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Manhattan Project
Session Seven
Collection Division 2: Oak Ridge

Stanley Goldberg, Interviewer

March 5, 1987

Huber, Paul

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Manhattan Project: Session Seven

Gaseous Diffusion

Interview with
Paul Vanstrum, James A. Parsons, Paul Huber

March 5, 1987
in Oak Ridge, Tennessee

by Stanley Goldberg
Interviewer

for the Smithsonian Institution Videohistory Program

NAME LIST

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11:00:58:00 [Begin U-Matic Tape 1 of 2]
[Begin VHS Tape 1 of 1]
[Interview begins with Goldberg and Vanstrum standing in the K-25 gaseous diffusion plant at Oak Ridge National Laboratory]

GOLDBERG: I am Stanley Goldberg. This is Paul Vanstrum. We are here in the gaseous diffusion plant, so-called K-25 plant, at Oak Ridge [National Laboratory]. It was built during the war. It was, ultimately, the process for separating Uranium-235 from Uranium-238. Paul, why don't you point out to us what kind of equipment we have here, and then we'll take a walk around.

VANSTRUM: All right. Be glad to.

GOLDBERG: Then we'll find out what it all means.

00:01:30:00 [Vanstrum indicates the centrifugal pump and diffuser]

VANSTRUM: All right. Basically, the diffusion process depends on the fact that the isotopes of uranium are of different velocities and so they diffuse in the gas at different speeds. The 235 diffuses more rapidly. What we do in this process is to pump a gas with the isotopes of uranium. It's in gaseous form as uranium hexafluoride. We pump that gas into the so-called "diffuser", which has a barrier through which the gas flows.

GOLDBERG: This is the diffuser here?

11:02:08:00 [Vanstrum points to the gas pipes]

VANSTRUM: This is the diffuser, and you can see it's pumped in with, in this case, a centrifugal pump, which gets its gas from two pipes, one coming down the cascade or down the plant, mixes with a stream coming up from the stage below. Together these mixed gases run into this converter, so-called, or diffuser. The 235, diffusing more rapidly, goes preferentially through the barrier, which is a porous material, and is slightly enriched in 235, the gas that diffuses through the barrier.

GOLDBERG: Because it moves faster?

11:02:54:00 [Vanstrum moves to the end of the diffuser and indicates red gas pipes that connect to another diffuser]

VANSTRUM: It moves faster, it diffuses through the barrier more readily or quicker, and the stream is therefore enriched on the low pressure side or the downstream side. Now, we can see that the way that gas comes out of the diffuser in two streams. One is the upflow or the enriched stream; it's the low pressure side of the barrier. And the "B" stream, which is the slightly depleted gas, goes down the cascade. This process is then repeated, the gas is pumped up the cascade and through this red pipe. It's mixed with the stream coming down from the stage above this one, and the same thing is repeated here in this diffuser. The gas is pumped in, one stream, the enriched stream, goes up the cascade, the slightly depleted stream goes down the cascade.

GOLDBERG: How many stages are there altogether?

VANSTRUM: Well, in this plant, I think there were something like three thousand stages, so that by the time you did this many, many, many times, just in series, the gas could be enriched to very high enriched material. And depending on the flows and the recycle ratios and so on at the top of the cascade, one could deplete the stream to, again, well below the natural enrichment of uranium.

GOLDBERG: The natural enrichment is one part in--what is the. . .

VANSTRUM: .0715 is the. . .

GOLDBERG: .0715 is the percent?

VANSTRUM: Percent 235.

GOLDBERG: And the rest is mostly 238.

VANSTRUM: Mostly. So the gas is mostly 238. Thus the long plant to get the high enrichment. The separation factor, of course, is very, very small at any one stage. One had to take the very best analytical mass spectrometers to determine whether, in fact, you were getting separation across the stage. So it's only over a large plant that one got significant separations.

11:05:19:00 [Goldberg indicates the air pressure lines and pressure taps suspended from the ceiling]

GOLDBERG: What are all these pipes up in here, these little pipes up in here?

11:05:24:00 [Vanstrum points to the air-actuated control valve]

VANSTRUM: Well, there was a control of this flow. Obviously, these pumps have to be controlled, how much flow goes where. In this particular building, the main control is by means of a control valve, an air-actuated control valve, which can open and close to modulate or change the pressure on the B downflow. So that one could keep the right ratio of flows, the right flows in each pipe by controlling the back pressure on the control valves. So one of the things you see here is air to the control valve, pressure taps, so that you can determine what the pressure is. It was mostly pneumatic instrumentation in the years that this plant was built. Thus, there's a lot of lines both for air pressure and for pressure taps to determine what the pressure is.

11:06:27:00 [Camera scans across the cell]

Additional lines are provided. As you look down the cell, you see quite a number of other lines. There were sampling points. We'll probably see a station upstairs where one can withdraw gas samples from the streams in the cell to determine whether you had excessive in-leakage or not. Since this process is running below atmospheric pressure, any cracks in the pipe or anything like that causes in-leakage into the process. That was one of the great concerns. All of this is vacuum equipment, and the concern was that if air in-leaked, leaked into the process, it would hamper your operation at the very least, and could plug up the barrier and things like that. So that there was a lot of attention given to in-leakage, and samples were provided so that you could see what the in-leakage was. We had mass spectrometers analyzing this.

GOLDBERG: A mass spectrometer is a device. What's it do?

11:07:40:00 [Vanstrum points to the green cooling pipes attached to the compressor]

VANSTRUM: It's for looking at materials of different mass. You could run the gas into the mass spectrometer and actually get a printout or a chart of the impurities. For instance, you could see whether you had an air leakage or a coolant leakage. These were all cooled. You can see the green pipes here where to cool a gas, to take out the heat of compression from the compressor. You could see whether it was leaking in. That was done continuously as a process, because you wanted to isolate--if you had, for instance, a big leak in this particular cell, you would want to isolate this cell and bypass it and then come in and fix the leak. There were provisions for that in the pipe. There were big block valves at the ends of the cell and a bypass pipe that would enable you to bypass this cell and shut it down. This was the smallest group of equipment that you could shut down if you had problems. The rest of the plant, the hundreds of other cells, could go on operating, but this one would be shut down to fix the leak.

GOLDBERG: When you say a cell, I mean, the camera probably can't see it, but as I count, there's one, two, three, four, five, six of those.

VANSTRUM: Right. In this particular size equipment, this is an intermediate size equipment in this particular plant and in this particular building and this cell, which is repeated many times over, there were six stages, we called them, or six diffusers in each cell. And that could be isolated, could be shut down, could be repaired and fixed while the rest of the plant was operating.

GOLDBERG: One other thing I guess we ought to point out here is that this cell, the floor is actually steel plate.

11:09:33:00 [Camera focuses on floor]

VANSTRUM: Yes. The whole cell enclosure initially was welded tight and was supplied with dry air. The uranium hexafluoride is a very reactive gas, and it reacts with moisture. For instance, water immediately reacts to form a non-gaseous uranium oxyfluoride, UO_2F_2. If you had wet air leak into the process, the solid material would coat out on the barrier and plug the barrier. So what they did initially was to surround all of the equipment and piping with dry air. So if air would leak in, it would be dry. You wouldn't have any moisture reacting with the UF_6 and no plugging. As it turned out, we were able to get the plants leak-tight enough that we no longer provide dry air, but just regular air.

GOLDBERG: Literally, this was all sealed up?

VANSTRUM: This was all sealed up and provided with very dry air that was dried in a plant inside of the plant area here.

GOLDBERG: Very good.

11:10:45:00 [Pause in interview]

PARSONS: . . . had like seven or eight people who just tore down and looked for those red lights flashing. You could look down this half-mile and see one, you know, all the way down. We took all the people out. There were just about a dozen people in this mile-long building.

11:12:18:00 [Interview resumes; Vanstrum, Parsons and Huber are seated near a diffuser in the plant]

GOLDBERG: We ought to say this building is like a big U. We'll look at it later, but it's like a big U, and each leg of the U is a half-mile long, isn't it? And altogether there's twenty -five hundred stages?

PARSONS: That's close enough.

GOLDBERG: Well, we've looked at the equipment. Now let's talk about the schematic drawing on the wall, about how it works.

VANSTRUM: Do you want me to get up and get to the chart or just sit here?

GOLDBERG: Why don't one of you go to the chart. Let me introduce you all so we know who we're talking to. We have Paul Vanstrum again, and on his right is Jim Parsons, and on his left is Paul Huber. All of you were working here in this gaseous diffusion process during the war. We'll talk a little more about that later, but now let's try to understand this process so that we'll sort of be comfortable with it when we go to various places in the building. Why don't one of you be the pointer. Just chip in. Let's see how this works. We'll talk it over.

11:13:33:00 [Huber moves to the schematic chart on the wall illustrating the gaseous diffusion process]

We're using a gas called uranium hexafluoride, U^{F}_{6}, which, I guess, in the jargon is usually referred to as "hex."

PARSONS: Or UF_6.

GOLDBERG: UF_6, yes. That's a pretty reactive gas.

VANSTRUM: It's a very reactive gas in terms of its reaction with moisture. For instance, if you were to feed uranium hexafluoride out into the atmosphere, you'd get a cloud, a white cloud, because the uranium hexafluoride reacts with the moisture in the air and forms solid uranium oxyfluoride or UO_2F_2.

PARSONS: And HF.

VANSTRUM: Right. And HF. So the process. . .

HUBER: It's the HF, of course, which forms a cloud.

VANSTRUM: The process had to be leak-tight. In other words, you didn't want wet air leaking into the process, because it would react with uranium hexafluoride, form the solid materials and HF, which would react or plug up the barrier materials. And so this whole enclosure was tight so that it could be supplied with dry air, and any in-leakage into the process would be dry air and, therefore, no reaction products.

HUBER: Another concern, as related to reactivity in the uranium hexafluoride, was the reaction with the components of the equipment itself. And to minimize this, all the equipment was nickel-plated, and the main component, the diffuser or barrier material, was made out of nickel. Prior to bringing these components into the process, they went through a very strenuous cleaning operation, degreasing, rinsing in various cleaning solutions, drying. And one of the checks that they made at that time was to take surgical gauze and wipe it over the surface of the equipment, the pipe or the converters, and if you could see any sign of dirt, why, it would go back through the process. So this was another step that was taken to make certain that the uranium hexafluoride remained in that chemical form, in the gaseous form, rather than reacting with the surfaces and dropping out on the equipment.

GOLDBERG: You used nickel because it doesn't react with nickel?

VANSTRUM: That's right. It forms very slowly. It forms a natural protective layer that's very unreactive subsequently.

HUBER: Another precaution that was taken prior to the equipment being exposed to uranium hexafluoride, it was first exposed to fluorine gas to form a metal fluoride surface so that this reaction would be satisfied and would not then take place with uranium hexafluoride.

GOLDBERG: We're going to say a lot more about uranium hexafluoride, which is really interesting stuff.

HUBER: Yes, it is.

11:17:20:00

PARSONS: We've been asked quite frequently, "Why use fluorine and fluorides, since they're such awful materials to handle?" The primary reason is that fluorine doesn't have any isotopes, and therefore it did not complicate the isotopic separation process. Many of the materials you might have thought about would have isotopes, and then you'd end up with intermediates, and it would be very awkward to deal with in the diffusion process.

11:17:51:00 [Huber has returned to his chair]

VANSTRUM: There aren't too many volatile components of uranium either, and so we were fortunate to have a compound that's isotopically clean.

GOLDBERG: Of course, if you had isotopes with fluorine, then you'd have a whole spectrum of things coming through.

PARSONS: Then it would be very awkward. That's a vein in mass-type separation processes.

GOLDBERG: I never thought about that before.

PARSONS: We actually have that problem, of course, because there are other isotopes of uranium other than Uranium-235 and 238, so we do have an isotope 234, for instance, that somewhat complicates the situation in our separation. And if we refeed any material that came back from previous operations in nuclear reactions, we'll have 233.

VANSTRUM: And 236.

PARSONS: And 236. Right. These, again, complicate things. We haven't had to face that problem very frequently, but it is possibly in the future of these operations.

GOLDBERG: Why don't we now go over the process again. This time let's use the schematic, and then we'll all understand totally how this works.

11:19:14:00 [Huber returns to schematic chart and traces the path of the gas]

HUBER: Possibly it's a little easier to see in the schematic. In this case, you have the feed compressor feeding into the converter. The dotted line represents the diffuser or barrier material. Roughly half the gas passes through the walls of the barrier to the low-pressure side, and then is picked up in the suction of this pump and compressed and fed on up to the suction of this pump, where it is joined from the downflow of the stage above here. The stream that is the depleted stream, that has not passed through the barrier, joins and is fed into this unit.

[INTERRUPTION]

11:20:34:00 [Huber moves to the other side of the chart]

GOLDBERG: Why don't we go through, again, the logic of the process. Use that diagram there, and then everybody will understand how it works.

11:20:47:00 [Huber indicates the diffuser's barrier material wall in the diagram]

HUBER: Well, the logic of the process is that the velocity of the gases are dependent upon their mass, and the 235 being lighter than the 238, it moves faster and so will strike the barrier material wall surfaces a little bit more frequently. And therefore there's a little bit better chance that it will pass through the pores in the barrier. This is a separation-rich stream, and this is the basis for the separation.

PARSONS: The separation factor, from a theoretical point of view, is 1.00429 to 1. It's so small that you just can't. . .

HUBER: That's the theoretical. The actual is something else again.

GOLDBERG: It's very, very close to one, so the logic of it, then, is that you have to repeat it over and over and over and over again.

HUBER: That is the reason why there's so many stages involved in the enrichment process using the gaseous diffusion method.

GOLDBERG: And that's why we're in a building that's on three floors and a mile long.

HUBER: That is correct.

11:21:58:00	[Huber traces the path of the gases from the diffusor, to the compressor, to the next stage]

HUBER: Well, the enriched material does pass through the barrier, and the depleted material is fed to the stage below. The enriched material, having passed through the walls of the barrier, has lost some of its pressure, and this is picked up by this compressor here, and the two streams then are fed into the stage above.

GOLDBERG: When you say the two streams, there's also the depleted stream from the stage above this one.

HUBER: That is correct. And this process then is repeated just hundreds of times over in various stages.

VANSTRUM: You might mention the control on the flow through the control valve. One has to control the pressures to get the right distribution of flow, and that's done with the control valve shown there. Also the heat of compression of these compressors is taken out of a cooler that isn't shown in this schematic, which is at the front end of the diffuser--an unreactive liquid coolant in this particular plant that was developed specifically for that application. This just goes over and over again. Now, there are different sizes of equipment. As you're near the feed point, for instance, you have the largest flow.

GOLDBERG: So that, when you say the feed point, that's where you start from.

VANSTRUM: The device that is fed with the natural uranium.

GOLDBERG: Which is not 7 percent, as we said before, but .7 percent.

VANSTRUM: One in one-hundred forty.

VANSTRUM: Counting the diffusion, counting the purge cascade, if you want to call it. There's some very small units.

PARSONS: We never put a number on those.

VANSTRUM: Okay. [Laughter]

11:25:43:00

GOLDBERG: Before we move on, let's say just a little bit about the barrier, what is has to be like.

VANSTRUM: Well, we're talking, really, molecular-scale almost.

GOLDBERG: It's got to have tiny, tiny little. . .

VANSTRUM: It has to have very, very small holes, so that, in fact, the flow through the barrier is diffusive flow. That's what you'd like to have, because that's where the difference exists in the diffusion characteristics of the two isotopes, depending on mass. If you have any viscous flow or just a big hole through the barrier, the 238 and 235 flow the same way through that kind of hole. So what you want is very uniform pore material at a size where you maximize the diffusive flow through the barrier.

PARSONS: Something equivalent to about one-half the mean free path of the molecules in the gas.

VANSTRUM: So you not only have small holes, but you need a lot of them, obviously, if you're going to get the large flow that's needed. So you want a very highly porous material with very, very small and controlled size holes.

GOLDBERG: When you talk about the area of barrier that you're talking about in one of these, in the whole building, you're talking about acres and acres of square miles.

11:27:02:00 [Vanstrum refers to diagram]

VANSTRUM: Many, many acres. In fact, these diffusers are literally packed with barrier materials that are shown here schematically as one sheet. Actually, it's many, many thousands of tubes of barrier material that are located in the barrier. One can change the geometry, the size of the tubes, and the number of passes and things like that to meet whatever the process requirements are.

GOLDBERG: Now let's back up a little and talk about what it was like in the early days. What was the building like? When did you come, Jim?

11:27:49:00

PARSONS: I got here Labor Day weekend of 1944. I had been working at Columbia University earlier in February, and I went to the Linde [Air Products Company] plant in Onawanda, New York, where we were manufacturing barrier for this process, got here in the late summer of 1944. Nothing was running yet. Mostly emphasis was on construction and the training of the people who ultimately would run the plant.

11:28:25:00

VANSTRUM: I arrived here shortly before that, in August of '44, amidst the dust and dirt and so on of ancient Oak Ridge. I think it was an exciting experience. I think I felt that, as most people did at that time, and still feel privileged to have been part of it. But there were thousands of construction people swarming over this equipment, with welding sparks flying every which way, and new technologies, vacuum testing, process control, sophisticated instrumentation by those days' standards, and myself, as a young, inexperienced engineer, was thrilled to be here.

There was, of course, tremendous pressure to get this before some other country. The Germans, in particular, were able to separate isotopes. So that people worked with a vigor that, I think, I've never seen since. Without complaints or anything else, we pitched together as a team to really get this place put together and running.

GOLDBERG: But there were labor problems, weren't there?

VANSTRUM: Well, sure, whenever you put together thousands and...

PARSONS: Seven-thousand people.

VANSTRUM: Thousands of workmen with new technologies and stringent controls, the cleanliness controls Paul mentioned, the vacuum tightness that had never really been accomplished on this scale before. Sure there were problems. But we weren't focusing on the problems other than to get them out of the way and get the job done. It was a thrilling experience, I think for all of us.

PARSONS: It was pretty free-wheeling. The money flow was relatively simple. You didn't have a lot of the problems that one has today in going out and buying hardware. In fact, you could travel with an Army captain who had a blank checkbook in his hip pocket, who could place an order, you know, on the spot if you really needed the hardware that somebody was displaying to you. These compressors, for instance, that were built in this particular building by Allis-Chalmers [Manufacturing Company] the final order was placed in August, and the first compressor was delivered in November, if you can imagine such a thing.

GOLDBERG: And there are thousands of them in here.

VANSTRUM: This whole building was built in a time now that it takes to generally do the engineering and design.

PARSONS: We worked so closely with those people that, you know, we formed lifelong friendships. Charlie Codrington and

Harry Welsh from Allis-Chalmer's compressor shops were just like one of us during this kind of work.

11:31:29:00

GOLDBERG: How long did it take them to build this building?

HUBER: Let's see. They started--I guess the first work was done in 1941, wasn't it?

PARSONS: 1943.

VANSTRUM: Early work was done by laying the groundwork and some. . .

GOLDBERG: The building itself?

HUBER: Of course, it was well under way in 1944. The buildings themselves were erected by that time. Basically, they were erected in 1943. The equipment started coming in then in 1944. It was a great help to all of us who were later to operate the plant to be able to see the equipment go in. This was a tremendous help in understanding the process and to later be able to operate it and to control it. One of the reasons for the enthusiasm and the vigor with which we went about the job had to do, I think, with our age. [Laughter] We were all quite young at that time. As a matter of fact, I think Oak Ridge was noted at that time as being the youngest city in the United States. I think it has completely changed by this time. [Laughter]

PARSONS: The average age was on the order of twenty-five.

HUBER: So this was one of the early reasons that we had the enthusiasm and the vim and vigor to go about the job. Also the fact, as Jim has pointed out, that there really was very little red tape as far as getting things done in those days. If you had a good idea, you could present it, and it was, as Jim said, funded on the spot.

VANSTRUM: Things would happen, right.

HUBER: So with that type of atmosphere and all these young engineers swarming over the place, things really did move. It was an experience that I think all of us cherish and would not give up for anything.

PARSONS: I remember having a checklist of maybe fifty items to complete in a single shift, an eight-hour shift, you know, that would be left by the day supervision. Rarely did we leave it behind.

VANSTRUM: Running up and down the steps a half-mile distance over one side of the plant and another half-mile down the other side.

PARSONS: I checked myself one time just to see how many trips I made up and down these stairs on a shift, and I went up and down twenty-five round trips in one eight-hour shift.

VANSTRUM: That would be hard now.

HUBER: Later on, they matured and got bicycles.

GOLDBERG: They actually did. We're going to go upstairs later, but they actually rode bicycles back and forth.

PARSONS: Sometimes we would never get off one the whole shift, just move from one point to another.

11:35:06:00

GOLDBERG: What was your training? Were you all engineers? Did you have college degrees?

VANSTRUM: Chemical engineers. There were, I'd say, a preponderance of chemical engineers. Union Carbide [and Carbon Corporation] was an operating contractor, and, of course, they're in the chemical industry. And their knowledge of chemical processing was one reason they were involved, and they hired a lot of chemical engineers. I was actually with Carbide before I came down here, but many of them were hired from elsewhere.

PARSONS: As I recall, the name of our employer was the Carbide Chemicals Corporation.

VANSTRUM: Carbide Carbon.

PARSONS: Carbide Carbon Corporation.

GOLDBERG: The building wasn't built by Carbide.

VANSTRUM: No, no. Carbide was hired as the operating contractor. And so they knew right at the beginning, when they first got in the thing, that their job would be to operate the plant once it was built. They, of course, became deeply involved in the engineering and design and so on, to become familiar with what they were going to operate. Also, Linde, as Jim mentioned, he went to the Linde plant, where they were doing a lot of barrier development work and barrier manufacturing work. So they were not only involved as an operator, but involved in the technology early on in the process.

PARSONS: Carbide took over the control of the barrier program in November of 1944.

GOLDBERG: Wasn't that Hershey-Houdaille [Houdaille-Hershey Corporation]?

PARSONS: Houdaille-Hershey operated that big barrier plant in Decatur, Illinois, and that was where most of the barrier was actually made, although a significant segment of it in the lower part of the plant here came from the plant that Linde operated in Buffalo, New York.

11:37:02:00

GOLDBERG: So while we're here and while we have this thing in front of us, let's say a little bit about what some of the problems were. This building was being built, it was in the middle of 1944, and yet there still was no barrier material for inside these things, was there? I mean, that was one of the problems, was to figure out how to make the barrier.

VANSTRUM: It was pretty thin for a while. In fact, there was a pilot plant in operation at Columbia University that was run by us Scrib kids like myself, and some of the barrier that's installed in this plant is actually barrier that was produced in that power plant in the basement of Scibur Hall at Columbia University.

GOLDBERG: At Columbia University?

VANSTRUM: Right. I think both Jim and I were involved in that. We were laborers, I would say.

PARSON: We called it the salt mine, but it was a very interesting place to be. We did everything. We swept the floors, we cut the nickel up, we did everything including going out to get our lunch at this delicatessen.

VANSTRUM: And we were, of course, all anxious to get down to the plant to see what things were really going to be like, and so it was fun to get down here when we did.

HUBER: I think Carbide itself, other than Linde, did not get as directly involved in the barrier manufacture in the early days as they did in some of the other items such as the compressors, the seals on the compressors, the general construction work itself. I think they paid a great deal more attention to that and just prayed that the barrier problems would be solved. There were enough problems here to keep everyone occupied, that they just had to rely on somebody else to resolve the barrier problems.

PARSONS: They had a lot of fingers in the pie of the whole project, not just the diffusion plant. They were the primary suppliers of the graphite blocks, for instance, that were used in the piles at Hanford [Engineer Works]; they were involved in the processing of the uranium ores in Colorado, and so on. So it was a major business enterprise to them. It did include this, but there were a lot of other parts of it. They were involved in virtually all parts of the program.

11:39:41:00

VANSTRUM: You asked about the problems initially. Of course, there were all the uncertainties. Nothing like this had ever been done before, and the full-scale equipment had never really been tested and run together, much less on a giant scale such as the plant is. The seals, for instance, were one of a kind, developed specifically for this process.

GOLDBERG: Compressor seals.

VANSTRUM: Compressor seals, to prevent leakage from the environment going into the plant.

GOLDBERG: But a seal is a seal, isn't it? You just couldn't use, let's say, something like an O-ring?

VANSTRUM: Well, the leakage requirements were much more stringent, for one thing, and, of course, with uranium hexafluoride having its particular characteristics and these pumps having their particular characteristics, there was not a seal available that would meet the requirements.

GOLDBERG: That would actually hold the stuff?

VANSTRUM: Well, the processors are under vacuums, so you're really primarily keeping air from leaking in, and a very stringent requirement, almost unbelievable "in leakagrie" requirements were put on the seal. So some very fine work was done to develop that seal. The pumps, of course, nobody had pumped uranium hexafluoride before.

GOLDBERG: And you're pumping it around.

VANSTRUM: It's an unusual gas. For instance, I think in atmospheric pressure, it weighs about a pound per cubic foot.

HUBER: That's heavy, though, compared to the in-leakage gases. This is one of the concerns: to be able to move the gases. If the pump is designed to handle uranium hexafluoride, a relatively heavy gas, when you hit nitrogen and air, it's light, and so the performance of the pumps changes radically.

PARSONS: The pressure ratio goes to virtually zero in the light gases.

VANSTRUM: So in-leakage was a crucial problem, and a whole new technology of vacuum testing was developed to assure that welds and equipment were leak-tight when this plant was built.

11:42:04:00

GOLDBERG: But hexafluoride also has got problems with lubricants, too, don't you?

VANSTRUM: Well, that was solved by putting the bearings and stuff outside and having a seal that would seal against the air, and so the only other in-leakage you were concerned about was the coolant gas that I mentioned. You had to have some way to remove the heat of compression. This is picked up in a fluorocarbon gas which is unreactive, again specially developed for the diffusion plant. It's a liquid that doesn't react violently, at least with uranium hexafluoride.

HUBER: It's a fluorocarbon.

VANSTRUM: Fluorocarbon liquid.

PARSONS: Dimethyl cyclohexane, completely haligenated.

VANSTRUM: You could pump it up through the stream lines and to a water heat exchanger and dissipate the heat in cooling towers.

PARSONS: It has a vapor pressure almost the same as water. It doesn't boil at reasonable temperatures. It's a very nice performer.

11:43:18:00

GOLDBERG: When you first came here, you knew what you were working on? When you went to Columbia, obviously you must have known what you were working on.

VANSTRUM: Yes.

GOLDBERG: But you had to be careful when you got here, because the people that you had to deal with here, for example, the people who were actually going to operate the plant, didn't know what they were working on.

VANSTRUM: No, they were people from all walks of life, recruited energetically, because we had to hire a lot of people. And we couldn't tell them what the process was, what the purpose was, or anything else. So that in training, we used code names for all of the gases, and all people could see was a tremendous plant with a lot of pumps and pipe, with very little going in and coming out. It was hard to explain without a real thorough explanation.

HUBER: It was based on the need to know. You were told what you needed to know, and that's all.

PARSONS: A common explanation among the local folks here was that we were building the front ends of horses to ship to Washington for final assembly. [Laughter]

GOLDBERG: [Laughter] I hadn't heard that one before.

PARSONS: That was a fairly common story.

VANSTRUM: I think most of the people that came here were as dedicated as the engineers and technical people. And it was, again, a challenge to train them adequately, make them understand the importance of leaks in the plant, the importance of keeping things in a steady state and smooth operating, without really explaining what it was we were doing and why exactly some of these things had to be done. Also, the safety problem. You know, these are hazardous gases, and so a lot of attention was given to that, without people getting overly concerned about it.

HUBER: I think it can safely be said, too, that this was the best job that they probably ever had, and so that they were quite cooperative in the basis of the job alone. This was a very isolated area and was selected partially for that reason. So there had been no industrial activity of any kind in this particular county region of Anderson Roane and Morgan County. It was all more or less mountain foothill type of country.

PARSONS: There's another saying locally that the folks working here were making "that big government money."

11:46:29:00

GOLDBERG: [Laughter] The one I've heard, that Oak Ridge was a place where everything came in and nothing went out. You know, in a way that's true. What came out of Oak Ridge during the war was a couple of hundred pounds, maybe, of Uranium-235.

PARSONS: A lot of people came out. When this facility first really started, it required the attendance of something like twelve thousand people. Before the operation had really gotten broken in, that was down by at least eight people. They let the air out rather quickly, so there was. . .

HUBER: I think you left a little too much air out there, though.

PARSONS: Was it?

HUBER: I think we got down to about--the early projections, as you say, were up around twelve thousand. I think we actually peaked at around seven.

PARSONS: Okay.

VANSTRUM: I think the people that did the engineering and design work on some of this equipment are real heroes in this country, because one of the reasons we were able to get the population down was the equipment ran very well and we, of course, learned how to run it well. And so some of the difficulties that were anticipated and could have occurred didn't materialize to the extent that we were prepared for.

GOLDBERG: So you had hired all these people because you had anticipated. . .

VANSTRUM: Right. You didn't know how much equipment was going to be in maintenance shops.

HUBER: A very good point.

VANSTRUM: And how much trouble you'd have with leaks, how frequent would they occur, how big would they be, how much disruption would you have. As it turned out, it was very reliable.

HUBER: Yes. I don't think the bugs were any greater than you take a standard process like the manufacture of sulfuric acid, for example. I don't think the bugs were any greater than in a new plant of a known process. It was a remarkable engineering job that they did.

GOLDBERG: The people who designed it wasn't Union Carbide; it was designed by the Kellex Corporation [Kellex Company], which was a new corporation, sort of broken off from Kellogg Corporation [M.W. Kellogg Company].

HUBER: Yes. Of course, this was headed up by Manson Benedict, who did a lot of the theoretical engineering work.

GOLDBERG: Very good. Let's take a break here. Very nice.

PARSONS: Is it going the way you want it?

GOLDBERG: It's going the way you want it. It's terrific.
11:49:21:00 [Pause in Tape]

11:49:37:00 [Interview resumes with Goldberg and Vanstrum standing near the backside of a pump]
GOLDBERG: Paul, why don't we, while we're here, just identify what we've got here. This is the outside of the cell that we're going to go into in a minute.

11:49:45:00 [Vanstrum indicates the pump and points to the motor, drive shaft, seals, electrical gear and utility lines]

VANSTRUM: Yes. As you know, in the gaseous diffusion process, you're pumping a lot of gas, the process gas is uranium hexafluoride and you pump it in very large quantities. Here we have a pump, the backside of the pump that is doing that pumping. It's driven by a motor, here in this case, a 60-horsepower motor connected by a shaft to the pump impeller. It's lubricated in a conventional way with lube oil circulated to two sleeve bearings. And, of course, you have the sealing problem, which we've discussed or will discuss some, and the various utilities supplying the equipment here--the electrical gear, the lube oil supply, which is pumped from a central location in this building, and the utilities to the seal and to the other equipment here.

GOLDBERG: How big a motor is it?

11:50:45:00 [Vanstrum points to the 30hp motor on the adjoining pump]

VANSTRUM: This is a 60-horsepower motor, and the one adjoining is a 30-horsepower. This handles only half the stream. It takes the diffused stream out of the diffuser that we'll see inside, boosts its pressure back up to that of the "B" stream or the high side pressure, pumps it in this direction to join with the stream coming down from the cell above. And here the whole flow, both the flow going down the plant and the flow going up the plant, are joined in this larger compressor or larger horsepower compressor to run it into the diffuser for the separation process.

GOLDBERG: That's very good. Now, let's go inside.

11:51:35:00 [Goldberg and Vanstrum walk through the cell door]

VANSTRUM: All right.

GOLDBERG: Looks empty again, huh?

11:51:58:00 [Tape fades to black]

[Begin U-Matic Tape 2 of 2]

12:01:18:00 [Interview resumes; Goldberg and Vanstrum are standing on the control room floor of the plant]

GOLDBERG: Today is March 5, 1987. We're at Oak Ridge, Tennessee, and now we're on the third floor or the operating floor, control room floor, if you like, of the gaseous diffusion plant. I'm here with Paul Vanstrum, who worked in this plant until it closed down, I guess, in 1964.

VANSTRUM: Yes. Yes.

GOLDBERG: So this plant operated from 1944 until about 1964. At the time that it was operating, Paul, I guess this place--there would have been a lot of people here.

VANSTRUM: Well, initially, when the plant started and we really weren't sure of how much equipment failures and maintenance effort would be required, we had quite a few people. There were people on each panel board, there were people at other control stations. We found that because of the reliability inherent in the equipment and the reliability we could get in operations, that that was soon diminished, and very few people ended up in later years being at this particular location in the plant.

GOLDBERG: We can't see down right now, but, in fact, these corridors are half a mile long.

VANSTRUM: Yes. The building is a large U-shaped building, a half a mile down one side, a few blocks across the end and another half a mile down the other end.

GOLDBERG: And this is the place where people rode around on bicycles.

VANSTRUM: Right. Right. It was a quick way to get around and enjoyed by most of us.

GOLDBERG: Why don't you say a word about this.

12:02:46:00 [Goldberg indicates the block valve coming from the floor]

VANSTRUM: Well, obviously, in a large plant like this, we don't want to shut down the whole plant when we have an isolated equipment failure, so we provided block valves and bypass valves, bypass piping, so that we could shut down equipment, a cell of equipment, six stages, say, and bypass it, go in and fix that equipment and, at the same time, leave the process in main operating. So it was an ability to shut down, isolate equipment, keep the whole plant running all at the same time. Again, because of the reliability of the equipment, we had to use this a lot less than was anticipated. But it was essential to keep the plant running, even though you had local difficulties.

GOLDBERG: Why don't we go over now to these scales, to the product removal, is it?

VANSTRUM: Yes. This is product withdrawal. As the plant was built, initially, of course, we just had part of the plant running down near the bottom of the plant, and we used some manifolding that was built into the system for analytical purposes to give us access to the process equipment. As the plant was completed, we moved the withdrawal point up towards the top of the plant. This ended up being the location where we withdrew the top product, top assay, top 235 concentration product.

GOLDBERG: So it's here that the enriched Uranium-235 product would be removed.

12:04:20:00 VANSTRUM: [Vanstrum points to one of the refrigerated vessels] It was withdrawn as uranium hexafluoride solid. In other words, the gas would come from the process system up to these tanks which really are refrigerated vessels, a bath refrigerated. You'd hook the withdrawal cylinder onto these connectors, a gas would flow into the cylinder, which was positioned into this bath. You'd let it go until you got the right amount. The whole thing is mounted on a scale that can move. You'd run it until you got the desired amount of product in the cylinder and then shut this off, go to the next station and continue the withdrawal process.

GOLDBERG: Why do you have to worry about how much comes? Why couldn't you just cram it in?

VANSTRUM: Well, with highly enriched uranium, you have what they call a "critical mass." You can get uncontrolled fission of the material if you have too much mass in one location. So they would restrict both the size of the cylinder and the amount you'd withdraw to essentially get double protection and really minimize to the point of vanishing probability the risk of criticality problems.

GOLDBERG: But then you'd have to worry about not getting too many of those cylinders together.

VANSTRUM: Well, for that purpose, we devised what they called "bird cages." The cylinder would be nestled in the center of this cage, and the structure built around the cylinder would prevent that cylinder from coming into close proximity with other cylinders. Again, you relied on the always safe geometry to protect you from any approach to criticality. Actually, all the safety factors being built into the thing.

GOLDBERG: And you never had any trouble?

VANSTRUM: We never had any problem here at K-25, no. So this is where the early withdrawals were done, and it worked very effectively.

GOLDBERG: Now let's go around and take a look at those manifolds.

VANSTRUM: Okay.

12:06:38:00 [Vanstrum and Goldberg begin to walk towards manifolds; Goldberg pauses to note a warning label attached to the scales]

GOLDBERG: Oh, I see. I didn't see that before. Over here it says, "Do not exceed 55 pounds of UF_6 in cylinders."

VANSTRUM: Yes, that was another one of the controls. The cylinders were of a maximum size to restrict that, but also a double control, you might say, was on the total weight of the cylinder.

GOLDBERG: I see.

12:07:00:00 [Vanstrum indicates scale used for measuring tare weights]

VANSTRUM: That was checked even further, using this scale over here, which was used to measure the tare weight of the cylinder and rechecked the full weight of the cylinder again, to be doubly sure that you had what you wanted in the cylinder.

GOLDBERG: Well, let's go.

12:07:20:00 [Goldberg and Vanstrum arrive at the manifolds; Vanstrum indicates the valve handles on the outer door and then opens it to display the manifolds and their connecting pipes]

VANSTRUM: Over here we have the manifolds through which we could connect to the desired cell. One had a lot of valve handles here that connect to the manifold we have. You can see the pipes coming up from the cell enclosure below or the group of stages below.

GOLDBERG: Where we were before.

VANSTRUM: Where we were before. Across each cell there's a connector that circulates UF_6, uranium hexafluoride, up to this point, and using these valves properly, one can withdraw material from each cell location in this particular building. That was originally set up so that you could analyze the contaminants in the gas stream. We'd like to have pure UF_6, but we know there's going to be some in-leakage, either coolant or air or nitrogen or one of the other materials, and with these sample lines, one could get a quick analysis of the gas stream as you monitored it through this valving system and the analytical instrumentation we have shown on the other side.

GOLDBERG: Could I ask a naive question? You know, before, we were talking about the fact that everything had to be nickel for this piping, but it looks like copper to me.

VANSTRUM: Copper is also quite a good material.

GOLDBERG: It is?

VANSTRUM: Yes. It's not as good at high temperatures as nickel, but essentially all of the pressure-tap tubing coming up to the instrumentation or fed from the cell location to the transmitter in the cell enclosure--all of this piping was copper, and it proved to be quite satisfactory.

GOLDBERG: So you could use copper.

VANSTRUM: Could use copper. Aluminum is also quite a good material, but wasn't used very extensively in this plant.

GOLDBERG: Okay.

12:09:28:00 [Goldberg and Vanstrum move to a panel board]

VANSTRUM: Over here we have some of the panel boards, and they've obviously been cannibalized for useful parts, but these were to control the mass spectrometer analyzers that were an important instrument in detecting in-leakage and contamination of the process stream. Here you could set the instrument up so that it was operating correctly. You could get a record of what all of the impurities were in the gas stream, and this record was also duplicated in the control room so that someone could look at the whole plant and see whether one had a big leak or small leak or whether it was a steady increase, just what the condition of the gas stream was in terms of contaminants.

GOLDBERG: There would be one of these in every. . .

VANSTRUM: Every building.

GOLDBERG: But what's the difference between--this is all one building.

VANSTRUM: I'm sorry. The building I'm talking about as a building is a group of stages that can be independently isolated from the rest of the plant. The breakdowns start with the cell enclosure, like we were inside of. That's the smallest group of equipment that can be isolated from the rest of the plant.

GOLDBERG: Six diffusers.

VANSTRUM: Six diffusers in that case, and I think there were six diffusers in this building also. There are maybe, say, ten of those cells in a building.

GOLDBERG: About sixty diffusers.

12:11:03:00 [Vanstrum indicates the manifolds and the panel board]

VANSTRUM: Yes. That's the building I'm talking about that's consistent with this and this.

GOLDBERG: Okay.

VANSTRUM: And you can isolate the building as well as the cell. In other words, if you had extensive difficulties here, you could isolate the whole building and bypass the building so that this whole building, whole group of stages, cells, is out of commission.

GOLDBERG: Okay.

12:11:29:00 [Vanstrum walks to the mass spectrometer and indicates its working parts]

VANSTRUM: This is the heart of the analytical system that was used. Professor Al [Alfred Otto Carl] Nier from the University of Minnesota developed this instrumentation specifically for the diffusion plant. He was an expert in mass spectrometry and was called on to develop a mass spectrometer that could work in UF_6, which was a chore in itself, and could respond to a wide range of masses and do it with more or less automatic readout and automatic recording. This is a newer version. His model originally was all glass. This is the working part of the tube. It has a means of injecting a sample, ionizing it, sending it down, accelerating it down through this magnet, deflecting it sixty degrees into a collector down here. By varying the accelerating voltage, one could tune in various masses in the spectrometer, so you could cover all the way from nitrogen up to very high molecular weight fluorocarbon materials, and determine what your contaminant concentrations were.

GOLDBERG: But this is really in your specialty, wasn't it?

VANSTRUM: Yes. Nier was the world expert, I think you could say, in mass spectrometry. Using his spectrometers up at the University of Minnesota, he took some of the natural uranium, separated it in very, very small quantities--I suspect you couldn't even see the material hardly--and sent it up to Columbia University, where it was determined that Uranium-235 isotope was the one that fissioned. So his spectrometer had a fairly substantial influence on the whole acceleration of the Manhattan Project.

GOLDBERG: That was very early in the game.

VANSTRUM: That was in '39, I believe, yes.

GOLDBERG: '39 or '40.

VANSTRUM: Yes.

GOLDBERG: But he was also the person who, using this kind of equipment, I guess, was analyzing the samples while this whole system was being developed.

12:13:49:00 [Vanstrum refers to the spectrometer during his dialog]

VANSTRUM: Yes. That's another spectrometer that he contributed to the project, one that doesn't measure impurities, but measures the isotopic concentration, which, of course, is much, much harder to do. You're looking at a uranium sample, and you're trying to determine the percent Uranium-235 and 238, and in some instances, 234, which becomes a factor when you get up to high assay 235. He developed that spectrometer. Those were used in the laboratory. You could withdraw samples here just like you withdrew product. You could draw a small sample, send it over to the laboratory, and analyze it isotopically and determine, over the length of the cascade, what the gradient or isotopic gradient was over the whole plant, as well as certify your product as being at a certain isotopic concentration. So those were essential, also, to the operation. Dr. Nier made a wonderful contribution, actually, to the program.

GOLDBERG: We're here now, it's the middle of March, beginning of March, sort of chilly in here. If this place were operating, would you have to heat it?

VANSTRUM: No, no. It would be warm here, if not hot. The heat of compression, although it's removed generally through the coolant that we discussed at the front end of the diffuser, still generates enough heat to keep this place quite warm, and in the summertime, it was a warm place to be.

GOLDBERG: Okay. Well, thank you very much. That was very nice, very nice. Very good.

VANSTRUM: Very good.

GOLDBERG Very good.
12:15:40:00 [Pause in Tape]

12:16:38:00 [Interview resumes with Goldberg and Parsons standing next to a control panel]
GOLDBERG: We're still on the third floor of the K-25 plant. We're now at the control panel for the individual cells downstairs where we were before. I'm here with Jim Parsons, who at one time, you were a foreman in this part of the building.

PARSONS: Yes, I was.

GOLDBERG: Why don't we just start out by going over the instruments, what they controlled or what they were measuring and how they worked.

12:17:00:00 [Parson indicates the thermometer and water-control valve gauge on the first panel]

PARSONS: As we indicated downstairs, the heat from the compressors is removed by a fluid, a heat exchange system. This panel here indicates the condition of that system. It was used to show the actual temperatures on the individual stages. There are six stages, of course. It shows the position of a water-control valve that is used to modulate the water flow through the heat exchanger so we can change the temperature of the stage by varying the position of that water control valve.

12:17:45:00 [Goldberg indicates switches loaded beneath the thermometer on the panel]

GOLDBERG: So these six switches here, one is for each one of the cells?

PARSONS: Actually, these yellow ones are for the stages. These are for other points on the system.

GOLDBERG: Okay. There's actually five there, not six. Interesting. [Laughter] This panel here?

12:18:08:00 [Parsons points to the compressor seals' gauges on the second panel]

PARSONS: One of the most crucial features of our entire control system is the maintenance of proper conditions in the compressor seals. This panel is used to indicate the performance of the seals and also can be used as a means of checking for failed seals. Probably the most important failure we had was in the seals in the plant. I'm confident that there are seals still installed in these buildings that were a part of the original installation, but on a relative basis, at least, the seals were the biggest source of failure. We rarely had any failures of the converters or the valves. Primarily, maintenance was aimed at replacing and holding the seal performance.

GOLDBERG: Designing the seals, I guess, was one of the real crucial sticking points.

PARSONS: It was. It still is a most highly held secret in the design of these plants.

GOLDBERG: You mean just how the seals actually are made?

12:19:33:00 [Parson indicates red light alarm signals on panel]

PARSONS: Yes. We have some miscellaneous alarms that start showing up in this panel. If the temperatures are out of control, the high-stage temperature alarm would sound. If for some reason the coolant flow is interfered with, we get a low coolant pressure alarm. One of our more sensitive measures of trouble in the stages is the power load, and this is a high-cell amperage. If there's an overload, this would probably mean that inventory is being shifted down the cascade from some point upward and hitting us. If, for instance, they had an air failure upstream, all the control valves would fly open, and the inventory would start dumping down onto these stages here, possibly kick them off. In my experience as a foreman, that actually happened to me one day. As a matter of fact, the gentleman that was with us earlier, Mr. Huber, was the guy that opened the valve that kicked me out. [Laughter] But we finally came to agreements on what we would do in the future.

12:20:46:00 [Parson points to the coolant temperature alarm; then he moves to the panel which measures seal exhaust]

We have our coolant temperature alarm. Since uranium hexafluoride condenses at fairly nominal temperatures, we're very sensitive to that condition. Here again, we have a seal exhaust pressure measurement, and we have a little tank supporting the seal, so if there's a momentary interruption in the supply of gas to the seals, this tank has a little reservoir to hold that seal pressure and ride through a minor variation. These are the actual means for setting the pressures on the seals, to hold the pressures above the process pressure, and to establish a basis for controlling leakage out into the atmosphere.

All of our controls are based on kind of an expanded scale which is operated from a datum pressure. In other words, instead of going the full range of pressures, say, from zero to 15 pounds or something like that, you might have a datum of five pounds and operate within zero to five.

GOLDBERG: So you can't really tell from looking at the valves.

PARSONS: No. These are blind, and it's done both for security reasons and it's done simply because you end up with too much bookkeeping, if you start trying to keep track of what is going on here.

GOLDBERG: So the people who operated these, the operators, they didn't really know what it was they were controlling.

PARSONS: Oh, they knew, yes.

GOLDBERG: Did they?

PARSONS: Oh, yes. In our training program, that was a very important feature, was to explain. Variable datum was an awkward thing to explain to an uninitiated operator, you know, this reference pressure concept.

GOLDBERG: We said before that the product, what they were dealing with, was known only by a code name. They didn't actually--they wouldn't know the absolute pressure, for example, that the system ran at.

PARSONS: They could estimate it from the information that they had, yes. This was primarily the "casual observer" type of prevention.

GOLDBERG: I see. The rest of these, are these just repeats for different stages?

12:23:39:00 [Parson indicates meters, dials and valves on the remaining 3 panels as he explains them]

PARSONS: These three panels here cover the actual operating conditions of the stages themselves. The pressures that we set, indicated by these permanent recorders, the control valve position on the B line, the depleted line that we saw in the cell downstairs is indicated on these panels or dials here. If we are at the appropriate permeability and flows, the control valve positions, as indicated here, will be at fifty percent. The valves are actually, of course, located downstairs. But we'd drive them with air pressures from measuring instruments downstairs up to this panel. We can set the controllers on automatic, or we can set them on manual. When we're starting up the systems, we frequently will set them on the manual set point to get control over the system at the appropriate point, and switch them through this switch below here, through the automatic. But as the barrier might plug, for instance, these control valves will tend to open up. They will tend to decrease the flow through the barrier, and that tends to choke up the flow up to the depleted side.

12:25:40:00 [Parsons points to the ammeter attached at the end of the control panels]

This one here is an ammeter for the total load. It is an extremely useful and sensitive means of telling about the stability of the cascade. We can watch this, tell whether the inventory is moving around, fluctuating, whether the compressors are in surge. It's a very, very useful item which was actually added on after the plant was built. We finally realized that that was an important variable that had been overlooked by the designers.

This system, by the way, the instrument system, was the result of thousands and thousands of hours of calculation by mathematicians to look at the stability of this thing. This is a very unique plan in that all these stages are interconnected with a compressible fluid. It was a nightmare to the designers as to whether they could stably establish a relationship from one stage to another that, you know, you could actually handle. So they crowded a bunch of mathematicians into a room in the Woolworth Building in New York City, and they pounded their calculators for months, looking at stability calculations of this facility.

GOLDBERG: Before it was built.

PARSONS: Before it was built. They actually designed into it three or four different ways that the controllers could be set up in order to make sure that they had one that would work, and they were very successful.

12:27:25:00 [Goldberg indicates the row of black valves and points to the two red ones]

GOLDBERG: Let's go back here just a minute. All these valves are black, except these two. They're special.

PARSONS: Well, they are because they control the reference pressure against which all the other pressure measurements are made. If you start fiddling with this, you're changing, then, all of the other pressures, and this could be very troublesome. If, for instance, you raised the reference pressure, you'd also raise the stage pressure, and you could raise it to a sufficiently high level that you could kick the motors on, for instance. So that just to make sure that the operators, through mental lapse, didn't grab the wrong handle, we painted those particular units red to give them a little extra attention.

GOLDBERG: Very good. I don't know about you; I'm tired. Let's go over here and sit down.

PARSONS: Okay.

12:28:28:00 [Goldberg and Parsons walk to chairs and join Vanstrum]

GOLDBERG: Let's join Paul Vanstrum. Well, now we've sort of gone through the essential parts of this plant, even though the building is--each leg of the "U" is half a mile long.

PARSONS: Approximately.

GOLDBERG: Approximately half a mile long and about--what is it?--three hundred yards wide?

PARSONS: About three hundred feet.

GOLDBERG: Three-hundred feet wide. That's a football field. So it's a football field wide and about a half a mile long on each leg. What we have, as we go down, is repeats of this pattern all the way down the building, right?

VANSTRUM: Right.

GOLDBERG: So even though it was automatic, when we first started out, we had a lot of people in here operating this.

VANSTRUM: Yes.

GOLDBERG: And the question, of course, comes up about training them. I guess you, Jim, had some hand in training them.

PARSONS: I had some participation in this. When this plant was first started up, there was a small community college down the road here called the Wheat School. It was a multistory brick building that was part of the old community that had been here, and Union Carbide took over that building and made a training facility out of it. Literally thousands of people passed through that facility. A very interesting gentleman by the name of Jim Hunter operated it, and as young engineers like myself came through, we were asked to specialize in some particular part of the plant and give the operators training in those areas.

VANSTRUM: We were students one day and teachers the next.

PARSONS: Right.

VANSTRUM: And we were drawing on, of course, a wide range of people for the operating positions, some out of the hills, so to speak, in the surrounding area; others, wives of engineers who were college-level people. People from all over the country, really, came here to work. One of the challenges in training was to get them to understand what they were doing without telling them everything. For instance, we had to give them the right feeling about what is a vacuum. The process was operating below atmospheric pressure, and the concept of vacuum and pressure, absolute pressure, was a new thing for many of these people. You couldn't describe what the materials were. You couldn't say "uranium hexafluoride" like we do now; it was C616. I'm not sure--some of those names stayed with us for a long time, but we had code names for all of the materials and chemicals and utilities that we used here. So they would talk in code, and, hopefully, we could teach them enough about basic physics and chemistry that they would do the right things when they were at the panel board.

12:31:47:00

GOLDBERG: Oh, so you taught them basic physics and chemistry?

VANSTRUM: Well, to get across the idea, for instance, the mass spectrometer. How do you take somebody who is totally unfamiliar with science generally, and teach them enough to operate something as way out as a mass spectrometer?

GOLDBERG: They operated the mass spectrometer?

VANSTRUM: They operated the mass spectrometers; they operated these panel boards for the cells in the buildings. We had technical people generally in the area, but these people, operators, that we trained did the main work in the facility.

GOLDBERG: So you taught them things like Boyle's Law?

VANSTRUM: We didn't get quite that scientific, but we tried to give them the concepts of what they were saying, you know, the difference in mass.

PARSONS: We did teach them arithmetic.

VANSTRUM: Right. Sometimes you had to get refresher courses for them. Another interesting thing for some of the groups that I was involved with was the training continued over here in the plant, you remember, and the plant was still being built while we were training these operators. And we had no heat in the building. It's cool here today, but in the wintertime, we had what they called salamanders--fifty-five-gallon drum burning coal on the operating floor to keep us warm, and we wore overcoats and so on, because we had no finished facilities to meet in. But this was all done in a great, enthusiastic spirit, and I don't remember people complaining about it; they just went on with the job. It was very interesting.

GOLDBERG: You started to say before that you taught them mathematics.

PARSONS: Some of the folks we got had not completed even the third grade.

GOLDBERG: They were operating this.

PARSONS: They were taught to operate. They weren't operating it yet. But we had a wide variety. We had lawyers and schoolteachers and people that had not completed their schooling, and we tried to pair people up in such a way that they could support each other to some extent. But actually, these people turned out to be remarkably competent. Uniformly, the people who came out of these hills here were good performers, understood things well, and did a very fine job. We were very proud of them.

12:34:13:00

GOLDBERG: The people we've talked to over in Y-12 said that starting out, E.O. [Ernest Orlando] Lawrence was convinced that you'd have to have a Ph.D to operate the calutrons. It turned out that the people who operated the controls, in fact, were like the people you described and did the job better than inquiring Ph.Ds. Were there people, for example, from the Kellex Company or with Union Carbide, who thought that you'd have to have highly skilled people to run this?

VANSTRUM: No, I think it was--right from the beginning, we had a core of technical people who would go through the school, so to speak, and they were then assigned jobs as managers or leaders of a particular area. I don't think it was ever anticipated that you'd staff the facility with technical people. Right from the very beginning, before the building was built, we were training these operators. They'd go out and hire them from wherever they could get them. At that time, it was difficult to hire as many people as we were interested in.

PARSONS: I think you can draw some comparisons that the Carbide people that came in here came from Charleston, West Virginia. They had gone through very similar circumstances, you know, in the plants that they had come from. They knew what to expect, I think, from Appalachia, if you will, so it wasn't quite the same thing as you might expect if somebody had come in here cold and not know, you know, what you could really expect. A substantial number of our foremen came from Charleston, West Virginia. A substantial number of them came from Buffalo, New York, strangely. A very large munitions plant, the Ontario Ordnance Works, shut down in Buffalo, and a man who ended up being the employment manager for Union Carbide for this project came from that plant, so he brought along a very large contingent of supervisors.

GOLDBERG: They were glad to escape Buffalo winters, I bet.

PARSONS: No. As soon as the war was over, they went right back. [Laughter]

GOLDBERG: They missed the Lake Effect.

PARSONS: I guess. I used to live in Buffalo myself, and I certainly never have missed it.

VANSTRUM: But this was sort of a melting pot of melting pots, I guess, as far as the technical people and many of the foremen came out of such facilities. We had people from all over the country, and that made it a nice place, too.

PARSONS: A very large fraction of our engineers came from shut-down munitions plants. This plant started up right about the time when they were beginning to shut down plants in Virginia and West Virginia and Kansas and Illinois and New York State, all over the country. So probably thirty percent or forty percent of our technical people came out of that kind of operation.

GOLDBERG: Is that because we had an ample supply of munitions for the war?

PARSONS: They were beginning to cut back, yes.

12:37:46:00

GOLDBERG: Let's see. This building was begun in, what, the middle of 1943?

PARSONS: It's about that.

VANSTRUM: The construction started in 1943.

GOLDBERG: As to construction, about the middle of 1943.

VANSTRUM: I think the design started about a year before that, but the construction started in the middle of '43, and essentially in two years' time, we were essentially completed. So it's a remarkable, remarkable construction.

GOLDBERG: Now, it was the J.A. Jones Construction Company.

VANSTRUM: Right.

PARSONS: They had a lot of subcontractors. They had two piping subcontractors, for instance, Kagin and Hughes and Poll, for instance, that did a lot of the work. Poll put in all the lubricating piping here. Kagin and Hughes did a lot of the process piping.

GOLDBERG: A whole we haven't even looked. There's a whole gallery of piping that we haven't even looked at.

VANSTRUM: The building was really a beehive of activity during construction with the various contractors working together, the leak testing done by Carbide people, essentially Carbide people, operator training being done by Carbide, and interfacing with the engineering groups to learn about what to do, how to do it, and learning the chemistry that we needed to be cognizant of. But it was a fast learning and fast doing experience for all of us, and we wish we could see more of that today, I think.

PARSONS: There were enough arcs being struck here that during the night, it looked like, if you looked towards the plant, it looked like the Northern Lights. The glow against the sky was just rising and falling.

GOLDBERG: Just from the welding.

PARSONS: Right.

GOLDBERG: Let's sort of get the skill of how this place was built. It was built--they began in the middle of '43. The building was still being built when you first started processing hexafluoride.

VANSTRUM: Right.

PARSONS: 1945, yes.

GOLDBERG: So you began in the beginning of 1945. That's about a year and a half from the time that. . .

VANSTRUM: Ground was broken.

GOLDBERG: The ground was broken, to the time that you actually started processing some gas.

PARSONS: Right. This building was all on by the end of that year.

GOLDBERG: By the end of '45. But let's say, by July the final shipment of uranium for the first bomb was sent to Oak Ridge. By that time, this place was operating not at full capacity, but it was about thirty percent?

VANSTRUM: I can't tie the percentage into a particular date, but what we did was to increase the concentration in stages to be compatible with what the needs were at Y-12, where the finishing and separation was done.

GOLDBERG: So you were taking off hexafluoride that was partially enriched?

VANSTRUM: Yes.

PARSONS: Right.

GOLDBERG: And sending it over to Y-12.

VANSTRUM: Yes. And we didn't go in a continuous increase in concentration; we went in steps to interface with their process in the most effective possible way.

PARSONS: Also, the so-called S-50 operation was going at that same time, and they were shipping also enriched material.

GOLDBERG: That was the thermal diffusion plant.

PARSONS: Thermal diffusion plant, yes.

GOLDBERG: The plant that was built in ninety days.

PARSONS: Right.

12:41:38:00

GOLDBERG: Do you remember, when the bomb was dropped, where you were?

VANSTRUM: Well, I was home in Minneapolis at the time. Of course, I had been accustomed to very tight security. My family, my wife, none of them knew what I was doing--this mysterious project. I was downtown, I remember, at the time that the papers came out announcing the dropping of the bomb, and I got it out of the corner of my eye and wondered, "What can I say now?"

I got home, and my mother said, "Well, we know all that you've been doing now in Oak Ridge." Of course, they didn't, but it was a burst of information at that time. And I think we all had a lot of pride in the job that had been done and knew that it had shortened the war. We got a lot of satisfaction out of that.

PARSONS: I was working the midnight shift, and during the afternoon, one of my friends burst into my dormitory room and flashed a newspaper in front of me and said, "You're famous! It's too bad you aren't rich." [Laughter] That was how I learned about the fact that the bomb had been dropped. Of course, I still have some of the newspapers at home that were published here.

VANSTRUM: I think we knew when the threat was made to the Japanese: "Surrender or face ultimate destruction," that it was imminent, either that or they'd surrender. So we were all very apprehensive about what would happen and what the effects would be and so on. It was really the fulfillment, essentially, of all we'd been working for, to see the war come to an end as a result.

GOLDBERG: Okay, well, thank you very much.

VANSTRUM: Enjoyed it.

PARSONS: It's been interesting to come back.

VANSTRUM: Right.

GOLDBERG: That's what everybody says. Thanks a lot.

12:43:50:00 [End of Session Seven]

[End of U-Matic Tape 2 of 2]

[End of VHS Tape 1 of 1]

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