

EUGENE WHITNEY

An Interview Conducted by

William Aspray

Center for the History of Electrical Engineering

December 8, 1993

Interview #181

For the

Center for the History of Electrical Engineering

The Institute of Electrical and Electronics Engineers, Inc.

and

Rutgers, The State University of New Jersey

Copyright Statement

This manuscript is being made available for research purposes only. All literary rights in the manuscript, including the right to publish, are reserved to the IEEE History Center. No part of the manuscript may be quoted for publication without the written permission of the Director of IEEE History Center.

Request for permission to quote for publication should be addressed to the IEEE History Center Oral History Program, Rutgers - the State University, 39 Union Street, New Brunswick, NJ 08901-8538 USA. It should include identification of the specific passages to be quoted, anticipated use of the passages, and identification of the user.

It is recommended that this oral history be cited as follows:

Eugene Whitney, Electrical Engineer, an oral history conducted in 1993 by William Aspray, IEEE History Center, Rutgers University, New Brunswick, NJ, USA.

Interview: Eugene Whitney
Interviewer: William Aspray
Place: Pittsburgh, Pennsylvania
Date: December 8, 1993

Aspray: Can you begin by telling me what your parents did for a living and about your early life?

Whitney: My father started out a minister, but after ten years he gave up on that. [Laughter] He became a personnel director for an auto body manufacturing place. That went broke. It made chandlers and such things, and all those guys went broke. Then my parents went to Flint, Michigan, and worked for Fisher Body. My father was personnel director at Fisher Body. We went camping quite a bit up through Michigan. I'd see these little dams, but that never really influenced how I happened to get into waterwheel generators. [Laughter] But he always thought maybe it did. I went to the University of Michigan.

Aspray: Before we go on to that, when you were a child, did you have interests in things like ham radio?

Whitney: Ham radio was at the very beginnings in those times. We had a crystal set, but I didn't get really interested in radio. I did build a Tesla coil, [Laughter] which annoyed the neighbors considerably.

Aspray: I can imagine.

Whitney: Those were the days when Detroit was winning all kinds of ball games. You could walk down the street and hear the ball game continuously. Everybody's radio was on. But I played with the Tesla coil at times when the ball games were on, and the discharge from the Tesla coil annoyed the neighbors. [Laughter] I guess I got my engineering interests from that and from physics and chemistry in

high school.

Aspray: Were you a good student?

Whitney: Mostly A's in scientific stuff. But B's in English, C's and D's in Latin. [Laughter]

Aspray: I see.

Whitney: In some ways that was a good training because it taught me I should not take up something that had a language barrier. I should go toward the scientific end of it. I took one of the early exams that were leading into vocations, and they said I was fit for an engineer, a mathematician, or a farmer. When I said I had no interest in farming, that kind of disturbed them, the fellow who was developing the test. [Laughter] But I can see why some of the same characteristics would fit. Well, I went on through college, and I had excellent courses in machine design.

Aspray: Did you know when you went off to the University of Michigan that you wanted to study electrical engineering?

Whitney: I knew it was something in the engineering field, I thought it was electrical. So I went that way, and I wasn't disappointed.

Aspray: Why did you go to Michigan rather than some place else?

Whitney: It was sixty miles from home. And of course being a state school, tuition was a little bit less. It was something like \$37 per semester.

Aspray: And it was the Depression, so....

Whitney: Definitely! The class I happened to get into was an exceptionally good one. For example, the dean gave out about six A's in his class, and he'd never been known to give more than one in that particular class. It was an exceptional class. My interest was definitely partly due to some of the professors in electrical machines.

Aspray: Did you also take courses in telephone, radio topics?

Whitney: There wasn't much in those days. No, I stayed as much as I could toward the power side. I had some hydraulics and some mechanics, too, and that sort of thing. To show you the difference between now and then, when I graduated there was only two fellows out of the exceptionally high class of 35 that had jobs at graduation. One of them, his dad owned a factory, and he had a job with his dad. The other one was the biggest B.S.er in the class. [Laughter] He had a job as a salesman. I was more or less offered one job as a salesman, but I wasn't interested in being a salesman. It was July 15th before I went to work for Westinghouse, but in the service department in Detroit. My folks lived in Detroit at that time.

Aspray: What did the service department do?

Whitney: I was in the switchgear department where it was primarily labor. But it was an electrical company, and it was the only job I found. But I was just labor. I was doing everything from driving crooked nails in boxes, to shipping boxes, to occasionally hanging a few meters on switchgear, things like that. But they encouraged me at that time to come down to Pittsburgh. That job petered out at Christmas time because the model change in the automobiles didn't need any more switchboard, changes. So I went around to GE, and they weren't allowed to hire anybody out of the state at that time. I came to Pittsburgh and interviewed for a job there, and they saw my résumé, which interested them. There were a few jobs opening up on the test floor. They weren't allowed to hire anybody outside of the district as a straight hire, but they could transfer me because I was on the roll in Detroit.

Aspray: I see.

Whitney: In those days the hiring rule was pretty much one wage earner per family. For

example, a husband and wife couldn't be working at that time. If they found it out, they would fire one of them. It was a time strictly to spread the jobs around so that you weren't destitute, or so much so. It's quite different from today. I worked on the test floor for a year, and in the fall I of this first year I took a couple of classes. It was a little bit happenstance. I took Dr. Kilgore's class. I took one other on application of equipment. But I was more interested in the design stage because I'd been working on the test floor, and I'd had a couple of freak machines on the test floor that I had worked on, and they saw I was interested in that. Dr. Kilgore was teaching design classes at that time. So I was interested and took a couple of jobs near the end of the first year of my working there. A boss of the department asked Kilgore to pick out three likely people out of the class, and I was one of them.

I went on and transferred from the test floor up to the engineering department. First I designed most any of the kinds of machines that happened to come along. I did some work on turbine generators, I did some for MG sets, frequency-changer sets, diesel generators, high-frequency machines. In some ways I was kind of lucky the boss took a little shine to me. He seemed to give me the oddball jobs rather than the routine ones. Of course that was a better learning experience than the routine ones because you got greater variety of applications.

Aspray: Can you tell me about how the design activity was organized? How many people were in the department? Were there people with different kinds of backgrounds? How many people would work on a project, and was it for a specific customer?

Whitney: The department at that time was going after the Depression problems. There were five of us in the group which I was put into to begin with. They handled the big

waterwheel generators, the turbine generators, the high-frequency machines, some of the big diesel generators, and the special MG sets for specialty frequency changes of all kinds. Then there was another motor group which Kilgore wasn't the head of at that time, but he was a little later, which handled induction motors, synchronous motors of the usual kind, and, motors to drive MG sets for steel mills.

Aspray: These were custom designs for a specific customer? Is that right?

Whitney: Well, a little bit of both. The motor section was much more standardized than the generator section because the generator section was primarily the big ones that were for specific customers. Those customers usually wanted some specific things that were different from the run-of-mine standards. I did some work on run-of-mine motors too, but the run-of-mine ones were standard designs that all you would do is make a winding for a different voltage or something like that. Otherwise, it was pretty well adjusted. You could change a few things, but they'd prefer you didn't change much. That way I was lucky to get into the ones that had more flexibility to adapt what was necessary for a particular job. I was also kind of lucky they had decided that they would build some turbine generators. The turbine generators had been pretty noisy because of the two-pole effect of distorting the core from the magnetic pull on one axis. So they had made a machine which was spring-mounted so that the punchings didn't touch the outer frame, with the idea of isolating them so that the noise didn't transmit out through the foundation. At that time there had been some work done on short circuit torques, but they really hadn't had a whole lot to do with measuring the torque that you got on the short circuit. I was assigned to do that with one of the

mechanical engineers. We measured the torque pulsations on shorting machinery. I shorted it about 50 times. [Chuckling] Bent some coils and things like that. But it was real good experience, and I got to understand a lot more about it. Also we wrote a couple of papers about it. That was a good experience, putting it forth in a way that other people could understand what was done and why.

I started to get some of the bigger machines. My first boss died, and then they broke our group up into smaller groups because it had also expanded a little in the meantime. The customers liked the machines my boss made because he was always a little bit cautious about the size. He was a little too generous sometimes. But he got taking too many pills from the doctor; he was kind of a pill man. [Chuckling] His heart began giving him trouble, and so he decided he'd retire under medical disability. They gave me the job of being the boss.

Aspray: This was in what year?

Whitney: 1949.

Aspray: During the war had you done war work?

Whitney: Yes. I'd made some Navy machines and a lot of diesel generators for driving 6-, 12- and 16-inch guns. That kind of thing. Plus some Navy machines to go on shipboard. Not a whole lot of fancy stuff like that, but it was enough to get a deferment anyway.

Aspray: How much of Westinghouse's business during the war was of that kind? Or of the nature of building power equipment for vital industries like the aluminum industry?

Whitney: There was quite a bit of it. I don't know that I have a distinct knowledge of just

what percentage. On the other hand, it's kind of hard to separate some of it. For example, Hoover Dam work started in the Depression, but they were required to build a lot of that just about the time I came. I didn't have very much to do with that because it was largely done just before I got there. But those machines were going through the shop. Then Grand Coulee came along, and there were a number of other generators built for supplying aluminum factories. I didn't have anything to do with rectifiers or what went into it, but there was also a rectifier section of which Kilgore was part for a while.

Aspray: Right.

Whitney: Kilgore was a wonderful man in the sense that he was always very generous as far as giving credit to other people who were concerned with doing something. He was very generous with his teaching, and he had a better understanding of machines than almost anybody else. He's still the world authority. You can tell he's slowed down a little bit now, but...

Aspray: Still very impressive.

Whitney: He's still faster than most anybody. He was always very helpful, and you could go to him any time you had any questions on something. He was a wonderful teacher in that respect. He was always very modest and very helpful. I still talk to him once a week or so. Why, he'd come and help a little bit, see that I was on the right track anyway.

Aspray: Let me bring you back to 1949 again. Just at the time you're turning to be a manager. Before you talk about your own work there, can you give me some background about Westinghouse being in this business? How long had they been in it, and where did they stand in the industry?

Whitney: Well, Westinghouse started the Electric Company in about 1890-something, along in there.

Aspray: Right.

Whitney: Of course their main claim to fame at the time was to build the machines at Niagara Falls. Westinghouse himself had had a peculiar facility for recognizing talent. He had people like Lamme and he hired Tesla for a while to get the three-phase concept and the motors, the rotating field concept. Tesla never liked working in a factory. He wanted to do research. First of all, Westinghouse signed an agreement with him to pay a dollar a horse-power on motors using his patents. It was quite a sum of money, for that time anyway. But after a while, when the motor business started to grow bigger and there was more competition in the motors, they realized that the fee that they were going to pay him, a dollar a horse power, was going to break Westinghouse. Westinghouse went to Tesla and said, "We just can't pay you that much." Tesla very graciously forgave the entire royalty because he said that it was much more important to have the motors built and advance society than it was for him to collect the money for it. And he said that Westinghouse was the only one that came along and paid Tesla for his patents, and that he was very grateful for that. He'd been reamed out of it by Thomas Edison on the d.c. machines.

That was the big start of that. Of course the 1893 Exposition had. They didn't know how to make three-phase machines at the time, and they had to rush that thing through. They put two single-phase machines on one shaft, put them 90 electrical degrees apart, and made two-phase that way to get that. Then they made the stopper lamps and those kinds of things, too. Westinghouse got the contract

for doing the Niagara Falls generators, the first ones. You might think this was strange, but Ed Harder, you know him?

Aspray: Oh, yes. Very well.

Whitney: His father was superintendent of the receiving end of the transmission line at Buffalo.

Aspray: Right.

Whitney: He had to make switchgear and all that kind of thing, sometimes by hand, because nobody else knew how to do it. He was only 26, I think. But he got that job. So Ed was mixed up with Niagara from the beginning. They made the first machines, and they operated fine. Lamme was one of the designers. He was the practical guy. Those fellows had guts, I'll tell you that. They tackled and built machines that they really didn't know too much about. Westinghouse was definitely a leader and a promoter of a.c. They had William Stanley who more or less got started on the transformers. William Stanley thought they could build conductor generators cheaper than other people, but he went broke with it. About 1940 I had to put one of those on a diesel generator, and they wanted all the modern constants from an old conductor generator. So I had to dream up what that was. But those people really started the a.c. business, and of course there were battles with GE. The only reason that the electric chair in Pennsylvania was a.c. is that Edison, who had a strong in with the governor at that time, said that a.c. was more dangerous than d.c., and he could capitalize a certain amount on publicity that the electric chair was made with a.c. because it was more dangerous and could kill people that way. How stupid! Today our illustrious governor, that bum, ordered the previous electric chair dismantled. He's the only one by law that

can authorize reassembly of it. So none of the people who have been convicted for death in Pennsylvania have had it for 20 years or so now, and they're just sitting in their jail at 25,000 bucks apiece per year. I think the guy now takes his orders from the pope because he won't assemble it. But they could now do it if they wanted to with something like a heart pacer. Let the guy pass out without ever doing anything. They'd never feel any pain in any way, and just drop off.

Westinghouse had a lot of problems for a while, but then it got to be a real engineering company. Of course Westinghouse was also in the air brake business. I'm a docent right now for the Westinghouse Museum. That's one of the few places that you can find much about Westinghouse. Westinghouse was a promoter of the a.c. Although GE was first in some things, we were first in some others, as you might expect. We were about equal to GE in waterwheel generators. We built waterwheel generators. The first ones were 1893. There were actually a few before that. Kind of Tinker-toy compared to the ones at Niagara. But they were considered very large. They were 5,000 hp to begin with. But then in 1901 they built a 7500 hp steam turbine-driven generator; we built about 19 of them for Fifty-Ninth Street in New York. That was when they built the old factory in East Pittsburgh for building that. Because the height of the crane rails was built so they could assemble one of those things; they were horizontal machines. They were 407-5/16th inches diameter core. Why they ended up with that number, why they had so much distance I'll never know. Anyway, they built those, and that was a tremendous undertaking. By far we were the leader in the business at that point.

Then about 1923 was the first time we built something bigger in diameter, and that was only five inches bigger. That was down at Conawego. It took until 1960 to build anything bigger, and those were only, essentially, 30 inches bigger in diameter. But compared to those steam engine ones, they were triple expansion steam engines. In 1901 to 1903, we built the machines for out in Skamania County on the Columbia River. They were almost exactly the same weight as the machines that were built in 1901. But they had 18 times the rating for the same weight, with reference to rpm of the machine. There was that much improvement in that time. While we've built bigger ones since then, that's sort of a steady growth from the time I was the engineer on them. I was given the Silver W, and later the Tesla Award, primarily for designing the machines at Niagara. My group, there were about 12 of us then, designed the generators for that. That didn't include the draftsmen, however. We had about the same number of draftsmen.

Aspray: Perhaps you can walk me through the process of designing one of these systems. What are the challenges?

Whitney: Each one of these machines has a certain challenge. As they grew bigger, there were challenges in thermal expansion, and mechanical expansion, and compensating for that so that it didn't rub. The fundamentals of design were reasonably well established. The ventilation was always a problem. Over the years, we gradually improved the ventilation arrangements so that we could count on it much better. We really designed them around one pole pitch. In other words, you've got a number of poles around, and you design for how much you get out of each pole per inch of length core. Then you take out many of them, and put

them together. So that you really start out with the size that somebody wants, not the physical size but the rating, because somebody's figured out from the amount of water that comes down the stream and the size of the dam that they're going to build from the geography of the local spot. From that you knew how much rating they would require. It was your job to design them for the speed that they wanted and the voltage and the amount of power they wanted, and the efficiency that they'd asked for, and so forth. But the efficiencies were more or less standardized. They weren't published for quite a long time, but kept getting them a little better. And better for portions of the particular poles. You've got to design such that you could ventilate with the blowers that you put on. This sort of thing. It was a compromise. You had to have the electrical engineers talking to the mechanical engineers because the electricals might design something that the mechanicals couldn't build, or vice versa. You had to become acquainted with both sides of the fence to do a good job. That was always one of the problems because each one of them kind of wanted his own kingdom. [Laughter] You had to make them cooperate that way. But by getting them to understand each other's problems, we got better machines out of it. As time went on we pushed the iron a little harder, and we got better iron, and better assembly methods.

Then along came Niagara, and that was a real challenge because there were 13 machines to be built, all of them bigger than we had built before. Because the dam was kind of behind time, they didn't want to slow up the generators. So they insisted that we design all 13--and make all 13--machines and put them in a warehouse before we started to assemble one of them. You couldn't afford to assemble them in the shop and take it apart. On that particular machine, the rotor

is 405 inches in diameter, and the rotor weighs 595 tons without the shaft. Because of things like that, you can understand you have to break the machine down into little pieces. That was always part of the challenge of building these kinds of machines because they were always big enough that you had to make them in pieces that were shippable, but have it such that you could put it together out in the field reasonably simply. So we had to put all those machines in a warehouse. They wanted us to put them together as fast as possible. The stator was made in four parts to get it to shippable sizes. I made an arrangement that, for the first time, you could set the parts down and then by twisting them a little bit slide the coils in. Previously it had been done by putting all the stator core sections together and then lifting coils back, 50 coils, and putting some more in to close over the split. I shipped them with coils extending over the split to begin with, and then we just slid them into the slots.

Aspray: I see.

Whitney: We managed to put those machines together one every five weeks until we had about six of them going. Then they told us to hold up because the load wasn't building up that fast. The first ones they wanted to get in there right in a hurry. So we had to make a record there. We were kind of lucky, I guess. When we got finished, everything worked, and we didn't have any real boggles in the whole process. They were putting them together with three shifts a day, seven days a week. To keep a gang going like that was a considerable task. I was not directly involved in the assembly, except that any technical questions came back to one of us in the shop. But I was chiefly responsible for getting the answers to any problems. We were really fortunate that we didn't run into any real bugs.

Aspray: It may vary considerably from one kind of business to another, but does Westinghouse move engineers or managers from a design team to a manufacturing team?

Whitney: Occasionally it happened that way, but not regularly. As design engineers, we were required, if there was any problem in the shop, to be down in the shop probably within an hour of the time they called.

Aspray: I see.

Whitney: At that time they realized that having people sit around in the shop to wait for an engineer to come down was not profitable. So we learned an awful lot out of the practical value of seeing the people making them, and seeing what they could do and what problems they ran into. The visualization of the machine was something we could see building them. In a lot of ways it's like having a baby in the family. You are responsible for it from the time it is conceived. In those days, we would go out and sell to the customer from the technical standpoint. There was a sales department which did the pricing. We also had to make a preliminary design, and then they would estimate the cost from the preliminary design. The sales department would put a price on it. Then we'd have to go out and answer the questions from the customer and see what particular adaptations were required for a particular job. We were quite successful at that. You had the job from the time it was a gleam in some customer's eye to the time that it was running.

Aspray: I see.

Whitney: And even after that, if there were problems. We'd get it again when the windings would be finished, and you'd have to put new windings in. The windings generally lasted 20 odd years. So you really felt responsible for the job from the

very beginning, and that was key. You wanted to make the job so that both you and the company looked good. This kept you on the straight and narrow. Today, the company is completely changed. Between the environmentalists and the lawyers involved with product guarantees, and the like, I think it scared the people downtown. When JFK was President, at that time because he wasn't dry behind the ears yet when he got to be President, he thought he was doing something to save the country, but he declared the "Buy American" Act null and void. Whereas I had been going out to customers and trying to convince them to buy American-made stuff, see. At that time the Japanese had wages one-tenth of ours. When JFK ended the "Buy American" Act... First of all, Engine Charlie came from GE into the Defense Department and gave American manufacturers a chance for a period of ten years or so. If our bid wasn't more than 50 percent above the foreign bid, we could get the job. That went by the board when JFK said that. Well, with our labor rates and so forth, it was very difficult to match what the Japanese were doing. We knew right away that Westinghouse would probably have to go out of business, along with GE. And they have, as a result of that. It became somewhat unprofitable because the Japs could bid two-thirds of your price and still make a good healthy profit. They started making a pretty good product, too. The worrisome part of that was that, well, like the Bureau of Reclamation, and the Army Engineers, and so forth, they loved to go to Japan and be wined and dined more than, say, to East Pittsburgh. [Laughter] Some of those rules got changed today, and they couldn't accept as much gratuities as they were for a while. But still in all, with the environmentalists saying that you were responsible for the job forever after that you sold it, if anything went wrong for

50 years, why, you were still stuck! The profit wasn't that good. Some of these management training kind of people went to management schools. They were mostly trained in the philosophy of ten-cent store management, where you had no responsibility afterwards and no product responsibility really. If you didn't make the bottom line profitable this time or next time, you only had maybe one time to try and bring it off.

Some of the Westinghouse management decided that the company should become a financial institution. Between greed and otherwise, they changed to a financial institution and that's where they got into this awful mess with real estate and so forth. The dummies guaranteed loans that were 120 percent of the value-- or more sometimes--of the thing they were loaning for. The net result is that that's been almost the death of Westinghouse. Well, Westinghouse Electric used to have 120,000 to 150,000 employees. But employment is down noticeably now. Some of the same greed is going into the government right now and the bureaucracy. But we'll never settle that.

Aspray: Was there any thought of getting back into the hydro-generator business once Japanese wages came up closer to a par with the U.S. wages?

Whitney: No. Our senators seem to be thoughtless. They seem to think that because the foreign people don't have so-called tariffs, that because it isn't that name, that they don't give things under the table to the manufacturers. Actually, the Germans used to sell machines at half to two-thirds their domestic rate simply because the government didn't charge any taxes on anything that went out of the country. But our government, they were very eager to get money, so they would charge the same markup as the domestic person. Then dumb Carter came along, and he

announced that anybody caught paying anybody under the table for a job would be prosecuted. Essentially that said, "Thou shalt have no foreign business" because in the rest of the world you get jobs by barter under the table. Essentially it just said, "Thou shalt do no more foreign business." Now the Democrats are joined onto the free trade racket, which is going to kill the country and get us down to the Russian problems in a fairly short time. But that just killed the foreign business for us. So I don't think they're ever going to do that. They're trying to build some gas turbine-driven generators now with gas turbines, and I think they're shooting their foot off by some of the things they're doing. Our contracts say where they have to run the machines for a couple of years, and they don't know anything about running them. Every job that we took like that, why, we usually lost our shirt. I'm sure that the ones that are running it now don't know as much about it as we did. So I don't think that's going to last too awfully long. They've gotten some jobs that way, but it's still by world proportions, very small. Because somebody stuck their neck out and stayed in the nuclear business, because Westinghouse was very much in the nuclear business, I don't know whether they're going to be able to keep up with it or not. I kind of doubt it, but then the future will tell that.

Aspray: Let me go back and ask you to trace more closely your own career from 1949 on.

Whitney: In 1949 I became manager. But my strength wasn't in so-called straight management skills where you move people around. You know that kind of management is just a small chunk of the business. I was much more interested in the engineering part of it than I was in the management, such as details of budgets and other miscellaneous things. So I became the manager. One of the

things that soon began to develop, the hydrogen-cooled machines, the sales department objected to. They had a price book, which originated about 1929-30 on synchronous condensers that stated: such-and-such, it would be 12 poles, and above such-and-such it would be 8 poles, 12 poles, and 14 poles. Along came one job at the end of the war when they were building the atomic separations and so forth at Oak Ridge. They wanted a batch of synchronous condensers. I looked over the tracers as far as the sales department was concerned, and told them that it was foolish to make hydrogen-cooled condensers for 50,000 kV those were, 12 poles. It just made it so big in diameter you couldn't ship it. So I'd build an eight pole where I could ship it all in one piece. They put it on one car and shipped the whole thing. It cut the weight from 640,000 pounds for a machine down to 430,000, where I could put that on one freight car and haul it up to the customer's place. So we made good money on that. And then we had eight, ten of them, something like that for several different customers. Then there were several big waterwheels.

Maybe you remember that the government prosecuted Westinghouse and GE for price-fixing. I never saw any price-fixing. Yes, they priced things out of a catalog. Sometimes they would take leniencies and give them this or that or the other thing. But I never saw any price-fixing as such going on. But as a result, they had what they called the "white sale," in which they promised to take a job the customer wanted at so much discount from the book pricing. Some of those jobs, the customer really didn't have any idea, but he thought it was a bargain. One of them came up (the Washington Water Power) where they bought it at a cheap price. They didn't settle down on what they wanted for about five or six

years.

All of a sudden, one day I got called to New York to meet with the turbine people, the customer, and the consulting engineer, and settle all the details. We didn't even know what size it was at this point! So I got on the train and went to New York. In two days we settled all the details, the size and everything. I came home and wrote a trip report of it, and we built it. We actually had the first machine shipped and ready to be assembled in one year from the day I was at that conference, which was a shorter time than it had ever been done before. That was before computers. All of this had to be hand carried through the shop. When computers came in, why, it slowed the wheels of progress down no end. Then they had to write all the information on the computer, and that slowed it down. Then it went from a year and a quarter or so up to two years, two years and a half, three years. It just slowed down things. People couldn't get things done better. Anyway, we built those machines in a year's time. We had to do some shifting of orders for forgings and this kind of stuff. On that particular plant, the Army Engineers had had a proposition where they would build a tunnel around and then build the dam in the dry waterbed. Washington Water Power decided to take the risk and build the dam, put up a cofferdam ahead of it, and just keep ahead of the water as it went up. As luck would have it, they got a big gully washer upstream. They wanted to put on force draft poured concrete, and they kept ahead of the rising water. They built the whole dam for less price than the Army Engineers wanted to build the tunnels around it to dry up the riverbed for building the dam. But those were 60,000 KVA machines, and we had everything going in time to rescue the trout. Those are the interesting kinds of jobs. Regarding the political

business of writing the contract, the machines were in and running for a year and a half before they got the contracts straightened out. They'd ask us what we'd built, and then they'd write it in the contract. But it was essentially built to my specifications from the two-day conference.

Aspray: I see.

Whitney: We had other machines come along, but in the 1950's the Niagara machines came along, and that took a good share of our activities because that was the biggest job on the horizon by a long shot. They were both bigger machines than we'd ever built before, and we had also the Skamania County machines which were the same physical size, a little smaller rating. To build 20 of those at one a month in the shop was quite a challenge. Plus a few other small ones came along. By small I mean maybe 15 to 25 feet in diameter, or 40 feet in diameter. Then we had synchronous condensers, and there was quite an advance in those. The other guys handled a good many of them. I couldn't do all of them by any stretch of the imagination. I didn't want to. But I tried to do the electrical design on the ones where if something went wrong, I was the one that got the heat. I got some criticism for that. I thought it was better for the group. I would put in things that they were afraid to tackle from the technical standpoint because I felt I had a little better background at it than they did. After they'd done them once, why, then it was easy for the rest of them to do the same thing again. But that's, in general, the way we led it, and came along with those.

One job was the pump storage job up at Kinsel. Well, before that we had one at Dupar. The starting problem with those machines was to get them on the line quickly, and the motoring direction was always a problem. With the techniques

known at that time, you couldn't get enough copper alloy non-magnetic materials in the pole head to absorb the heat necessary during the line starting situation. So I began looking for something better and decided that I could make them with steel, use steel in the damper fires. In the first place, the steel has 20 percent more thermal capacity per degree centigrade than the copper alloys. Second, it's about five times as strong, and it didn't conk out as it got too hot. The copper alloys got mushy when they got around to 180^o, 200^o centigrade. With steel you could go to 400^o centigrade and only lose 5 percent of the strength.

Aspray: I see.

Whitney: I could put bigger sections in because it didn't stop my magnetic flux from going through. We tried it on one 16,000 hp motor, but I guess I was foolish. I didn't insist that the guy who made that motor in some other section, my dictating the kind of compliance it was going to be. I let him do it, and he picked the rottenest steel you could find to do it. So that it wasn't very satisfactory in that particular machine. But the first machine I had was 137,000 hp at 180 rpm, and there were six of them. I used steel there. That's worked out very nicely, except that I thought GE was getting away with something, and I was suspicious of it, that the leakage flux from the ends of the bars came up and cut through the stator coils and heated the stator coils so they deteriorated more quickly than they should have right at the ends of the core. But we fixed that up by putting non-magnetic ends on them. These other ones were 230,000 hp at 120 rpm. Those you more or less line-started, except that I talked them into buying a transformer with a double secondary, and we started on the one secondary. That put a lot of leakage flux in.

It was like starting it on a reactor at 50 percent voltage. That worked out real well, except that the transformer people didn't realize the bracing problem. It wasn't a Westinghouse transformer, it was somebody else's, and they bid the cheapest transformer, and they couldn't brace it. The windings broke on the transformer, and they had to buy a new transformer after a while. It wasn't too bad. But our machines really did very well. They were used every day and started up.

Then came along Kinsel. That was to be a synchronous start. That was kind of an unusual characteristic because that's on the Allegheny River near the border of New York and they wanted to synchronously start one generator with one motor. Those motors operated 325,000 hp. They wanted to start it with a 29,000 kVA generator, little bitty one, and bring it up. GE did some studies at the computer, and they concluded you couldn't do it. Kilgore and I went down to the shop, and we played with a 1500 kVA generator and 15,000 kVA motor, and started it. We found that by doing certain things, it was all right. We told the customer that we knew more about it than GE did. I don't know whether this was in GE's minds or not, but they wrote some papers saying you couldn't do it because of certain inherent instability in starting two machines at low speed like that. They'd done some computer studies, and they got so interested in the problem, they forgot to look for the solution. [Laughter] As a result, we got the job. That was kind of interesting because the upper reservoir was 700 feet above the lower reservoir, and they had no water in the upper reservoir to start. They had to run the smaller generator to have a certain amount of water to get the bigger one going. They'd run fire engine pumps into this reservoir for three months, and it didn't amount to

much. It about filled the pipe, is about what it did. [Chuckling] So you had to make it start the first time. We went up there. It was kind of comical to watch the people because the control people: "Well, I think I'm ready. Are you?" The turb man, "Yeah. Well, we're ready. Are the generator people ready to tie these machines together and start?" Nobody wanted to say, yes. [Laughter] Because if they didn't do it, they'd have to spend another three months pumping water into the plant. But luckily it started. They started pumping water up. Each of those pumps throws a hundred tons of water per second up 700 feet. That fills bathtubs pretty fast!

Aspray: It sure does.

Whitney: That's one of the interesting kind of features that we'd find with GE. Making it work. The customer told me about five years later, he said, "It never fails to start." We proved to him just how to do it. That worked out very successfully. The next big job was with the steel damper burn on the California Water Aqueduct.

Aspray: What year was this?

Whitney: These motors were 80,000 hp. They went out for bids on this, and we told them we'd build them line-start motors of 80,000 hp. In the bids that came out, GE said you couldn't build a machine that size for line-starting. Allis-Chalmers said that maybe if everything was just about right, they thought they could do it. We said we could do it. Well, of course that put the customer in a bind. Three supposedly reputable companies having diverse opinions like that. So they hired a consultant from the West Coast, who had worked both for Westinghouse and Allis. He was a very good man. No criticism in any sense that way. He was one that understood

the problems. He went to GE, and he wasn't much impressed with their capability. It turned out that the person in charge of the building of that kind of machine had very recently been moved from small and medium motors up to big ones. It was just bigger. He just hadn't realized it, and he hadn't grown up to that point yet. When we got the contract he said, "Oh, it was all a misunderstanding," because some other guys got at him. [Laughter] But by that time it was too late. But we built them, and they worked quite satisfactorily. Even some people from PG&E said, "You can't line start a motor like that." I said, "Well, if you've got a system that's big enough to run 14 of these 80,000 hp motors, you've can line-start one." Not only that, but that was one station, and then only about ten miles away was another station that was half as big again. Or half as big as the Tahachapee Station. Those motors lift water up 1920 feet in one lift. They move 10 tons of water up 1920 feet, two fifths of a mile, vertically, each. We put those in. The first one was about a third built in the shop when one of the computer boys came down to me, and "those aren't going to work. You can't do that." This was the secondary scheme how to start it up that they had in case the first one didn't work. I said, "What makes you think so?" He said, "The computer says it won't work." I say, "Well, what have you got in the computer?" [Chuckling] I told him, well, there was some saturation in the machines that made it so that it was going to work all right. I was glad he told me because it kind of made me look at a few other things I hadn't looked at too closely. I really didn't have to modify anything, but I did go out at the start-up to make sure that things were adjusted right. On a job like that, if it doesn't go right the first time, then you've got everybody and his brother looking down your throat, and you don't even have

time to look at what the problem is. So I wanted things adjusted right to begin with. It worked fine. So I was glad he told me because it made me a little more cautious in looking out at the right things for adjustments. They've been going ever since.

Aspray: Your stories make me wonder whether there's some sort of difference between the approach that was used by Westinghouse and the approach that was used by GE. Did they take a different way of dealing with problems? Can you characterize that?

Whitney: No, I don't think so. They got into computers a little bit earlier than we did. Computers thoroughly frustrated me because the first computer we had had 5,000 vacuum tubes, and it occupied a room five times as big as this one. You had to fill out two or three sheets to get a computer program run. And you had to put in all the parameters of the machine. If you didn't put every decimal point in just right it wouldn't run.

Aspray: Right.

Whitney: Usually I had to make up my mind in 20 minutes on something. But this you would have to put it in and run it through, maybe get it back the next day, that is, if you hadn't made any foolish syntax errors, right.

Tactical errors. Sometimes it wasn't quite right, but you could fix it in doing it, so that by hand you could do it faster than you could with the computer. They just frustrated me no end. I never did get quite up to speed with the computer. But the hand-held computers that you got a few years later were more powerful than that thing with 5,000 vacuum tubes. They would run it at night, but then sometimes they would turn out the lights. Then the computer would cool down, and the

thermionic emissions from the tubes would go down, and the thing would start making mistakes. So we would claim that the computer was afraid of the dark. [Laughter] It was kind of comical, but we got over that eventually. We got individual computers. Trouble was you couldn't make all the improvements, and you didn't have to have the knowledge to see how the flux was going to do it. You can see million-dollar mistakes being made all the time nowadays because they believe the computer, and they use a program that wasn't made for doing exactly what they thought they were doing. The net result is that you'd get wrong answers. It was irksome. But that's why they call some of us old guys to go do things at various times. Like I'm supposed to be in Alabama next Monday for a steel mill drive.

I don't think there was basically any difference between Westinghouse and GE. There was always strict competition between the engineers at one place from the other to see who could build the thing that was the lowest cost and come out the best. Pretty much it ran 50-50 between GE and us as far as the number of jobs we got. They beat me out on one job in California in which I didn't think they could do what they thought they could. But they did it. But I did some things they didn't think I could do. That's all right. They were the competition.

Aspray: They were already a quite a bit bigger company than Westinghouse, weren't they?

Whitney: As far as total company is concerned, they were always a lot better marketing in domestic things, like refrigerators and lamps. Somehow or other, Westinghouse never got organized properly in this area.

Aspray: Consumer goods.

Whitney: Consumer goods. But when it came to this power stuff, this included turbine

generators. In the waterwheels we were very close to 50-50. Some years it would be one way, and some years it would be the other way. With the steam turbine generators, they always got a little bit more, they had a little bit better, aggressive policy-makers, I think. They would wine and dine a little bit better than we did. In this kind of stuff, we were essentially equal.

Aspray: How large a part of Westinghouse's business was this business you were working on?

Whitney: Of course it varied with what contracts you got in any particular year. But I'd say the power apparatus group varied between 20 and 30 percent of the company's total business.

Aspray: So a good sizeable portion.

Whitney: Oh, yes. It got so it was well over a billion dollars a year. So it was a sizeable chunk. For a number of years we were one of the big revenue-producers in the company. After the foreign competition got real bad that decreased.

Aspray: What would your percentage of profit be on a total contract?

Whitney: There were some years it was down to not much of anything, and then at times it got up to maybe 25 percent. Depending on the contract and depending on whether we had any problems along with it, it would seesaw up and down. Some of the later managers didn't feel that the potential was there, considering the risk of building something that big, like this Grand Coulee business. At least we broke even, and if we'd gotten the second contract, we'd have made money on it. But Canadian GE got a little too eager, and they bid a little less than we did. They wound up getting the job, but I think they were sorry that they did. US GE chewed them up pretty badly on that because they didn't think they should even

be bidding it. I heard from rumors that they spent more money--or at least as much money--fixing the job, as they got for it. They had a great amount of trouble. The Bureau of Reclamation is having to replace all those stators on their job, and ours have now run for 21, 22 years. We had a few problems, but they were kind of small.

Aspray: I got you off track from going through chronologically on the important projects. Do you want to go back to that?

Whitney: The Niagara Project took about seven, eight years in the process.

Aspray: You had just told me about the aqueduct for _____ California, which I read here, by the way, was 1966 to 1972.

Whitney: Then I retired in 1975, theoretically. But at that time they let me go out and watch the start-up of the first Grand Coulee machine. That was essentially six times the physical content of any of the previous jobs that we'd built per generator. That kind of generator we mostly made less than 200,000 kVA. This was half the speed and three times the rating. It has to go up to 690,000 kW, a million horse power, turbine power. The rotor is 60 feet in diameter and weighs 1920 tons, and a hundred toles[sp?] on the rim. It was a big machine. I have a picture of it here if you want to look at it.

Aspray: Yes, I'd like to see that.

Whitney: I believe that's Niagara. This was one of the outdoor machines.

Aspray: The Niagara one was in the Westinghouse News, Vol. 15, No. 22, Tuesday, November 8, 1960.

Whitney: This is a picture of the Grand Coulee machine lowering the rotor into the stator. This is a big rig that they made because they couldn't put cranes up large enough.

These are wheels that come along, and as soon as it carries a load, the pistons come down against the concrete and four pistons lift this up. Then they can carry it along. This is a very big piece. This is a cross-section picture of the generator. Doesn't tell you the scale, but, see...

Aspray: It says this is 23 feet.

Whitney: Ok. That was the shaft, and it's a hollow tube. That was one of the first big hollow-tube machines that were made. This outside diameter is 100 inches from the shaft. It carries 70 million pound feet of torque. In other words, if you put the force at one foot radius to drive the shaft, it would be 70 million pounds to rotate the shaft.

Aspray: These numbers are just so big to me.

Whitney: Yeah. Well, you have to get used to just moving the decimal point and keeping track of it.

Aspray: Right. [Laughter]

Whitney: Here you can see the rotor diameter out to here is 60 feet. This is the center line. It's 60 feet out to here. So it's a big thing. We had a special rig that towed it. When you build something that big, it's hard to make it. If the rotor isn't perfectly centered in the stator, it may collapse and go into an ellipse. We put 15 beams here and pulled out on the stator to keep it round. GE had that trouble, incidentally, that it came in and pulled part of the punchings right out of the stator. Each one of these has a million and a half pounds when the machine is hot, and about two million pounds when it's cold, pulling out to counteract the magnetic pull on the air gap. It's a big magnet. You can understand the punching stress gets kind of high in the process. Just the rotor expands enough

mechanically and thermally with respect to the stator that the air gap varies from 10 to 15 percent between various stages of hot and cold in between the two parts. You have to take into account that sort of issue when you're building it. This bearing down here supports a load of nine million pounds, 4500 tons. One of the interesting parts of this career, you might say, was the Bureau of Reclamation found that the World Power Conference was going to be in Russia, just about the time we started on this. So they called up and asked that I go to the World Power Conference and visit the Electro-Seal Factory in Russia to see what they were doing with their Kresenyard[sp?] generators, which were then the biggest ones in the world. The Bureau of Reclamation picked the rating of this machine to just be enough bigger than the biggest ones that the Russians had made so that it wouldn't excite them to build something bigger, but it would still be the biggest. [Laughter] So as a result, I had three weeks' notice to go to Russia. They said I should take my wife along. It was a very interesting to attend the World Power Conference. She learned the Russian alphabet in the three weeks, and it was quite helpful. When she pronounced some of the Russian words, why, then you could tell they were close enough to English, and she knew whether it was a restaurant or a toilet in Russian. The Power Conference was very interesting. It worked a little bit like the League of Nations or the United Nations in New York, where you could give a speech in English, French, Russian, but absolutely no German. Because the Russians had had such a hard time with the Germans, during World War II they wouldn't have anything to do with the Germans. So the speakers could talk in any of three languages, and then there would be translators who would translate as the speech was going on. You could dial which language you

wanted from the school desk. As long as we were talking engineering, we could talk reasonably well with the Russian people. But when it came to economics, they were off in space. They didn't know the cost of anything the way we costed. Instead, everything was just run, so many people until you got something done. They were claiming their steam turbines, ran at 84 to 90 percent efficiency. That was a shocker. We couldn't figure out how they were getting that kind of efficiency. We came to find out, as a condenser, instead of pouring it down the rivers like we do, they would put a 100,000 kW generator in Moscow, and that would feed all the heating for all of the apartment houses within a 10-kilometer radius. They charged all the heat in the steam from 25 psi, which is about what they were exhausting on their turbines, to heating the apartment houses. So that they only counted the mechanical efficiency of the steam turbine. This 100,000 kVA station, it seemed to me they had about 130 or 140 employees. We ran a station that size with four to six people. How come? These other people were responsible for taking care of the lawns, all the coal handling, all of the apartment maintenance of the condenser tubes going to all these apartments, and so forth. It was a different world.

Aspray: Yes. Was the technical design of the generator different?

Whitney: I saw them building some of the parts. To a great extent, they were much the same but they were kind of more generously built. For example, just one little thing. I saw how they were putting punchings in the cores, and they were quite wavy in the stacking. I said, "Well, how much wave do you allow in that thing?" We were pretty careful about getting the thing flat. The guy turned to me with kind of a twinkle in his eye, he says, "Oh, we don't allow any." [Laughter] But I

saw several things. The Bureau wanted me to look and see if there were things that might be advantageous in building the machines we were going to build. I didn't see anything that I felt was as good as what we were doing. I saw several things that I felt were going to give them trouble. I did hear by the grapevine yes, they had to replace quite a few of the machines for the reason I was suspecting. But in meeting with their engineers, there was a secretary there that did the translating. All of those engineers, going from the chief engineer on down (and there were about 25 of them in the meeting), I'm sure that all of them understood a fair amount of English, but they didn't want to appear poor at it, so the secretary would translate. I asked the secretary later how she got so good on English, she said that when they built the Aswan Dam generators she got a lot of practice. [Laughter] But I asked them questions, and I got very little response. But they asked me if they could ask me questions. So I said, "Sure. Go ahead." They started asking questions. Well, I could tell what their problems were much more by the questions they asked, than I could by getting a direct answer. It was interesting. We spent a couple weeks there and flew around Russia and Russian plants.

Aspray: I noticed on here you had done some work on hydro-generators for other countries: Zaire, Brazil, and Venezuela.

Whitney: Yes. After I retired they asked me to go back and design the machines for Zaire. And then the Itaipu generators or power station was starting down in Brazil. It was by far the largest power station of any kind in the world, whether it be steam, hydro, or gas, or whatnot--13 million kilowatts in one station. I was officially retired from Westinghouse, but they thought I could go to work as their

consulting engineer in San Francisco to handle that. It was the time they were trying to select whether they should build the generators for two frequencies-- they had 50 cycles on one side of the river and 60 cycles on the other side--or what they should do about it. Whether they should make one generator to run both speeds or two different speeds to generate the power. I told them and some of the problems. They got into trouble because they didn't pay attention to what I told them. But they knew right away what was the trouble because they remembered what I told them. I told them they were going to get into trouble if they forgot that. They got into a little more vibration trouble than they expected on the 60-cycle machines.

Aspray: Was there any difference in building them? Were there different regulations, environmental concerns, willingness to spend certain amounts of money that affected the pattern in these different countries?

Whitney: Brazil wasn't dumb like the U.S. in that they said, 70 percent of the contract had to be Brazilian-made. They awarded the contract to a consortium of Brown, Bovari, and Siemens. Brown, Bovari did a good share of the bearing, but they were allowed to build essentially half the machines, and the others were Siemens. There were different philosophies in some of it, and, in general, they worked fairly well. They were higher speed than the machines we built for Grand Coulee, so the shaft torque is actually a hair less (by a percent or two), than it is at Grand Coulee. But they're running now. It pretty near broke Brazil in the process as far as cost is concerned. They said they weren't going to pay anybody under the table, which I know didn't happen. But I don't have a real concrete point of it, but they prosecuted a few people down there for paying under the table of one sort

and another. I insisted certain things on the bearings. For a while Brown Bovari was calling it my bearing, the Whitney bearing. But when it worked it was theirs.

[Laughter]

Aspray: I see.

Whitney: I insisted that they would have trouble if they didn't make a large piece for the bearing runner. Their bearing expert, the head of their research on bearings, was over there, and he was listening to my talk. He didn't quite believe me, but he didn't dare say it on the problems with thermal expansion and whatnot on the job-particularly on the bearing problems of curvature in the shoes, the stress shoes. But I give him credit. He went home, and he made a computer program doing what I told him was the cause of the problem. In the Brazilian airport one time I was just leaving to come home, and I heard somebody call, "Hey, Gene!" I didn't expect to see anybody I knew. Here was this bearing expert. He says, "You know, I made a program on the computer. It came out almost exactly what you described just verbally." [Laughter] I made a believer out of him.

So I had an influence on the job. But they wanted water-cooled machines.

Westinghouse made a water-cooled machine, which was kind of a fiasco, after I retired. I think that's what killed any hydro, because they goofed in some places, and the net result was that they spent a lot of money fixing it afterwards. I think that was just a plain management failure. After I left, why, they put some people in it that really weren't technically-knowledgeable of the problems, and depended on the regular boys to do certain things. They just didn't have the background to understand. I wouldn't say that I wouldn't have mixed up something on the job, because I could very well have. But I know I would have avoided at least three or

four of those bad problems that they got into because I'd had experience with them, and I'd be looking for it. Those are just what happened when some of the new managers seem to think that all you have to account is bodies for engineers, and it'll come out. That isn't the way it works. I've had them tell me you should scrap all records over ten years because they weren't worth anything after that. Well, 20 years is just about the time you begin needing the records because that's the time that they begin needing new windings. They're just totally unable to understand the problems of making machinery that has to last for a long time, and work hard.

Aspray: Can you tell me, say, from the early twentieth century until today, what are the major technical innovations that have caused so much improvement in hydro-generators? Could you elucidate a few of these for me?

Whitney: There was a lot in design from 1900 to 1905 or 1906. But then the major ones were Kingsbury __ bearing, the principle of a sliding shoe with an oil film which was dragged in there by the friction on the two sides that was causing an oil film, so that the machine floats on an oil film. That was one of the big ones. On steam turbines, there practically wasn't any steam turbine before 1900. They started building steam turbines--and Lamme was one of the main people that got straight in building them--but they went from salient pole type of rotors to round rotors in about the 1904, 1905 period. Then they went to forgings. Around in the twenties they went from what they called parallel slot rotors to radial slot rotors. The next major one was going to hydrogen cooling about 1927 through 1935. The first machines that they built with hydrogen were synchronous condensers, which are nothing but things to help hold the voltage on transmission lines and keep the

power factor up on transmission lines, on the third generator, which just floats on the line, and you vary the excitation to move the voltage up and down. Then it went to the steam turbine generators.

The first Westinghouse steam turbine generator that was built with hydrogen cooling went on the line just about 1936, when I first started in East Pittsburgh. Well, Ben Rose was a mechanical engineer just about 1940, who wrote a big article that said that maybe sometime they would be able to get to 100,000 kW in steam turbine generators with the then-known properties of the steel and rotors. It was only a couple of years later we jumped from 200 to 250 to 300, and in the next five years or so they got up to a million. [Laughter] I learned right then never to say you can't do something, you can't build a big one if need be. They actually have since decided that a million and a half, which is about what they got to, was really too many eggs in one basket. They standardized on 500, 800, 900 thousand kW units. What will happen from here on, I don't know. But there've been tremendous changes in my lifetime. There was no TV. Radio was very much in its infancy. At the start of World War II we'd given all the watch-making business to the Swiss, and we had to start from scratch. That's when they got into the crystal-operated watches. Made a quantum jump of at least ten times in the accuracy of the watch. It was really a tremendous change.

Then the movement from asphalt insulation types to thermal ___ is the Westinghouse name for it. Chemically, it was long-chain molecules to make a stable chemical compound that you could impregnate and it would set up chemically. That was a major change in insulation quality. The ___ irons were big in transformers, but the only other irons never made very much headway with

turbine generators and waterwheel generators, for the simple reason that it was appreciably more expensive. You could get higher densities. But in the waterwheel, in a rotating machine, the fluxes had to run in every direction in the (sic). So you couldn't orient it in one direction. The doubly-oriented irons never really got to first base. They were always too expensive for the amount of good that they did. So they didn't get very far in rotating machines. But there are certain ones of them, such as aircraft generators, where the price per pound gets up into the dollars. Of per-pound saved, well, you get an appreciable dollar benefit out of saving a pound. In the very expensive irons that get up to 25 bucks a pound and this kind of stuff. But not in the commercial machines.

Aspray: I notice that most of your publications listed here are in IEEE places.

Whitney: Yes. I also published a couple of things in handbooks.

Aspray: But mostly in IEEE. What's your experience with IEEE been over the years?

Whitney: I'd say good. I was on a lot of committees, power generation stuff. Several user standards. One of the real troubles is they get committees from all sorts. Some of them were Bureau of Standards, and some of them were manufacturers. The biggest problem in getting something done is the education of the people that are in those standards committees to understand why it's necessary because they come from different orientations. Consequently, one has to educate them enough on the technical matters. Well, especially during this price-fixing stuff, the government said that there shall be no conferences between engineers without having salesmen and customers listening in. If you were doing something that was ahead of the field, you didn't like to discuss it with your competitors in such meetings. There was a real problem in that, e.g. with this steel damper bar

business. At my insistence my group made over 6 million h.p. motors. There aren't that many groups that make that many horse-power motors other than us, anyway, with steel damper parts.

I thought the Westinghouse patent department was somewhat useless in that they would only patent little things that didn't mean too much. It was very hard to sell them on something big. For example, on the steel damper bars. I found that GE had made steel damper bars, in machines in the 1903 to 1905 period, but they had made them lead pencil size bars, and the steel damper bars are not worth much at that point. They're too high a resistance. It's only good when they're big. By the time I realized that that was holding up any consideration of a patent, it had elapsed and I'd made machines. [Laughter] So I just kept it as a trade secret. I know that GE, Allis, Brown-Bovari, and Siemens all came and witnessed what I had done, saw the machine. But the bars were so buried, so that I don't think they understood. And as far as I know, the net result is that nobody else is using it yet. Since Westinghouse is out of the business the process is effectively lost. I've felt guilty that maybe I should write a paper sometime, but I don't know whether I could get sued for peddling Westinghouse secrets or not. So I've kind of stayed off of all of that, although the patent department gave me clearance at one time. I was nonetheless scared of the lawyers not paying attention to that. If they think there's any money in it, they'll sue no matter what.

Aspray: While you were a regular employee, did you have the opportunity to go and give talks on the things you were working on? Did you have any problems with that? Or write papers?

Whitney: Some of those papers that I wrote, they were early enough that they were in that

period. The short-circuit torques, for example, that was something that the industry needed, and they figured that was all right.

Aspray: But did you feel some constraint on you?

Whitney: I don't think that they ever cautioned me from that standpoint. I felt that it wasn't kosher to tell them everything you knew.

Aspray: So it was self-policing in a way.

Whitney: Yes. To a large extent. Mr. Lofune, who was Kilgore's boss for many years, was a very progressive fellow. As an engineer he made some dumb mistakes, but that's all right. He had a lot of faith in Lee and me, and he would let us go with a pretty free hand. When I was manager, I was always blessed by the manager who took over. The morale of the place was bum up until about that time. They got a new manager who was a switchgear engineer, but he says, "Look, you fellows run your business like it was your own." He says, "If I think you're getting off the track and you need some help, I'll come see you. If you feel you need a little help, come and see me." As a result, I didn't see him very often. But it was a good relationship, and he built up the shop so that it was a very good working team about the time I got to be a manager. Then he got shipped off to Europe. The next man that took it was good; he was also an engineer. In fact, he's the father of my son-in-law. [Laughter] But he wasn't quite the one to give confidence to all the people as much as Jim [last name?] was. The next one had too much training under the Admiral. He could run a cost-plus business, and I thought he was going to be a breath of fresh air when he came in. I liked the guy. But they started having downtown people make sales presentations. They made a video, where they talked about the size growth of waterwheel generators. They quoted Wrong-

Way Corrigan and things like that. We showed it in one place and were politely asked not to ever bring it back. They'd send out five people theoretically with the idea of training them with canned speeches to give to the customers. The customers weren't interested in having a canned speech to talk about something that was ordinary. They wanted you to talk about and ask them questions about what they wanted, and how it could be affected, and what could be done with the generator to do this. When I went out, I just let them ask questions. Talking was a two-way street as far as I was concerned. I wanted information out of them about how I should design it to suit their particular problems, and they wanted information on how I should design it to suit their particular problems, and how we could relate to them. As a result, I got along great with them. But that was a difference. But then when they'd send five young fellows, who really didn't know the answers. Of course in a lot of ways that was good for training, but...

Aspray: It wasn't good for your customers.

Whitney: As far as the customer was concerned, it wasn't so good. One of the things I got assigned on just before I became a manager was one customer hated commutators with a passion. Anything with a commutator was big trouble as far as he was concerned in running a powerhouse. So he asked Mr. Lofune if we could design a brushless machine--a machine without an exciter as such. I don't know why, but I was given the business of building a turbine generator that would feed a brushless exciter, with a mercury arc rectifier to furnish the excitations to the machine. I designed it before I became manager and wrote the design specs for it. I almost heard no words out of the drafting room. I either wrote it so well that they didn't have any trouble, or else it was easy for someone else to interpret. They built it,

and it operated up here at Warren, PA. It operated for 40 years. Finally, it was replaced by a static exciter that was solid state. It wasn't because there was any problem with what we had designed, but that the environmentalists had made it such that people couldn't make mercury vacuum tubes and get a good seal, and the health people wouldn't let them work with the mercury for mercury poison. So that they couldn't buy replacement vacuum tubes. That was the reason that they decided to replace it with a static exciter, which was actually better than what we had there. No argument about it. But at the time I designed it, there was no such thing as solid-state electronics.

Aspray: If you had to identify a few people from either Westinghouse or your competition that are people that we might think about interviewing over the next year or two, do you have any names to suggest?

Whitney: I think you've already got the name of Baudry, but he's over in France.

Aspray: Somebody on my staff will be going to see him.

Whitney: He is a remarkable guy. He's 94 now, I think. And he was mechanical. Actually he was in the Balloon Corps in World War I in France. Then he emigrated to the United States. He came in the mid twenties. He was an idea man. In fact, it was hard put for most of the rest of us to keep up with him as far as ideas were concerned. He had a new idea every five minutes. The big problem with him working on machines was that his ideas would change faster than we could manufacture the machines. [Chuckling] One of my jobs, which was never dictated from the boss but the way I soon found out I had to do it, was picking out the best of Baudry's ideas to go with. He was a marvelous fellow as far as ideas were concerned. He was credited a lot with the inner-cooled turbine generator,

one where they blow the gases through the conductors and cool it that way. A big sparkplug on that and many other mechanical innovations which most of the rest of them wouldn't dare use. Well, you're not going to interview Lofune because he's dead. Kilgore was probably the most outstanding engineer in our area. He was primarily electrical, but he's world-known on transmission problems. One day some people brought up a three-month computer study on the cause of the New York Blackout. He told them in 20 minutes on the back of an envelope in the dining-room that the study was all wrong. "The machines are better than what you're saying." They went back and did the study over again. But that's just the kind of guy he is, see. In 20 minutes he could find the hole in something like that. As far as the rest of them are concerned, now Paul Johrde has had quite a career. He was out here in Monroeville. Then he went to work for GE for about ten years. Then he was mad at GE--just penny ante kind of stuff that goes on in some offices--and he was ready to quit, even if he had to go get a job as a mechanical engineer. I'd wanted to hire him at the time that the other outfit went belly up. But we'd just gone through one of these deals where every department has to cut 10 percent whether it makes good sense or not. So I couldn't hire him at that time. But I got to hire him which was good for us because GE had gone ahead with grid-ventilated machines, and we hadn't really done that, hadn't really seen the need of it yet. But for Grand Coulee, it was necessary. So I hired him and got the benefit of some background there. He's a very good man. So he's retired now.

Aspray: What about the managers?

Whitney: Well, Kilgore had a management job for a while. It wasn't really a mistake, but that wasn't using his talents to the best advantage. I don't think there are any

managers that are still living, that you could get a hold of that I regard real highly.

Aspray: Are there people that you came across through your other dealings--from other companies, from ABB, or Siemens, or General Electric, that you think are worth talking to?

Whitney: Jay White got the Tesla Award a few years after I did, but he's dead now.

Aspray: I see.

Whitney: I didn't know very many of them--because of the restrictions that were put on us. Now Duke Power, we got along with them very well. Bob Howell, he's quite active in IEEE committee work on waterwheels. I thought quite a lot of him. There's a fellow, Joe Fitzgerald, in Cleveland for Cleveland Electric Illuminating, who was a sparkplug. He thought highly enough of me to help sponsor me for the Tesla Award. He was a very good engineer, but he was more a manager toward the end. He had a lot to do with the selection of the process of the machines. He was always quite happy with the results. There was one from the Army Engineers in Portland, but he's dead. One thing that was kind of an interesting proposition. It involved a fellow by the name of Strandberg [sp?], who I think is still living. He was former chief engineer of the City of Seattle. We were testing the machines up at Ross Dam Powerhouse, and we were doing what was called a deceleration test for measuring losses where you run the machine up above normal speed and let it descend, and judge by the rate of descent the power loss for different conditions in the machine. That particular day they were testing the machine, and they decided that the windage force was too high. They didn't know quite why, but the machine was stopping

faster than it should. The consulting engineer for the turbine was down looking at the turbine, and he saw smoke coming out of the turbine. So he turned and said, "Turn the water on the seals." What he didn't know was that the friction had melted the steel almost the entire way around the periphery of the turbine. When they turned the water on, the thing froze, bump! like that at about 45 rpm. There was a 38-inch shaft, and it twisted the shaft several degrees so all the coupling bolts in the coupling, the bottom half of the coupling bolt mashed the head an eighth of an inch, and they stretched an eighth of an inch in the process. The shaft where it went through the center part of the rotor, the spider, had slipped forward, and the shrink fit wasn't quite enough to hold it, and it mashed the key way. This key was six feet long and something like four inches wide, and six inches radially. It mashed that into both the shaft and the spider an eighth of an inch, both places. It wound up sort of like a watch spring and flopped back. In the process of flopping back, it went back to its original position, except that the shaft had a kink of something like three eighths of an inch in it. So he says, "How we going to get that out?!" Various people told him that you had to take that old shaft out and then re-machine it. I said, "How you going to get that out when it slipped a quarter of an inch forward and then slipped a quarter of an inch backward?" So that it galled all the surfaces because it had a big shrink fit between them. I said, "How you going to get that out of there without just plain boring it out?" And then you don't have a shaft. Might as well start with a new in .

Had a big conversation on the phone between this consultant in Denver and the City of Seattle people in Seattle, and our district office in Seattle, and me on this

end. I said, "Well?" He said, "Well, what are we going to do with this thing? We're going to lose a lot of revenue in trying to get that out." Even taking it out was a problem. I said, "Well, why don't we straighten the shaft right into place?" He said, "How are you going to do that?" I said, "In where it's mushed it's elongated that section of the shaft" because it mushed the fibers and stretched it. I said, "Well, listen. We'll apply torches to it, right?" I said, "I don't like this business of spot heating," which is a fairly common procedure for straightening shafts. I said, "I don't like that. We'll heat it with torches up to no more than about 280° centigrade in this amount of area. It may take two or three tries at it to get it to come back just about where we want it, but we should be able to get pretty close." He says, "Boy! That's an original solution." [Chuckling]

About a week later this fellow Strandberg from the City of Seattle called me up, and he said, "Gene, we've talked it over, and we think your solution is better than any of the rest of them, and it'll save us a lot of money in the process." He said, "Can you do it?" And I said, "Yeah...." So I told the fellows, the erectors, who were out there anyhow what to do. I had a very good set of erectors, which was one thing. I think we had the best erection crew in the country by a long shot. I said, "Yeah. I can tell them how to do that. They're good enough so they can go do it." I told them over the phone how to do it. They measured as they were heating it about how far to go, and then it would shrink, it would over-stress the hot spots, and they had to do it inside of ten minutes, do the heating in ten minutes. They did it, and they brought the shaft back pretty close to center. Then they got cylinder-boring tools, and they increased the diameter of the holes for

the coupling bolts, and put a shim in between the two halves of the coupling such that it came straight, because that was kinked. The machine's running today. Herb Strandberg called me about five, six, seven years later, and said "Gene, before I retire, I thought it was a good idea to go up and see if there was any obvious strains and things that I should take care of. Four or five of us piled in the car and went up to the dam." It's right on the boundary between the United States and Canada. He said, "We went in there, and we walked around and around, looked at the thing, saw how it was running. We couldn't see any sign of distress at all. So we all got in the car and came back." [Laughter] That was after five or six years of running. They were very satisfied. It's satisfying when everything goes all right. I don't know whether he's still alive or not. I haven't heard of him for a long time now.

Aspray: Are there any other things you want to talk about, that we haven't mentioned in the conversation today?

Whitney: Well, here's a picture of that warehouse that they put all 13 machines in, and there are some other pictures that show them storing the pieces. You can see the size of them in the photograph. Here's one of the folders that they put out during the time of the project. This is a picture of the plant before they put concrete over the pipes. They used this 630-ton crane. Harness pretty nearly went broke on it, building those cranes for this job. You can see in this picture the power plant. They're revamping them now to try and up-rate the machines; but they're having a hard time. Here's a picture of the rotor being moved on by the crane over the hole and being dropped in the stator. That'll give you an idea of the size of it.

Aspray: This is from the Port Authority of the State of New York, Niagara Power Project

Construction Progress, October 1960, from Uhl, Hall & Rich.

Whitney: They're now not Uhl, Hall & Rich. This is the forebay and the water comes... I have to go through the tunnels. You can see some of the tunnels here. The tunnels are 46 feet wide and 66 feet high. The water comes down to feed the stations through those. Then it comes out up right here where the tunnels end; the water turns the corner and then comes over to the powerhouse here. It goes down the individual penstocks, then through the generators that are down below the covers, which you see down here. The spacing between them is about 65, 70 feet. So you get an idea of the size. We put in about eight of them all in one year's time nobody had previously done anything nearly that big. And they worked. This is some data on the Grand Coulee machines. The St. Lawrence Project. That was mostly GE machines and Canadian GE, Canadian Westinghouse. We were in communication regularly with Canadian Westinghouse about their building generators and so forth.

Aspray: I'm going to talk to George Wilcox tomorrow.

Whitney: Oh! I've known him--though never well. He was one of the better managers of the place, especially in the engineering department. He was all right. He grew up enough in the ranks to understand the problems. You'd have to do something different from what you'd done before. So that it was a challenging job in the sense of having to do different things. You weren't stuck in a routine. Well, there was a certain amount of routine.

Aspray: There was always some new challenge.

Whitney: There was always some new challenge, and I was blessed by having people that would let me go ahead and do what I thought was necessary without a lot of

argument about it. I didn't have to go through ten computer programs to prove that what I was thinking was right. They would let me go ahead. Kilgore was a big help in that respect because he recognized these things very promptly.

Aspray: It's nice when they recognize talent that can carry something through.

Whitney: Kilgore had the backing clean on up to the top. He didn't have any relatives or anything like that. But he proved himself. He's always been a very good gentleman, and gave credit where credit was due, and for that it was a wonderful opportunity to work in the place because that was the way it was. People were honest and helpful. You didn't have this backbiting deal which has occurred in so many companies of late, where everybody's jockeying for position. And not necessarily doing the right thing for the organization and the product. The product comes first, and you have to make it right. In that respect it was marvelous. You don't often find that in a lot of the companies today, especially now that they've had to downsize from this free trade racket. You go around Pittsburgh and see the slums and the areas where old factories are just decaying. I didn't get off on this, but one of my songs and dances is that after JFK declared buying only American products, which is unconstitutional, and he got all sentimental about helping the Japanese after World War II. Why, he ordered us to give the best designs we had for steel mills to the Japanese. Then he gave them the steel mill. The Japanese weren't at all dumb about it. They put in other procedures and so forth. When you're building a new factory, you can afford to apply that reasoning to the new materials. But most of ours were on the basis of what you could do on a replace basis and still justify. So they built the steel mill, and they didn't have any money in it. We'd given it to them. So what could you

expect, but they sent the steel back to us and ruined the steel mills here. That's exactly what happened. Their quality went up beyond what we could do with the old mills here, and it just drove all of ours out. It was quite pure and simple. Nothing but. But of course everybody in Washington. There's an article in the June Reader's Digest on why very smart people do dumb things. It's a picture of what went wrong with Westinghouse. It doesn't say that. But it's a picture of what went wrong with Westinghouse. It's what's going wrong in the government right now. Where a body of people, Clinton included, all his cohorts are afraid to argue with him very much, so he has an idea, and it's a "Yes, sir" type of lawyer group. They don't get proper feedback with where the faults lie in it. It applies to free trade which is not free trade, it's a lease give proposition. We have to give to these countries. Clinton bribes them with money so that they can buy something over here. We give it to them, and then they don't pay it back. He says that's foreign trade. Trade my foot! It's out of our pocket. But all this big batch of executives say, "yes, sir." Well, they don't say it quite that way, but they all dream up reasons why it's right and reinforce each other around the clock until they believe they can do things that aren't realistic. It's an excellent article. Westinghouse got in trouble because--or I think they got in trouble--because they got a management that didn't understand these long-range issues of building engineering products, big products. They looked at the financial market when people were making money, when the finances--they thought they were a whole lot better than they were. So they talked themselves into giving loans up into the neighborhood of 120 percent of the value of the property. Things like that just keep building themselves up until it went bust. It's just that procedure that's going

through the government now. We've got to help everybody under the sun. The only way to help them is to help themselves, usually. Our so-called adopted daughter, who was a German AFS student, came over here as a student for a year. She says that in Germany they laugh at the United States for giving money out. It's a sucker deal. Then the countries like Iran and so forth, they never pay it back. They're paying them bribes, really, to try and behave like they think we think they ought to behave. It's kind of ridiculous. You don't make money except in building real products, building wealth from the raw materials. The service economy just runs the money around and around and around fixing up old junk, and it winds up in inflation per year like the Brazilians. They've got over 100 percent inflation per year. Things like that. You've got to build products in order to do something. My brand of economics, I know, is really not in style, but....

[Laughter]