Well, I do have a little section here that I wrote.

GRAYSON: Okay.

FERRARO: Nothing […] <**T: 25 min**> in the way of prognostication. But my observations at the moment is we talked about miniaturization, I would say. I listed the limitations now, but I think it will continue up to a point. We're going to have more expansion of the UV Raman, I mentioned that. I predict that there's going to be more work in the terahertz spectroscopy region, more continued fiber optics implementation.

I think the fact that you can miniaturize, you can have more online research. You can follow a whole chemical reaction from beginning to the end by having these little small instruments on the way, you can tell what's going on in the immediate products and so forth. That will help increase…perhaps make a better product; not only that, but also causing you to perk up your reaction in different spots where you think it should be in order to give you a better product and more of a product too, quantitative-wise.

Then I talked about the inverse Raman technique, where the selection rules are different. I mentioned CARS, which, by the way, is Coherent Anti-Stokes Raman Spectroscopy.

GRAYSON: Anti-Stokes.

FERRARO: Anti-Stokes.

GRAYSON: Okay.

FERRARO: Each one has the capability, of course, of giving you a better result from normal Raman for particular, specific thing you're searching. The inverse Raman is kind of complicated, can be used with short line species. CARS can be used for spectra low

concentration, this type of analysis. I also look for the fact that they're going to use Raman more and more in the medical field.

The one thing that I did do some work with Professor [Jinguang] Wu, from a consultant point of view. I wasn't there. I asked to go into a surgical…in the hospital where they're doing some kind of a surgery on a cancer patient, as they were extracting the cancerous cells, whether they could determine diagnostically from Raman infrared spectra on site, *in situ,* the difference in the Raman spectra between normal and malignant cells. I think it's going to be more of that. I think this technique can go right into the hospital, right next to the surgeon, to be able to do some of it there. They're getting closer and closer to it.

GRAYSON: So it's kind of like it's not just a miniaturization though, it's the peculiar characteristic that Raman spectroscopy…

FERRARO: Yeah. Well, you see. You've got tissues loaded with water. You don't want to be doing infrared with water anyway. Raman gives you a blank check for water. So there's the advantage. So, those are sort of the things I speculate, presumably.

GRAYSON: Yeah. Well, it'd be interesting maybe to someone in the future. Okay, this is…what of your speculations came to pass.

FERRARO: Yeah. Let me just find this damn stuff.

GRAYSON: People have speculated before.

FERRARO: Yeah. Let me hold this. Okay. This is *Raman Spectroscopy Theory and Practice* by [Herman] Szymanski.[11] We had the course like one of the other places, infrared schools for a week. This was in Canisius College, and I participated in that. […] I wrote the chapter on advances in Raman spectroscopy in sampling techniques. This is from his book. The title is "Possible Future Developments." This is written 1967. "The future will see <**T: 30 min**> additional research toward the goal of more powerful monochromatic laser Raman sources. In all probability, a new laser suitable for Raman use will be developed."[12] I've got it labeled here that it was a new source that I predicted that would…it was rather logical that you could believe that, nothing spectacular. "In addition to being able to save energy in the region, electromagnetic spectrum where one chooses suitable sources…"

[11] Herman Szymanski, ed., *Raman Spectroscopy Theory and Practice.* (New York: Plenum Press, 1967).
[12] John R. Ferraro, "Possible Future Developments" in *Raman Spectroscopy* (1967).

GRAYSON: Suitable sources.

FERRARO: Okay. "Smaller samples can be used." Smaller size samples, there I'm talking about micro samples, in the Raman. "The expected improvement of the fluorescence […] with the laser source will allow one to study many colored aqueous and […] biological solutions that […] cannot be adequately studied by infrared technique, fluorescence improvement. All these factors will serve to develop more interest in Raman spectroscopy in years to come." So, that was just something I wrote in 1967. [It has proven correct with a passage of time.]

GRAYSON: So the…

FERRARO: A lot of things came to…

GRAYSON: Did it happen?

FERRARO: It happened.

GRAYSON: Some of the things that you say were no-brainers. Others were a little stretch.

FERRARO: Yeah, sure.

GRAYSON: So maybe your predictability…well, we'll check it out. So, I guess that covers the future innovations in spectroscopy that you had here on your topic list.

FERRARO: Yeah. I did talk on the other, didn't I?

GRAYSON: Golden Age of…

FERRARO: Yeah.

GRAYSON: Spectroscopy and …

FERRARO: Leave a little bit to that, I think.

GRAYSON: So you've known Marvin for a while.

FERRARO: Well, for a long time. But quite a while, yeah.

GRAYSON: And he was kind of more on the instrumentation side of the…

FERRARO: Yeah. He perhaps did more on the development aspect of it. He worked with people that developed instruments and whereas I was in the application area versus instrumentation. I think that's how you can differentiate us.

GRAYSON: Yeah. He kind of regretted that the two of you couldn't have sat together for this, because it would have been an interesting back and forth with your different perspectives on the field and how it evolved and developed.

FERRARO: Well, one of the things I was interested in the field, from my point of view was the fact that, okay, I got this big tool here. What do I do with it? I like to find out what I could do with the application there and how could this help some of the problems we had in the laboratory? So, it's a different viewpoint more or less. I actually feel you need both.

GRAYSON: Okay. I guess what I'd like to do now, if you think we've pretty well covered the bulk of the interview, if you have any other items that you want to mention…

FERRARO: Well, one of the things that we didn't talk about is what is important for the future vitality of chemical R&D.

GRAYSON: Well, let me see if I can get that on your…on the…

FERRARO: Oh, okay.

GRAYSON: On the video. I haven't started up the video yet. I thought I'd do that. So, I'll go ahead and stop this guy here.

[END OF AUDIO, FILE 1.3]

[END OF INTERVIEW]

LIST OF PUBLICATIONS

1. Katzin, L. I.; Ferraro, J. R. Systems cobaltous nitrate-water-acetone and cobaltous nitrate-water-tert-butyl alcohol at 25Â°. *J. Am. Chem. Soc.* 1950, *72*, 5451-5455.

2. Katzin, L. I.; Ferraro, J. R.; Gebert, E. Some new pyridine compounds of cobalt (II) salts. *J. Am. Chem. Soc.* 1950, *72*, 5471-5474.

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