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Dannenberg discusses his early life and education and residence in Hannover; origins of his interest in rocketry. Discusses involvement with Pullenberg's rocket group and arrival at Peenemünde. Discussed engineering education and assistanceship at TH Hannover. Hired by Thiel and assigned to A-4 engine injection system and JATO. Involved in refinement of the 1.4 and 4.2 ton thrust motors used in testing the A-4 injection systems and the 25 ton A-4 engine. Dannenberg discussed the design of the film cooling system for the 25 ton engine. Shortages of high quality metals forced changes in production; difficulty in getting production drawing that worked, parts often defective. Discusses in depth Reidel I, III and von Braun. Discussed difficulties resulting from August '43 air raid. Concludes with description of end of war and move to U.S.

TAPE 1, SIDE 1

1 Birthplace, father's occupation, early residence and education in Hannover, origins of interest in rocketry

2 Involvement with Pullenberg's rocket group in Hannover, education, drafting into army, industrial experience and arrival at Peenemünde

3 Witnessed Opel rocket rail car tests and Valier lecture; origins of work with Pullenberg

4 Read Oberth and Goddard books; after experimenting with solid rockets went to liquid fuels; got liquid oxygen from a professor at the TH Hannover; experiments were earlier than Opel experiments (1927-28). [Dannenberg has subsequently retracted latter claim.--MJN]

5 Not a member of the VfR; had own Hannover group; raised some money with public launchings

6-7 Engineering education and assistantship at the TH Hannover in diesel combustion

8 Industrial experience and Army service in France, 1940

9 Contact with Pullenberg leads to civilian draft assignment to Peenemünde later in 1940

10 Not a member of the Versuchskommando Nord, which was created later; Army officers confined largely to administration at Peenemünde

11 Hired by Thiel not long after he had moved from Kummersdorf; assigned to injection system of A-4 engine and JATO

12 Involved also in burnthrough problems of the 1 ton thrust JATO (Starthilfe) project for the Luftwaffe; witnessed aircraft tests at Peenemünde-West

13 Design of the injectors for the A-4 motor; experimentation with atomizing nozzles and straight holes

14 Worked empirically but had some useful advice from combustion and injection specialists from the TH Dresden; Lindenberg came from Dresden

15 Combustion/injection research of a NACA engineer also used; Dannenberg had seen at Hannover

16 Thiel deserves much of the credit for the A-4/V-2 engine; his death in the bombing raid was a big loss; with him they might have succeeded with the Mischduese, which had combustion instability problems

17 The A-3/A-5 engine designed at Kummersdorf; he had nothing to do with it; participated in refining the 1.4 and 4.2 ton thrust motors used to test the A-4 injection system

18 25 ton A-4 engine already designed when he arrived; involved in refinement, also of the throat area and film cooling

TAPE 1, SIDE 2

19 Repeated testing of the 25 ton engine facilitated by exchangeable nozzles

20 Problems in drilling the injector holes properly could result in burnthroughs

21 Design of the film cooling system for the 25 ton engine; function of the expansion joints

20-25 Film cooling cost performance, but was necessary; not used anymore; at the time could not get the high-quality metals of today

26-27 Later in the war shortages of material forced incorporation of new changes; aluminum had to be used for the lox tank, but paperboard tank considered for the alcohol fuel

28-30 Competing designs and problems of the Mischduesen ("mixing nozzles") which were investigated as competitors of the 18 injector system

30-31 Problems with the Mischduesen; vibration problems of the injector plate

32 Wasserfall used a smaller version of the injector plate; he was not involved with it because he was assigned to getting the A-4 engine into production and controlling the changes

33-35 Purpose of Stahlknecht's Nachbaudirektion; replacing of Riedel I by Riedel III; to some extent Riedel I ["Papa"] treated badly; attempt to create a set of production drawings a failure

TAPE 2, SIDE 1

36-37 There were serious problems getting production drawings that worked; parts were often defective

38 For the rest of the war (1943-45) was deputy of Riedel III in the Design Office; worked on production drawings; involved in the airburst problem

39 Riedel III was a good engineer and manager; pushed hard but held together the organization after the dispersal; dispersal reduced efficiency

40 The in-house research-and-development philosophy was furthered by problems getting manufacturers; but in mass

production had to go to contractors; materials problems made it difficult to get good production; but in the end all missiles made at Mittelwerk

41 Von Braun had a very impressive personality; an aristocratic and military bearing; not a snob; communicated with all levels of the organization

42 Von Braun wanted another year of development on the A-4; did not hear that Dornberger criticized von Braun for not being focused; was reasonably conservative in his design approach

43 Some left the group in Huntsville because they felt that von Braun's philosophy was too conservative; but he was correct in his approach and his decision to stay with the US government

44-45 Von Braun and Medaris pushed the in-house development philosophy/arsenal system; forced to depart from that during the Saturn V period by NASA

46-47 Von Braun was more than a manager in the German period; contributed ideas, especially in guidance and control Von Braun was not much involved in propulsion while Thiel was alive; after Thiel's death, he became more involved; Schilling mainly handled testing and propulsion development really slowed down

47 Wasserfall development had lower priority, and was often forced aside by V-2 problems; handled by air force people at Peenemünde

48-49 Scheufelen and the Taifun; a desperation project

49-50 Dornberger was a distant figure to him at Peenemünde; did not have much interaction with him

51 Dornberger opposed the bunker idea; he and Klaus Riedel pushed the mobile launch concept

52 Did not travel much during the war, except a few times to the Mittelwerk; problems always pressing Himmler came to Peenemünde in 1943/44; von Braun's arrest an attempt to remove an obstacle to a takeover

TAPE 2, SIDE 2

53-54 Does not know of the Zanssen affair and the SS's role; like Stegmaier and thought him a competent administrator; many people found Zanssen difficult

56-57 Did not have any direct contacts with Kammler; only with Sawatzki at Mittelwerk, who demanded drawings

57-58 Conversion to a company made little difference; does not remember change in pay, but money late in the war was not important, rations were; conditions ok

58-59 Air raid of August 1943 disruptive; loss of a few months due to dispersion, reorganization; does not remember other raids; air raid warnings not disruptive

61-62 At the end of the war production became more and more difficult; went straight on to Bavaria without staying in central Germany long

63-64 Stayed in Oberammergau until the end of the war; situation was tense and difficult; foot shortages and threatened with

shooting

65 Went to Backfire, then to States; reasons for going to the US; discussions about going to the US before the end of the war kept only among friends

Interviewee: Konrad K. Dannenberg

Interviewer: Michael J. Neufeld

Location: Huntsville, Alabama

Date: November 7, 1989

TAPE 1, SIDE 1

Mr. Neufeld Okay, we always start these interviews with a general biographical background, so could you give your birth date, birth place, occupation of your parents and so forth, that kind of information.

Mr. Dannenberg: Well, I was born in Weissenfels just south of Leipzig which is now pretty much in the news these days.

Neufeld: Right.

Dannenberg: So there, of course it's Eastern Germany, in those days of course there was just one Germany--

Neufeld: It was Saxony.

Dannenberg: Yes. My dad was in the army, and he moved pretty soon after my birth on the 5th of August, 1912, he moved pretty soon to Hanover and I really spent most of my youth years in Hanover. I went to school there. I visited the university in Hanover. And in the late 1920's we had some rocket tests taking place in the vicinity of Hanover. You may have heard about Burgwedel, where some Opel cars were being tested with (crosstalk) solid propellant motors strapped to it, and we had a suitable racetrack so they came to Hanover, and I observed these tests. I understand they made three of them, and I seem to recall that I saw two of them, and that interested me and some other people I worked with, some of my comrades at that time, to really become interested in rocketry. So I started relatively early, in fact we were thinking about rocketry already before we saw these tests, and these tests just provided some additional initiative.

Neufeld: I wanted to ask you, was your father an army officer?

Dannenberg: Right.

Neufeld: And was he killed in the First World War?

Dannenberg: No, no, he survived, and of course he stayed then in Hanover. My mother was there. I had a sister. She died during the war, and he worked for the post office. He was on long term duty in the army, and the German army then normally provided

employment in the postoffice, railroads, or some thoroughly run organization. So he was working for the post office when I grew up, and--

Neufeld: He didn't continue on in the Reichswehr?

Dannenberg: Right, he did not. And after I had seen these tests of course we became quite interested in rocketry, and we had our own little rocket field in Hanover. It was not quite as well known as the one in Berlin where von Braun worked, but you probably knew there were many of these amateur rocket societies. Apparently people after World War I at that time were really interested to look a little bit futher ahead, and there was not too much going on in Germany. We had the big inflation even during those years. And so people, I think, in general became quite interested in Raumfahrt--

Neufeld: Space flight.

Dannenberg: Space exploration. We had the movie, "Die Frau im Mond" in the late twenties or early thirties, must have been along that time.

Neufeld: The end of 1929.

Dannenberg: Yes. And that all enthused us, so when I finally heard about Peenemünde, I learned about Peenemünde from a fellow I'd been working with, Pullenberg, Albert Pullenberg, who is also still living in Germany today. He lives in the Ulm area. And he was really the head so to speak of our rocket activities in Hanover. He was the most active one. He later even married the girl who had a kind of a shop that he could build in bigger scale rockets, ground facilities and things like that. He did not decide to come to this country after the war. He decided to stay over there, and he took, even after the war, his own rocket activities up again. And I learned through him about Peenemünde. Of course he couldn't tell me we build rockets here. It was top secret. So he indicated in his letter to me, "between the lines, here is some work going on which I'm sure you would like and why don't you try to get away from whatever you're doing now and come and join me here?" And I think the name at that time was Karlshagen or some place close by, where most of the people lived. When the war started, I had graduated in the meantime. I went in Hanover to school as I mentioned earlier. And maybe one thing is even of interest. I went purposely into the area of diesel fuel combustion, diesel fuel injection, because we had learned in Hanover that that was at that time one of the big problems, how do you really properly introduce your propellants into your rocket chamber, how do you mix them properly and what do you have to do in order to get good combustion?

Neufeld: Right.

Dannenberg: So in order to learn more about it, I studied diesel fuel injection. Of course no one taught anything about rocketry, but it was the closest field to it, and before the war started, I had been a volunteer in the German army so I initially was drafted into the German army, but they sent me to a horse drawn anti-tank battalion, and that was for me enough reason that I finally got out of the army. I could use the fact that I was a technical man with Dipl.-Ing. in engineering, that I shouldn't serve in a horse drawn company, and so I managed to get out of the army and worked at that time just before the war for the VDO. They built tachometers. If you drive a Mercedes you probably have a VDO tachometer in your Mercedes. Of course, during the war they built all kinds of wartime instruments, mostly radar type, communication type instruments. They got me out of the army. They justified it with their needing me. And once I was back at the VDO, I didn't have too much of a problem to get from the VDO then transferred to Peenemünde. So that's the way I finally came to Peenemünde in the summer of '40, early summer '40.

Neufeld: I want to ask you a number of detailed questions before we even get to that stage. Your experiments, you participated in these rail car experiments in--

Dannenberg: --I watched them, I didn't participate.

Neufeld: '28, okay, you were there. That was Opel, wasn't it?

Dannenberg: That was Opel, yes.

Neufeld: Valier was involved, because I know that they had gone their separate ways. Just after the rocket car business.

Dannenberg: Yes. Valier had also been in town. He had given an inspiring talk. He was a pretty good talker, you probably know. He was a little bit the von Braun type. He could talk to the public. He could talk to them. He could convince them. And he did a lot of work, of course, but these tests, you are right, they were done by Opel.

Neufeld: When did you begin working with Albert Pullenberg?

Dannenberg: That must have been in the late twenties. It was before we saw the railroad tests, and they were all I think in '28, possibly '29, and we had started to work on our rockets before that, but that really gave us some additional new spirit again.

Neufeld: Really.

Dannenberg: Of course we didn't have any real funds. We had to

spend our pocket money. And we started out with solids. So we bought solids. You could buy them in Germany in those days, fireworks rockets, we took them apart, we cut them open, made them into bigger rockets and that was really the beginning of the work. And then we finally became aware of Oberth's book. I had also read Goddard's book, how to Reach Greater Altitudes by Means of Rockets. And we decided that yes, the right way to go is to use liquids, so we switched relatively early, in the '27, '28 period, to the use of liquids. And we were fortunate enough, I was living in Hanover, Hanover was a fairly large city and we had an air liquefaction plant in Hanover, and separating air you can easily make liquid oxygen, and through a professor at the university, an aeronautics professor, Proell, we got permission to use some of their liquid oxygen as an oxidiser.

Neufeld: Proell?

Dannenberg: He's dead now. He was already an old man at that time, so he's not alive any more, but he wrote a number of books and he was interested in rocketry, from the viewpoint of application to airplanes. You probably know, right after World War I, Germany was not allowed to build powered airplanes, so people strapped solid propellants and later on liquid propellants onto sail planes to get up into the air. That was one method. There were other methods to get up into the air. And actually in Hanover we had a contract from one of the sail plane people, Espenlaub, to build a rocket for him, a liquid propelled rocket for him, and to eventually develop it, but we had so many problems we never came to the point of delivery.

Neufeld: All of this sounds very familiar. You see, I've written an article about that period in the late twenties, and I know that the sail plane idea really took off after the rocket car and so forth in 1928, in April of '28. But you are very sure that you and Albert Pullenberg and anybody else in that group started before you ever even heard of the rocket cars and so forth?

Dannenberg: Right. That came later. I'm pretty sure about that. We had been working on it before that.

Neufeld: Because I don't know of any other private rocket experiments that were going on at that time. If that's true you would maybe be the first. You know, Raketenflugplatz didn't start until 1930. So I don't know of any experiments so early.

Dannenberg: Were there not other activities going on?

Neufeld: I don't know of any private rocket groups. Nobody has mentioned it. Winkler really only started working with this right around '27, '28, as well.

Dannenberg: Yes. I think we started at about the same time. And we had heard about Winkler. We didn't meet him at that time.

Neufeld: Were you a member of the Verein fur Raumschiffahrt?

Dannenberg: We had our own GEFRA (Gesellschaft fur Raketenforschung). That was a Hanover group.

Neufeld: So you didn't feel it was necessary to join the VFR?

Dannenberg: Also that's too far away. Normally I wouldn't go to Berlin so normally we wouldn't have any contact with the people. We knew that they had a club similar to our club.

Neufeld: Yes, because that was later. I was thinking about the DIE RAKETE.

Dannenberg: Yes, I didn't even see, our activities may have been the very early ones.

Neufeld: Yes, because I know the Raketenflugplatz really only started in late 1930. Of course Winkler was experimenting. I don't know if he even started up a rocket engine before '29 or so, I don't think, even on the ground tests. You know, he started working only after he became involved with the VFR and RAKETE and so forth. So that would make you very, very early.

Dannenberg: Well, as I told you earlier, I'm a little bit poor with remembering specific dates. I mentioned Pullenberg earlier. He's still living in Germany. Maybe once you are over there again you might want to talk with him, if he's still alive. He's in pretty poor health, and also his memory is not quite as good any more, but he might even send us some documents. We published documents. We gave talks at that time. That was one way of raising money, to give a talk, to invite people to the launchings, to pass the hat around, to get a few extra dollars, and this was really all the money we had, and our own spending money, which was also very short, of course.

Neufeld: You went to a Gymnasium?

Dannenberg: No, I was in the Oberrealschule, which taught only English and French, no Latin and no Greek.

Neufeld: And more science?

Dannenberg: And more science, physics and things like that.

Neufeld: So you started with the University of Hanover when, in 1931?

Dannenberg: In 1931, and that's when I really stopped my rocket activities, so I'm pretty sure it must have been before that time, because I didn't do any major work at that time. Pullenberg every once in a while tried to involve me, but being a student you are so busy with new things that I really didn't have the time. And I also served at that time one year in the army, so that must have been from '32 to '33, I would say. I think it was still before Hitler took over so it must have been '32. And my dad wanted me to become a teacher, and I was not interested in teaching at all, so I was really not too hot about it, and that's why I left the university to have a year, to think about it, and after I came back in '33, then I really went into the technical fields.

Neufeld: Were you in the Technische Hochschule?

Dannenberg: Yes.

Neufeld: In the first year as well?

Dannenberg: Both times, at the same university.

Neufeld: So you were in the Technische Hochschule Hanover.

Dannenberg: Right.

Neufeld: From '31 to '32, then you were out one year?

Dannenberg: Right.

Neufeld: '32 to '33, then you started again?

Dannenberg: Then I started again and then I went into strictly technical fields. My dad had consented in the meantime, well, if you really don't like teaching, and also teaching jobs were not that plentiful any more. When I initially went to school we still had a lot of unemployment, yes.

Neufeld: Right, it was very bad, the peak of the chaos--

Dannenberg: (crosstalk)--and there was practically no job you really could get. That was really the main reason for me to go to the university: I couldn't find a job. And then my dad felt, if you are a teacher, once you are hired you have a lifetime position, so that's why he wanted me to go into that field. But as I said, I wasn't too hot about it, and I would have been a grade school teacher. I would have had to know how to play the violin. You had to take music. That was one of the subjects you had to dig into, and I really didn't like that at all.

Neufeld: So what kind of engineering did you do?

Dannenberg: Well, of course for the first few years we take basic engineering, and only the last few years I then concentrated on combustion engineering for diesel engines and I was even after I had graduated for about a year, maybe two years, an assistant to a Professor Neumann at Hanover. He was running the Verbrennungskraftmaschineninstitut and I was an assistant to him, and that was already just before the war. That was in '38.

Neufeld: Okay, so, just to pin this down, you went back in '33 and when did you finish?

Dannenberg: '36 or '37. Probably '36. And then I stayed for a good year, a year and a half, in the Institut as an assistant to Neumann, and my specific task there, with a group of students with whom I worked, was to convert one of our old automobiles, we had a 1905 Daimler, not Daimler-Benz, just Daimler, Mr. Daimler still did his own work at that time, and we converted that to Fluessiggas, to propane gas.

Neufeld: Okay, a liquid gas.

Dannenberg: Yes. We have gas, relatively small oil wells close to Hanover in Nienburg, and besides the oil we also recovered some natural gas. There was a factory which made on the one side gasoline from the oil, and also from the byproducts they got some propane and filled it in propane bottles. And it became clear already that we wouldn't have enough gasoline during the war, so there was quite a drive on from the Hitler regime at that time to go into these fields. And that's what we did. Well, I worked on it until the project was finished, and then I left and went to the VDO, as I mentioned earlier, the VDO outfit.

Neufeld: That was in Hanover?

Dannenberg: That was in early '39. I left Hanover in early '39 and went for about half a year to the VDO, so I was not there very long. Then the war started.

Neufeld: Where was the VDO located?

Dannenberg: It was at Frankfurt, Frankfurt am Main.

Neufeld: Okay.

Dannenberg: And when the war started, I was soon drafted into the army because I was serving in military reserve duty, and of course all these people were immediately called, and that must have been late August of '39. And from then on I was for about a year in the army, and then early next summer, I finally got my transfer to Peenemünde.

Neufeld: Did you serve in the campaign in '39 and '40?

Dannenberg: We walked on foot through all of France. We started way down south, south of Strasbourg even at the Swiss border really, and then we walked behind the Maginot Line almost all the way to Dunkirk. But Dunkirk had fallen, or the Allied forces had gone back over the Channel, so we never made it all the way to Dunkirk. But we stopped in there and turned around and walked all the way back again to Strasbourg, and in Strasbourg we then finally went back over the Rhine and we were stationed in Freiburg, Baden.

Neufeld: So you would have been transferred just after the successful conclusion of the French campaign.

Dannenberg: Right. Right after that.

Neufeld: The French and Low Countries campaign.

Dannenberg: Right. And my company later on was transferred to Russia, but I never went to Russia. Before that happened I got out of the army. I worked for a little while, just a few months, for the VDO again, and then I got "dienstverpflichtet". You probably have heard the term "dienstverpflichtet" already. Peenemünde really called me. That's why I said it was easy. Peenemünde had fairly good priority at that time, so they could call on people they knew were interested in that field, and so it was really called "dienstverpflichtet" to Peenemünde.

Neufeld: Now, I guess that raises the question, I guess I should get this straight. As far as Pullenberg was concerned, he wrote to you before?

Dannenberg: We had continuing correspondence. I knew him quite well. His dad worked also for the postoffice, so our dads were fairly closely acquainted, and due to that connection, I had also correspondence with him, not very frequently, maybe for Christmas and Easter or so, but we stayed in contact, and that way I found out about the activities in Peenemünde.

Neufeld: When did you sort of figure out what was going on, that there was something going on?

Dannenberg: That was after I had heard about it, I seem to recall, on my first visit, and had to introduce myself. I met Walter Thiel at that time. He was the number two man after von Braun. Before the bomb raid. He was killed in the bomb raid. And he apparently was interested and he then "dienstverpflichtet" me. He then called me to Peenemünde.

Neufeld: So you went and visited the first time, then you'd gone away again?

Dannenberg: I think I went home again, and then I finally got my final assignment. And of course at that time when I was up there, then I learned basically what they were doing.

Neufeld: In the past all you had known was that Pullenberg was doing something probably regarding rockets.

Dannenberg: Right.

Neufeld: You didn't know what.

Dannenberg: Right.

Neufeld: Did you even know approximately where he was or was that secret too?

Dannenberg: No. No, I had lost contact with him until he wrote to me again and announced that this kind of work was going on there, interesting work for me was going on there.

Neufeld: That would have been about 1940 already?

Dannenberg: That probably was early in 1940.

Neufeld: So you got called in, through that connection and through your going up there immediately, you got called to Peenemünde?

Dannenberg: Right.

Neufeld: In late 1940?

Dannenberg: No, that was early summer of 1940. So I would say June, July, relatively early in summer.

Neufeld: Okay, that would have been almost at the very end of the campaign then, right?

Dannenberg: The French campaign, was it not in '38?

Neufeld: No, the French campaign was just over in June, 1940.

Dannenberg: June, 1940. Then it was just after the end of the French campaign.

Neufeld: Okay, so you probably went just after you got back from that campaign.

Dannenberg: Right.

Neufeld: You got called into, you were probably assigned to the Versuchskommando Nord.

Dannenberg: I guess so, yes.

Neufeld: Do you remember the name of that?

Dannenberg: Yes, Versuchskommando Nord was really a military unit. It was not in existence at the time when I got up there. The military people were only assigned to Peenemünde in '42 or so. So in '40 it was strictly, there were some army people, Dornberger was there and a few other captains with him, but the main work force was really civilians, like I, "dienstverpflichtet".

Neufeld: So you were not then assigned as an army person?

Dannenberg: No, I had left the army. I was a civilian.

Neufeld: So you were back on reserve.

Dannenberg: Right.

Neufeld: Back on army reserve and you were dienstverpflichtet, sent to Peenemünde, then in the summer of '40. I want to get this straight. See, I'm not even sure about Versuchskommando Nord, when it started, when it existed.

Dannenberg: It must have been two years or so later. At that time Hitler had declared a case, as we called it in those days, of high priority, and then we could go on army personnel, and there was even an order out to the army to assign all technically qualified people to Peenemünde. But that happened only later. That was at the time after the A-4 had been declared again of high priority. You probably have heard already, at some time it was on, then it was off again, then it was on again, so that kept on changing. And in the beginning it was strictly an army project. The party had nothing to do with it. It was strictly run by the army. And that's why of course initially we got army people. Later on we also got local air force people, after the air force was also involved with the Wasserfall activity. But in the early years it was strictly army activity, and as I said, at the time when I got there, it was strictly a civilian activity.

Neufeld: You didn't see the army officers? Of course there was an old group of people from Heereswaffenant who had come through Dornberger, Zanssen.

Dannenberg: A few of them were there, but a relatively small group, and it was the managerial work. They administered the whole organization. They were not technical people. I would even say Dornberger was probably the only technical man. You probably know he had an engineering degree.

Neufeld: Yes. I think Zanssen was an engineer as well.

Dannenberg: Zanssen could have been one too. Yes. But all the others were regular army officers, so they didn't really participate in the development as such. They administered.

Neufeld: They were basically in base commander offices and at that level?

Dannenberg: Hm mm.

Neufeld: So you were then taken into Thiel's group?

Dannenberg: Right.

Neufeld: He must have actually just come from Kummersdorf not very long before.

Dannenberg: Yes, he was very new, I seem to recall. And probably that's why he was interested in hiring different people. That's why he was interested in me to come up and talk to him, and I told him I had a certain background in combustion engineering, and he was looking for people like that. And for that reason, of course he took me. After I was up there I was out right away on the job to develop the injection units for the A-4 engine. You probably have seen it, the way we have up there. We have 18 individual elements, Toepfe as we called it, that initially mix the propellants, and then of course 18 elements mix again in the main chamber. And my first job was to work on these individual elements. And for that purpose, we even had a smaller engine, a 1.4 ton engine, each and every one of these elements has 1.4 ton thrust and we did the basic, the initial research on the smaller unit. The 1.4 ton unit. I also worked on the 1 ton unit which was strapped to airplanes, the JATO, Jet Assisted Take Off.

Neufeld: The Starthilfe.

Dannenberg: Yes. And that was a very similar unit. It had also somewhat conical head, and a combustion chamber about that long.

Neufeld: About a foot long?

Dannenberg: Yes. And then another rocket throat area which gave us a lot of problems, so I spent quite some time on solving all these burn-through problems, and they normally burn through in the throat area where you have of course a very high velocity and fairly high temperatures.

Neufeld: Let me tackle these things one at a time. When you came to Starthilfe, and of course this is one of the things I have to figure out, the Starthilfe project, the JATO project, that was still going, wasn't it?

Dannenberg: Right. Right.

Neufeld: That was just at the end of development, or you still had problems?

Dannenberg: We have already built the ready units and they were being used. They were being flown. For some reason or other, I never really quite understood why, maybe the reason was these units were developed by the army, and they were then turned over to the air force, and the air force apparently wasn't too impressed with them. So they really, I think to my knowledge, never got put into major operational use. Some of them were used. There were certainly some demonstration flights, some of which I saw.

Neufeld: At Peenemünde?

Dannenberg: At Peenemünde-West, yes.

Neufeld: The test at Peenemünde-West was certainly later than when you got there?

Dannenberg: Right, they were later, after the units had been more or less developed.

Neufeld: So that would have been later in 1940, probably?

Dannenberg: Later, '40, and possibly even '41. Possibly even into '42.

Neufeld: I know that they decided to go over to a hydrogen peroxide one that was developed by Walter--they had other developments.

Dannenberg: I hadn't even thought of that. You have a point there. They are simpler. They are not quite as efficient, but you drop them anyway, also if they are a little bit heavier, it is not always critical.

Neufeld: Yours was based on liquid oxygen?

Dannenberg: Liquid oxygen and gasoline.

Neufeld: And gasoline. Not alcohol?

Dannenberg: To my knowledge, not alcohol.

Neufeld: So it was liquid oxygen and gasoline. Of course that meant handling a cryogenic fluid in the field.

Dannenberg: And that's of course pretty tough as you realize.

Neufeld: So it had its disadvantages, but as you say, it may also have been army versus Luftwaffe. But when you came, that one ton engine was still having problems.

Dannenberg: Both of them, major problems, one ton for the Starthilfe, and also the 1.4 ton unit, and one of the major problems was really the efficiency, the combustion quality was just not there. And my main job was to find out how to improve the injection system. I don't know how well you know the design. There were fuel nozzles all around, I think four rows of fuel nozzles, and some of them injected directly, some others atomized the fuel, and generated fuel mist, and we shuffled these around quite a bit, and we finally came to a design where lots of these holes could just be drilled into the wall. So there were just straight holes and we had only a few nozzles which atomized the fuel to improve, to quicken up the combustion, and it worked fairly, pretty well. Also when we finally put all these elements together, due to the additional mixing, apparently the combustion quality was pretty good when you used the whole, the larger system. There, you have the picture.

Neufeld: Yes. This is from Gerhardt Reisig's article series, and of course you know he has a fairly detailed discussion of the propulsion issues in there. So there were still more refinements needed on that basic injector head?

Dannenberg: Right, yes.(crosstalk) And also the LOX injection. You probably know the LOX nozzle in the center of the unit, and there's only one LOX unit to keep it simple, and that also--that had only straight holes in it, and the straight holes sprayed and they were supposed to spray over the entire unit so that you had LOX droplets right next to each and every fuel droplet.

Neufeld: I remember that from the pictures. There was like a little dome in the center.

Dannenberg: Right.

Neufeld: The dome was where the LOX was injected.

Dannenberg: Right.

Neufeld: So you just drilled straight holes there, you didn't try to build special nozzle holes?

Dannenberg: Yes. But the holes were at a specific angle, therefore it's not a straight sphere. It had some steps in it, so that the holes could be easily drilled at a 90 degree angle.

Neufeld: Okay, so as far as--

Dannenberg: That was one of my first tasks. We developed the

LOX injection system and the fuel system.

Neufeld: How did you proceed in the test process doing that?

Dannenberg: Purely experimentally.

Neufeld: You just tried something different each time that you did it.

Dannenberg: Right. Right. We worked with the University of Dresden, and they were specialists in fuel injection, and they consulted with us and they made recommendations for new designs and things like that, so it was not only my doing and my experimenting, but we had some scientific help really.

Neufeld: Was that the institute of Professor Wewerka or was there somebody else?

Dannenberg: No, Wewerka was turbo pumps, and I don't offhand even recall who was the head there. I don't think it was Wewerka.

Neufeld: Yes, I have some documents regarding Dresden, but I don't have them with me so I don't remember who was who. I know that there was a whole group of people there.

Dannenberg: Yes. We had Kuettner there, who was quite active and spent a lot of time at Peenemünde but was basically stationed in Dresden. We had Lindenberg there. I saw Lindenberg's name. He was the very first one to die in this country in Fort Bliss and he was permanently stationed in Peenemünde. So he did practically all his work there, and again he helped in all these design activities.

Neufeld: Officially, though, he remained at least for a while an employee of the Techische Hochschule Dresden?

Dannenberg: I think he did. I think he did, yes.

Neufeld: He officially worked in the institute at Dresden even though he was there. The other guy was Kuettner.

Dannenberg: Yes.

Neufeld: Were they involved from the beginning when you were there?

Dannenberg: Yes. They certainly were relatively early, relatively soon involved. I don't know if they were there ahead of me. Again, Thiel had all these contacts, and he invited these people, he came in contact with these people, and it must have been around the time when I got there.

Neufeld: Right. I've seen the documents that indicate that in September of '39 they brought Dresden in. In fact another folder, I don't think this one, I have the document that indicates a discussion at Kummersdorf between Thiel and a number of people from Dresden.

Dannenberg: Yes, Thiel was really the one who had these connections. I'm sure he also contracted or he provided the basic list for the contract and they probably had contracting people directly write the contract. And you probably know, he worked of course quite extensively with universities. Universities and also private industry.

Neufeld: I think that at the university angle there needs to be a lot more done with that than there has been. I think that's a whole area of research that nobody has--you know, every book states there was some university work. But it's one of the things I want to cover.

Dannenberg: And they wrote a lot of contracts. There may have even been some contracts in your stack there, that were written by Dresden, reports on injection, what kind of designs to use, what kinds of designs were successful. And I also started at that time, while I was still in the university, I started to use a lot of NACA reports, you know, before NASA we had NACA, and I read quite a number of the reports written by Mr. something, Rothstein, Rothenberg, something like that, and he did these reports for either Langley or--

Neufeld: --Ames?

Dannenberg: Ames. No, I don't think it was Ames.

Neufeld: Lewis?

Dannenberg: Lewis. I think he was working with or for Lewis.

Neufeld: This would have been on combustion?

Dannenberg: It was on jet engines, yes jet engine injection. And he also studied what we have to do in order to really have good efficient combustion.

Neufeld: You're sure it wasn't piston engine combustion?

Dannenberg: Could have been piston engine combustion. He did only injection studies, and then he put a piece of paper under it and he measured, where do you get most of your fuel? Then he tried to improve it to have an even distribution over the whole piece of paper. So he made some very basic studies, and I read quite a number of his reports, and of course I drew my conclusions from these reports and tried to implement some of his

ideas.

Neufeld: So there really was an influence from earlier aircraft engine--

Dannenberg: (crosstalk) --We had fair information. I think I mentioned, I knew Goddard's book. I had that. And we apparently, maybe through universities, we also could get these reports. Well, as I said, I was still in Hanover when I got hold of these reports, and of course universities have pretty good libraries that contain all these reports. And I finally even met that guy in one of the earlier meetings here.

Neufeld: Really?

Dannenberg: yes. He was also pleased in a way that his work was not only being used here but even over there.

Neufeld: OK. Thiel, I haven't asked you yet to describe him. What was he like as a person?

Dannenberg: He was also a very dynamic man. He was a little bit like von Braun. He was not quite as much interested in general publicity. He was more strictly engineering oriented. And I think he was an excellent engineer. I think really most of the credit for the V-2 engine should go to him. And the engine was more or less in existence when I came up there. It didn't work. We had to make it work, but the basic design was there. The combusion chamber was there. I think he was the one who came up with the idea of a turbo pump. And he worked with Wewerka. And that was space in the turbo pump area. He was the one who conceived the steam plant in order to drive the turbine. And we worked with Walter. We got our hydrogen peroxide from Walter. And so Thiel should really get an awful lot of credit for that, and of course since he died during the bomb raid on Peenemünde, he is normally not mentioned too much.

Neufeld: Yes. I guess actually Reisig agrees with you, because this article also emphasizes Thiel's role. Maybe I should leave the diagram out.

Dannenberg: Yes. I think that really was the biggest loss for Peenemünde when he died, when he was not there any more. And he was working already on a Mischduese, an improved version of the rocket chamber injection system, which is pretty close to the Redstone engine. He was working already on these designs, and I think the Redstone engine was finally built this way by North American Rockwell because Riedel, again from the University of Berlin who worked with us in Peenemünde, he finally went, he was finally hired by North American Rockwell, and so he knew about all these ideas and he then implemented them. We tried to do it in Peenemünde, but we had considerable combustion instability

problems, so the combustion, you probably heard about combustion instability.

Neufeld: Right.

Dannenberg: And we never got over that until we finally decided to use this engine. If Thiel would have been there, I personally would guess that he might have succeeded in switching to the much simpler Mischduese injection system.

Neufeld: Yes, there are a lot of details that I want to get out of that, all that you've just said. So you came in and you worked on the Starthilfe motor, and probably by 1941 some time you had solved the problems with getting that to work without having burn-throughs, right?

Dannenberg: Right.

Neufeld: And combustion instabilities. And you were also at the beginning working on this 1.4 ton thrust?

Dannenberg: Right, and actually these works went on in parallel. We had two different test stands. The one-ton was tested on one test stand, the 1.4 unit on another test stand, and so we could do the work parallel.

Neufeld: Is the 1.4 ton the same motor that you used in A-3 and A-5?

Dannenberg: It's actually this unit here, this head unit, and it was strictly a test motor so it was only used for testing. It had no project application.

Neufeld: Okay, so the A-5 motor was something that stemmed from an earlier design?

Dannenberg: That was an earlier design.

Neufeld: Fine, okay, that's right, that was this design, here.

Dannenberg: Right. (crosstalk) Right, and this had a very long combustion chamber, again probably people didn't atomize their propellants well enough, so you needed some time for them to react. If you have a good reaction you can do it with a very short chamber.

Neufeld: So yes, according to this description from Gerhard Reisig, in that motor you had the problem of the very great length meant that you ended up getting combustion instability in there. You'd have good burning in one part, good mixing and burning in one part of it, and you'd get waves, standing waves

set up, in which you had high--(crosstalk)

Dannenberg: Yes, and I never had anything to do with that motor. It was as far as I know designed and built already in Kummersdorf. It was tested finally in Peenemünde in the A-5 of course. So when I got into the act, we only worked on the A-4.

Neufeld: So that the first thing you saw was the first thing that you were working on was the 1.4. I also know that you had experimented with the intermediate size 4.2 which had three injectors--

Dannenberg: --Right, 4.2, three systems, in order to get some pre-mixing, and the 4.2 ton unit had therefore very better exhaust velocity. We used exhaust velocity. In this country you use isp. Which is basically the same. A different dimension, but--

Neufeld: Right. When you came in do you remember whether, in the middle of '40, there had already been work on the 4.2 motor?

Dannenberg: (crosstalk) ...Also pretty soon after we had solved the problems on the 1.4 ton, or whenever we had a good design which we thought was a good design, we introduced it automatically in the 4.2 ton unit, and again we had a separate test stand for that, so we could do all this work in parallel.

Neufeld: As far as you remember, the 4.2 existed already?

Dannenberg: (crosstalk) I did not do the design of the chamber. So it must have existed. And even this chamber here existed already when I came to Peenemünde.

Neufeld: So you'd already seen, it wasn't just a drawing board concept, the eighteen--

Dannenberg: It had been built already. It had been built. As I said earlier, it didn't always work. In fact, in most of the cases it didn't work, it blew up.

Neufeld: Do you know whether it was only tested at Peenemünde or at Kummersdorf?

Dannenberg: I don't think this was tested in Kummersdorf. It's a pretty large engine and needed a relatively big test stand for it. We had these big test stands only in Peenemünde. That's why they went to Peenemünde, to be able to build these big facilities, also to launch from there. So I don't think that was ever tested in Kummersdorf.

Neufeld: All right, I think you're right, because they didn't

have a test stand of sufficient size to test the 25 ton motor. So when you first worked with the 25 ton motor, when was that? Was that months after you got there?

Dannenberg: Well, it was a little bit after I got there. I would say late '41, '42. It may have been a little earlier. Let's say '41.

Neufeld: That's when the 25 ton motor was really put together and first actually tested. As far as you know, the drawing board concept of putting 18 injectors together was already--that was already in existence?

Dannenberg: That was in existence. Right, and there was nothing much I could do. I could only work on the details, the injection detail, the mixing detail, and of course we still made a lot of changes. You may have also seen on the engine we have out at the rocket center, we had to introduce a lot of additional cooling, FM cooling we called it, because basically it was done for the throat area. We called the throat area FM, FM for Flaecheminimum, and in order to prevent burn throughs here we injected extra fuel just on top over the FM area, and later on we found out we also had to introduce additional fuel in all these other things. So that detail of the design was not there. That's what I had to develop in order to make it work. But the basic principle was in existence.

TAPE 1, SIDE 2

Dannenberg: I think we were talking about injection systems, about the V-2 engine, and you just asked, that was in existence when I got to Peenemünde?

Neufeld: Right.

Dannenberg: So I did not participate in the basic design.

Neufeld: Of the 25-ton?

Dannenberg: Right.

Neufeld: A-4 motor. So that the first ones were built after you got there probably, is that right, as you recall?

Dannenberg: Or maybe at about the time that I got there. It takes some time to build these things. They are relatively complicated. And they ran the shop already. The fuel injection nozzles could be exchanged, and all the combustion chambers had all the nozzles exchangeable. Later on, as I mentioned earlier, we found greater means that some of them are just straight holes through the wall. But in the beginning, all the nozzles, all the four rows of holes were exchangeable, so you could make changes

after you had built the whole thing. Then you put the proper nozzles in; besides the fuel, the LOX injectors would also be exchanged.

Neufeld: So that you might use the same basic designs--assuming you didn't have a burn-through or some other kind of accident, you'd use the same combustion chamber repeatedly?

Dannenberg: Right.

Neufeld: By changing the injectors?

Dannenberg: Right.

Neufeld: Over and over again repeatedly on tests?

Dannenberg: Yes. And of course, if we had burn-through, as I said, really as an afterthought we introduced this extra internal cooling, just injecting some fuel, assuming it wouldn't burn, and then of course it has a film there of unburned fuel which cools your wall. Every once in a while, one of the LOX injection jets still got through the whole combustion chamber and hit the wall, so every once in a while we still had, even after this introduction, a burn-through.

Neufeld: What did you do about that problem?

Dannenberg: Well, either introduce a little bit more fuel, cool it a little bit more, which of course costs performance, so you have to be very careful how far you can go--and also of course you had to be sure that this just didn't happen. And I think in the early production, where we didn't have real production tools, where all these holes were drilled by hand, so to speak, you could, every once in a while have a chance that one hole was drilled on the wrong angle, and that, in that case, the fuel really got all the way to the wall of the chamber, and apparently once that happened you had a burn-through at that place.

Neufeld: Where you had an excess oxygen concentration.

Dannenberg: Yes.

Neufeld: Along the wall, that's where you tended to get the burn-throughs.

Dannenberg: Yes.

Neufeld: So the idea of--I guess it's been called film-cooling --

Dannenberg: Right.

Neufeld: --Came up after you got there?

Dannenberg: Right. As far as I know, it came up fairly late. And I don't want to claim it was my invention. With this whole team of universities, other people working on it, we finally introduced this as a necessity.

Neufeld: Was it introduced on, so you introduced that idea first on the smaller motors, do you remember?

Dannenberg: No, I don't really recall. We may have had it on the 1.4 ton. We definitely did not have it on the one ton. The 1.4 ton may have had it, and likely the 4.2 ton, probably one of these extra injection rings, because we know we tried these things first on the smaller engines. You can build them faster, and if you lose them, the loss is not quite as great as losing one of these here.

Neufeld: Right. So at the beginning, what you did was, you drilled a series of holes along the inside of the combustion chamber above the throat?

Dannenberg: Right. So of course we needed an extra high pressure chamber. So we had to go through the cooling jacket, and for cooling of course you had to have some holes drilled this way, and then the other small holes for the film cooling, as you called it, which is the proper term, we had small holes drilled in this direction. And of course you had to watch that the holes didn't interfere with each other. If that happened you were also in trouble.

Neufeld: Okay. I'm not quite sure what you mean by the other holes on the outside. I know that at six points around the bottom of the nozzle--

Dannenberg: --Right--

Neufeld: --You had the injection of the fuel into the cooling jacket.

Dannenberg: Right. Not into the cooling jacket. The cooling jacket has to let the fuel go through in this direction. That's why you need one set of holes. One set of holes in this direction. To cool the inside of the chamber you had to have holes in this direction, small holes, that was a relatively small amount, only very small percentage.

Neufeld: Okay, so these are drilled from the inside of the engine into the cooling jacket?

Dannenberg: No, no, not the cooling jacket. That's why we had these manifolds on the outside. They were little tubes on the

outside and they have a higher pressure--well, not necessarily a higher pressure, but they are independent of the cooling jacket.

Neufeld: So that the film cooling is not leaking fuel out of the cooling jacket then.

Dannenberg: It does not get the fuel out of the cooling jacket. It was an extra supply and that's why you had this manifold going all the way around. From that manifold there you had to drill your holes this way, to get the fuel into the inside of the chamber.

Neufeld: Drill the holes from the inside?

Dannenberg: No, they would really do it from the outside. It would be awfully tough to go inside the chamber, although you could get into the chamber. The A-4 chamber was relatively large. You could easily, and I was thinner in those days, I could easily get with my whole head in this area here, so we could inspect the nozzles.

Neufeld: Okay, so they would be drilled from the outside?

Dannenberg: From the outside.

Neufeld: Before the external wall was put on?

Dannenberg: Well, that was all really just one manufacturing process. So you took one ring. And you drilled your holes through that ring in this way. For film cooling. But you also needed holes going through in this direction so that the cooling flow did not get interrupted. And of course you welded the internal cooling jacket, the internal piece of metal which formed the cooling jacket and the outside piece of metal, you welded it also to the thing. Maybe we should make a little sketch. Let me draw one side of the cooling jacket. In order to permit the flow, and this is the internal wall, and there was an outside wall, and let me show that, just this one line, although of course it also had a specific thickness. Well, now I have two lines after all. And in order to permit the inside cooling, we had to cut the combustion chamber open and we had to weld a ring of metal in there, so these here are the welding seams now, and we had to weld a ring of metal in there that had on the one side holes drilled through here, so that the fuel could pass through, through that ring piece, through that very piece. And then we also had to drill small holes here, in this direction, and then there was another welded chamber so to speak which was supplied with fuel, and I don't recall right now where the pressure was really higher. We could influence the amount of flow that went through these film cooling holes by putting at the part where you have your line, by putting a Blende, we called it, a little

orifice in, an orifice which had again a relatively small hole in the orifice, and by changing the hole you could influence the flow, the amount of fuel that went to the inside.

Neufeld: You called it a Blende?

Dannenberg: Blende.

Neufeld: Okay. This is--

Dannenberg: That's the German word for it, yes.

Neufeld: Is this the outside wall here?

Dannenberg: This here is the combustion chamber.

Neufeld: Okay.

Dannenberg: Here you have the combustion going on. And of course, this wall here was relatively thick.

Neufeld: The inside wall?

Dannenberg: For structural reasons this wall was a little bit thicker, because this wall has not only to take the pressure but also the temperature, so that it gets hot, and seeing there's less rigidity once it's hot, this wall can for that reason be somewhat thicker. The outside wall is also still relatively thick and relatively heavy. And--now I forgot what I wanted to say.

Neufeld: You were talking about how the cooling flow, the problem that you have with the cooling flow on the one hand and then you have the injection of the film cooling on the other.

Dannenberg: Right. You could influence the amount of cooling you got by putting these little orifices here in the supply line. And that was another thing we basically did by experimentation. We really didn't make too many high level calculations. Of course you could calculate the amount of fuel you get through there. But it was really an experimental process, to use smaller and smaller orifices, in order to bring up the performance.

Neufeld: Okay. So this film cooling, you had these ridges around the outside, of the 25 ton motor, was that where the alcohol circulated for the cooling?

Dannenberg: Not necessarily, not necessarily all of them. Some of them (about half of them, I would say, roughly) had the following purpose: This relatively thick wall on the inside becomes hot and has an average temperature of around 1000 degrees farenheight. And that of course means it expands, it becomes

longer. And when the engine is firing it's about half an inch longer than when it's cool, if it's not burning. In order to take care of that expansion, we also at some places had to interrupt the outer shell, and we did it on the outside only, not on the inside. So there was a gap here, and then we also had to, in order to close the gap, to weld another thing, which looks almost like this one here, to it; and due to its structural flexibility, it permitted you to take short and small amounts of expansion. And since you couldn't handle the entire expansion with just one of these, we had several of those, and I don't remember any more how many. You would probably have to go out to the engine and look at it. But some of them were just expansion joints, expansion folds, and some others injected the fuel to the inside.

Neufeld: Where you had injection of fuel, was that accommodated into the expansion joints? Or were they two separate--?

Dannenberg: --They were two separate things. That's why we have so many of them; and they were set, the other four, for film cooling injection, only roughly about half of them.

Neufeld: In this picture in Reisig's article, page 46, you see this small tube that's going down the side of the engine. Is that for the separate alcohol supply, for film cooling, or was that something else altogether?

Dannenberg: It's one of the lines for the film cooling. In order to supply these extra lines here, we had a line going all the way down to the lower one. It doesn't go all the way down, it goes down to about here, and maybe there's even some film cooling injection for the lower uncooled part to keep that from burning through. And these lines supply these film cooling, supply manifolds.

Neufeld: So that you had a separate piping system?

Dannenberg: Right.

Neufeld: Film cooling, it went back up to the fuel line above the engine?

Dannenberg: And just see, they are connected up here, and since up here your pressure is of course always a little bit more than down here, the pressure in these cooling supply lines was lower than the pressure in the cooling jacket. And you didn't want to tap directly into the cooling jacket, which you probably could have done, but you had two disadvantages. First, you normally filled your chamber before you started your test, and your fuel would have seeped out. Your fuel would not have stayed in the jacket. That's why you needed these, so you could close them, so that you had no fuel loss, and also, by doing it this way, the

more complicated way, you could control the amount of flow. If otherwise you have direct holes, you have no control over the flow any more.

Neufeld: Right.

Dannenberg: The flow is completely determined by the size of your holes.

Neufeld: So this way you could experiment with different amounts of fuel flow?

Dannenberg: Right, right. And what we normally tried to do is to reduce it, so that was one of the purposes of the early development tests, to use as little film cooling as possible, without getting burn-throughs.

Neufeld: The fuel, I mean, what's the disadvantage of it? You're losing alcohol without burning it?

Dannenberg: Right. You lose high speed. You lose efficiency.

Neufeld: Do you reduce the exhaust velocity a little bit, injecting this cooling alcohol?

Dannenberg: --Right, you have a lower exhaust velocity. You have a lower speed and are left with a lower exhaust velocity. And the exhaust velocity of course determines your thrust, so you don't get all the thrust you would like to have.

Neufeld: Okay, so this was forced by the cooling problem on you?

Dannenberg: Right.

Neufeld: In order to prevent the burn-through?

Dannenberg: Right, and of course the burn-through is catastrophic. Once you have a burn-through, you have had it. If you lose a little bit in efficiency, maybe you cannot quite make your range. But there were many short-range firings, and for those you could still use the engine. So it's not catastrophic.

Neufeld: This gets out of chronological order, but was that limited essentially to the A-4 generation of motors that you worked on, the film cooling? Did you get rid of that?

Dannenberg: We don't have it today any more, but today you probably know we have these very thin fine cooling tubes. They cool much better. They don't have the problem of expansion because they stay relatively cool. They have normally more or less the temperature of the coolant. And that's also why we can

fire the Space Shuttle main engine up to 50 times now, we hope eventually to do it. With these engines you couldn't do it. Due to all these problems they wore out pretty quick. And I would say normally you could make three, four tests, but after that the engine was no good any more.

Neufeld: The expansion and contraction of the nozzle?

Dannenberg: Right.

Neufeld: Creates metal strain, metal fatigue and so forth. So did you use the film cooling in Redstone?

Dannenberg: Well, you ask me too much there. I would have to look at the engine. It is possible that we still used it, but a better mixing nozzle, where you don't have much concentration of LOX at one place might solve the problem. So I think that was to a high degree the problem with the V-2 engine.

Neufeld: I guess another problem, there's nothing can be done about it in the short run, is the development of exotic materials. You had to use steel basically--

Dannenberg: Well, of course at Peenemünde, there was no choice at all. We had to depend even on relatively low quality steel. It was not stainless like people use only today for rocket engines.

Neufeld: Of course with the material engines you had to make sure to provide an engine that could be--

Dannenberg: --That could be built.

Neufeld: Given the materials that you could get from the war economy. Okay, so that you were testing this 18 head injecting motor from, I would say, '41, got reasonable performance out of it by when? Any recollection?

Dannenberg: Well, we were still working on improvements when the engine was being used already, so I would say, the later V-2's had a somewhat better performance than the early ones, because again we had a lot of flexibility. We had to change the film cooling flow, that improves the performance, to change the injection system, and I think almost to the last moment where you finally went into mass production. Once we were in mass production, there were no changes of that type any more. Then the people took it. And I would say the mass production was finally all up in late '43, and so from then on you couldn't make changes of this nature, just to improve the performance. We still had many changes, and some people even complained we had too many, when you had real critical conditions.

Neufeld: Did you also have the problem that materials would suddenly disappear

Dannenberg: Right, you couldn't get it any more.

Neufeld: You had to make it an entirely different way?

Dannenberg: Yes. We were short on aluminum, so we were working on fuel tanks basically made from paperboard. Paperboard a little bit more like the milk cartons we use today. So relatively solid saturated paper with wax in it or something like that, pretty much like the milk cartons we use today. And again the main reason was, we just couldn't get enough aluminum. We did need aluminum for the LOX tanks so there was no plan to replace that. But we were seriously working on replacing the fuel tanks, although I think it was never done. We just did some research and development tests.

Neufeld: The LOX tanks had to be aluminum for reasons of interaction?

Dannenberg: For numerous reasons. Steel becomes so brittle, it just cannot stand the vibrations during burning, and contain the very cold liquid oxygen. So we had to go to aluminum for that, and that's why we also have a separate, you probably know, the V-2 has a separate outer shell. That has to be from steel because it gets awfully hot during re-entry. You couldn't use aluminum there. But the fuel tank, the LOX tank had to be aluminum because otherwise with our existing steels, we didn't have any steel that would take these very cold temperatures.

Neufeld: And the fuel tank, the alcohol tank?

Dannenberg: That was initially built also from aluminum. Then the aluminum supply became short. Then we were asked to work on alternate methods. And steel was also relatively short. Yes, steel was kind of ruled out also. We could have used steel. That would not have been too difficult.

Neufeld: You could have built a steel fuel tank?

Dannenberg: Yes.

Neufeld: But earlier on you had determined to build these things in aluminum.

Dannenberg: Hm mm.

Neufeld: Now, before I got to these other injector versions, you --I've forgotten what my question was now. Let me ask you about the injector. You mentioned before of course that you worked on other injectors, alternative engines, to replace this system

which was kind of complicated to make, a difficult problem to make. And I've seen in these documents a number of references. There's two main ones. There's one called Ringspaltmischduese, which was something that some guy in Berlin, Beck, I think?

Dannenberg: Beck, yes, he was a professor, the leading professor in Berlin.

Neufeld: And the other one was called a Bohrungsmischduese. And in the one report from Lindenberg he mentions you and him as the main workers on this other concept, so can you describe those different injectors?

Dannenberg: Well, the Spaltmischduese is just a different kind of injection. You use, you know what a spalt is, I guess? Ring slot, very thin ring slot that goes all the way around, and you save the work of drilling. Of course you need very highly accurate manufacturing methods. Your ring slot should have the same dimension all the way around, and that's one of the problems. And of course it's also much more difficult to change it, if you find out you don't have the right ring slot, you practically have to throw all your hardware away and start from scratch again. If you just drill all your fuel and LOX injection holes, you can start with a relatively small hole. You find out it's not big enough, you can increase it. You can make it a little bit bigger. So you have a little bit more flexibility, and also, for the Bohrungsmischduese, we tried in many cases to oppose the jets to each other, either fuel against fuel, or also, and that's one thing that Lindenberg proposed quite a bit, to use one fuel and one LOX jet and to let them impinge, and atomize by impingement. So I think most of the people believed that the Bohrungsmischduese would be more flexible, would be simpler, could be--whereas the other one probably has the advantage that it could be manufactured easier. Once you know how to do it, it's probably easier, instead of the many, many little holes, you have to drill with very great accuracy, because again, like with the cooling system, you don't have only holes going through this way, in order to inject your fuel. To supply your fuel you also have to drill holes this way. And again you have to be darned sure that these holes don't meet each other. So you have really quite an accuracy problem.

Neufeld: Now, from this document here, from this archive report from Lindenberg in which you are mentioned, it seems like he is complaining somewhat about what he sees as the inadequacy of that system compared to ... Okay, so to make this on tape, we're talking about this archive report 39/14 which is Lindenberg's, almost a complaint, in August 1943, actually just before the air raid, a week or so before the first air raid. But you were working on, there was the Ringspaltmischduese, I think we said a little bit before, on tape, but that was a single gap, a single?

Dannenberg: No, there were a few gaps. But relatively few gaps compared with the large number of holes you would have to drill. So it really should have led to a drastic reduction in manufacturing time, and that was the main purpose, of course. And also many people felt even, we never would be able to produce this very complicated 18 ton unit. And maybe, you made the point that this happened just before the bomb raid on Peenemünde. Due to the bomb raid of course we had many other new problems. So finally all these improvements could not be introduced, so they never got into real existence for the production phase, but we did quite a number of tests, as he pointed out. But they never were used in the actual production so they were all built with these 18 elements, and after the people had learned how to build them, really we didn't have all that many difficulties. I was always amazed by that. You see, it's a very complicated design. And if you have to weld all these things together, it requires quite a bit of skill. And of course we didn't have too many skilled workers, but we somehow managed, and to my knowledge, we never had any real big basic difficulties with the welding design as such. But still, it requires a lot of work, a lot of labor, special equipment, special tools, and in order to simplify it, there was quite a drive on for quite some time, apparently up to the time of the bomb raid, in order to simplify the combustion chamber. That was really one of the major efforts, going on parallel to the actual production design. And there were these two competing mixing nozzle designs, and Lindenberg even mentions another design which I hadn't thought about for quite some time, to not use only one big mixing nozzle, which of course has the problem with drilling these long holes with great accuracy, so you might be better off with using smaller units where your holes are much shorter. You can really go into mass production, you build six times as many so you can really build good manufacturing equipment for that reason, but apparently that also had quite some difficulties, and I can see the difficulties in the vortex zones between these injection nozzles. While the regular nozzle which covers the whole area injects fuel at all the places, here you have some vortex zones where no fuel is being injected and you get burn-throughs at those places.

Neufeld: So--

Dannenberg: --So that design apparently was soon dropped. In fact, for that reason I probably haven't even thought about it any more, but I remember, we worked on such a design, and really, in spite of that memo there from Lindenberg, the main effort was really to use the Bohrungsmischduese. Also the later introduction of the Redstone used basically the Bohrungsmischduese.

Neufeld: You have that basic, what is now pretty much a standard injector plate.

Dannenberg: Right.

Neufeld: With the holes across the plate.

Dannenberg: And the funny thing is, Riedel, who went to NAA and who finally built and designed the Redstone engine, he worked with Beck, so he really should have been more in favor of the Spaltmischduese, but maybe after all the tests which had been done, he also concluded that the Spaltmischduese had its own problems.

Neufeld: Now, this Riedel is Riedel III?

Dannenberg: Riedel III, right.

Neufeld: The second Walter Riedel came later, not the one "Papa" who was there for so many years.

Dannenberg: Right.

Neufeld: Okay, so as far as you remember, this Professor Beck's Ringspaltmischduese was tested in '41, '42, '43, somewhere in there?

Dannenberg: Must have been that time, because they had already done some tests here in '43. And they probably were still continuing to do tests in '43. On the other hand, as I said, after the bomb raid of course, many of these advanced ideas had to be dropped. We had to concentrate on getting the drawings out, getting the tools leading into mass production, and as I said earlier already, there was a point where we, where all the designers were being told, no changes any more for mere improvement. Changes which have to be done, where you know something doesn't work, they can still be accomplished, but no changes in order just to improve the performance a little bit. So they were all ruled out, and that was probably in a way in that category.

Neufeld: Okay. As far as you remember, then, your other concept of having this, what was called at that time the Bohrungsmischduese, injector plate with bored holes in it, that was actually the favorite concept for a second generation A-4 motor?

Dannenberg: Right.

Neufeld: What problems did you have with it when you put it on the test stand?

Dannenberg: Well, particularly the combustion vibrations problem, the vibration problems I mentioned earlier, very heavy vibrations that sometimes even destroyed the whole combustion

chamber, and we never got completely over it. Finally for the Redstone injection nozzle, the problem was solved. I am not aware of major problems in that area. But in Peenemünde we just couldn't solve it.

Neufeld: What is the cause of that vibration? I gather from the Reisig article that the injector plate would actually flex in and out, due to fluctuations?

Dannenberg: Of course, but that's only the result of the vibrations. Once you have the vibrations, that probably is going to happen. The question is still, why do we have the vibrations? We found out from other similar tests, once you increase your injection pressure drop, of course you lose some pressure when you inject your fuel, and once you have a higher value, larger pressure loss, so to speak, you are better off. The vibrations are not quite as tough. On the other hand of course it makes it tough on your pump. Your pump has to generate more pressure in order to get your fuel through relatively small holes. And maybe that's even what finally was done for the Redstone, that they went to fairly large pressure drops. I don't recall right offhand, what the pressure drop is, and that may have solved the problem.

Neufeld: So you have a problem then with the capacity of your turbopump?

Dannenberg: Right.

Neufeld: Turbopumps to push out fuel and oxygen at a certain rate.

Dannenberg: Yes, not so much the rate as the pressure.

Neufeld: The pressure.

Dannenberg: To generate more pressure in order to get the same amount of flow through smaller holes, so to speak. On the other hand again, if it solves your problem, if it's the answer to your problem, you probably are willing to do it.

Neufeld: Was the answer partly in the long run to go to smaller holes? Injector holes?

Dannenberg: That, I recall, was one of the ways of getting rid at least of part, a proportion of these heavy vibrations.

Neufeld: Because I think there's a mention in this article perhaps that the noise created by those engine tests was so loud that it was heard all over Peenemünde.

Dannenberg: Right. It was screaming, as people normally

referred to it.

Neufeld: That was all due to the vibrations--

Dannenberg: --Right--

Neufeld: --And the vibrations are created by fluctuations in the chamber pressure?

Dannenberg: And you have less vibrations if you have a stronger pressure drop. If your pressure drop is only very small, then these vibrations can easily even go back into the injection holes, into your injection flow, and that's at least my interpretation why it works better at higher pressure drop levels.

Neufeld: Okay. Now, for Wasserfall, what injector did you use? Did you use a modification of that injector?

Dannenberg: As far as I know, they went finally to a Mischduese.

Neufeld: So did you perfect a smaller version of it?

Dannenberg: Right, right. On the other hand, of course, the Wasserfall was never mass produced. They flew a few test vehicles, and I'm sure they still had some problems. I was not too close to the Wasserfall so I don't know the details there too well.

Neufeld: So you were not directly involved in the propulsion plant development for Wasserfall?

Dannenberg: For Wasserfall, no, I was not. I was at that time in charge of getting the V-2 mass produced. I was Riedel's deputy, Walter Riedel's deputy, and he as head of research and development and in charge to get the drawings out, to get the drawings to the Mittelwerke for production, and that was really my main effort in the last one or two years, to get all the drawings established, to stop changes. We had a fairly tight change procedure so the people had to propose to the change board what they wanted to change, and if the change board turned it down the change was not made. On the other hand, as you pointed out, there were many changes that had to be made. We didn't get the material any more. That is one of the reasons that we finally drilled the holes in these injection elements. We couldn't get enough brass. These and others were built from brass. We just couldn't get enough, so we finally went to the method of just to drill the holes in the wall, which of course was also simpler so you also save labor.

Neufeld: How would you have done it with brass? Could you cast

the brass?

Dannenberg: We would basically cast and then they would have to be turned on a lathe, and then they were screwed into the wall, so the wall had to have instead of a round hole a thread in it, a thread for these little individual nozzles.

Neufeld: The injectors, you mean, each. So you had originally tried to cast them in bronze?

Dannenberg: Right.

Neufeld: With the holes--

Dannenberg: --All the early designs were for all the nozzles, bronze nozzles.

Neufeld: They were cast with the hole already without having to bore--

Dannenberg: --No, no, you still had to drill the hole. And you also had to turn them. They had to be fairly accurate. You couldn't in those days cast a thread. They had to have a thread in order to be threaded in. So that involved a lot of lathe labor.

Neufeld: Okay, so at what point in '43 did you really start working on the mass production of the 18 injector engine? Was that before the air raid some time?

Dannenberg: That was very much parallel to the air raid. That was about the time when it had been decided to mass produce the V-2's and von Braun objected to it, initially, as you may have heard from other people. He felt the V-2 was really not quite developed. We should have another year or so of extra development time. But he was overruled, and the army and the SS at that time, who already was in the process of taking over Peenemünde, they decided, regardless of all the problems we are going ahead and we are going to mass produce them. And that's when I was put in charge to really get all the drawings out, to get them delivered to the Mittelwerke, so that the people there could write their orders. See, the parts had to be ordered. They had not been manufactured. To deliver the parts, to finally assemble all these things, and finally get the complete V-2's out.

Neufeld: So as far as this mass production task was concerned, you, I know that Speer started to press very hard for mass production right at the beginning of '43.

Dannenberg: Hm mm.

Neufeld: This is after Hitler had signed an order for that. And so then, the Sonderauschuss A-4 came into the picture in the spring of '43, Degenkolb and Saur and Sawatzki and those people.

Dannenberg: And all these people of course cried for drawings, yes, that's why I was put in almost as a commissioner to get the drawings together, because of course these people could not go to all the individual designers and force them, so that was a task of the design office to really say, "This is it, this is what we think we should produce." That really took most of my time during '43 and '44, I would say.

Neufeld: Now, I know that some time about the middle of '42 is the very beginning of this process. Stahlknecht came from Speer's ministry.

Dannenberg: Right. Was he already with Speer? I didn't realize that.

Neufeld: I think he was delegated from Speer's ministry. He came in the middle of '42, as I recall, and they set up a--on one organization chart it's called Nachbau-Direktion, which I gather was an office for trying to get the production going.

Dannenberg: To get the production going, and they initially also wanted to do all our drawings over. They wanted to simplify everything and make it easier to be produced. But that failed. That failed very badly. And at that time Walter Riedel I got a bad name, because he was also in the Nachbau-Direktion and he was in charge of all these production drawings, but when they finally built the parts and tested them, they found out most of the parts don't work, so we finally went really back again to the R and D drawings, to the research and development drawings, not to the production drawings, which had been prepared by a separate group of people, and the separate group of people worked under Walter Riedel III.

Neufeld: Okay, so this is an important area. I hadn't gotten the information on exactly what happened with this whole thing.

Dannenberg: Probably Rees would be a real good man to talk to about that kind of thing. He was involved directly. He was von Braun's deputy, and he was really in charge of production. Production activities, in Peenemünde, and also in connection with the Mittelwerke.

Neufeld: Okay. Now, as far as these--

Dannenberg: --And Rees has an awfully sharp memory. He remembers dates and names and everything.

Neufeld: I'm supposed to talk to him tomorrow. I don't know if they realize how many hours this could be if I were to talk--

Dannenberg: --Don't make it too hard on him. Try to make it relatively short.

Neufeld: So I'm trying to straighten this out, and I know perhaps I have to ask other people to get more information. Stahlknecht came in, and they set up this Nachbau-Direktion in order to create the production drawings, basically, in order to be able to put it--

Dannenberg: --Production drawings, and also set up the production, so it was not only the drawings, but the tools you need. They started to hire the labor force. They brought all the extra people in. And they were leading to sort of a complete mass production. And it was intended to keep Peenemünde the source and develoment agency.

Neufeld: Because I know of course on top of that, you also had what was called the Versuchsserienwerk or the Fertigungsstelle Peenemünde. That's Arthur Rudolph's production facility that was going to be at Peenemünde South. So he, Stahlknecht's people were working with I assume with Rudolph and so forth, in this Versuchsserienwerk, and there of course they brought in the idea of getting other places like Zeppelin, Luftschiffbau Zeppelin to working on it, so their first task was to set up the production drawings. Walter Riedel I was displaced as sort of chief designer, before that time?

Dannenberg: It may have happened before that time. He really was in a way replaced when Riedel III came in. These two never got along too well and I think Riedel III had finally a stronger voice in von Braun's ear, and so he apparently insisted that Riedel not be the design chief, be the head of the design bureau, so that was finally given to Riedel III although I personally don't think it has to be done that way, the research and development director, can in my opinion, do without the design office. But Riedel III apparently insisted and so that put Riedel I, who was up to that time in charge of the design office, that put him out of commission, and maybe that's one of the reasons that he finally went to Nachbau and that he then took over the production series. And again, the fact that people complained about him quite a bit and that they said the production drawings are really not what works. Maybe to a large extent due to Riedel III, he apparently picked up a lot of little incidents and put them all together and made him look in general pretty bad.

Neufeld: Walter Riedel I, was made to look bad?

Dannenberg: Right, yes. They were both Walter Riedels.

Neufeld: It sort of makes for confusion when you're relating this. So you're not entirely sure that Walter Riedel I was done justice?

Dannenberg: Well, he was to a degree treated badly. I think I can say that. He was himself quite a bit disappointed. I know that. And of course, up to that time he was in charge of all the design work, and then after that he was only in charge of the production design, and maybe the jobs, the task they gave him was too big a task, because you just cannot take these research and development items and put them in mass production type configurations. You are bound to run into problems. And that happened to a relatively large degree, and so finally, as I said, we finally had to switch back to the R and D drawings and they were really used for the mass production.

Neufeld: Hm mm.

Dannenberg: The production people still helped to a certain degree whenever we had to change materials. So there was still a lot of work to be done and our relatively small design office was not always capable of handling all the many, many things that still had to be changed.

TAPE 2, SIDE 1

Dannenberg So we were just talking about the Nachbau.

Neufeld: Right. ...So we were just trying to straighten out the whole story of Nachbau, and the production drawings, and I never heard this story before. You said that under Stahlknecht and with Walter Riedel I they had gone out and tried to produce parts based on this.

Dannenberg Yes, they wanted to simplify the entire V-2 design, and of course it is a very complicated design. It certainly can probably be simplified in many areas, but if you go into these kinds of problems as we discussed earlier, and if you change these kinds of designs, you easily run into trouble, and that happened quite frequently with welds, with all moving parts really. As soon as they were redesigned, they didn't work any more. And so then it was finally decided to still let these people participate but give them only tasks where they cannot hurt too many things, where they cannot do any damage.

Neufeld: Did you test, did these parts fail just in test stand type tests?

Dannenberg Many of them were tested in the lab and they just didn't perform in the lab the way they were supposed to perform.

Neufeld: Where were they manufactured?

Dannenberg Well, the intent again of making these production drawings was so that you could go out and you could have them manufactured all over the world. So you should have complete information and then anybody should have been able to produce them. Now, one of the problems is, many of these things were only built by specialists. And they may never have even documented on their drawings all the little tricks of the trade, and I think that was one of Papa Riedel's problems here. He didn't really have all the information he should have had. So many of the production drawings, as they initially were called, were really not up to par. They really didn't permit any manufacturer to build a part which then does the kind of thing it is supposed to do.

Neufeld: And so some of these sort of first run attempts at producing production parts were contracts sent out to manufacturers?

Dannenberg To almost any manufacturer.

Neufeld: Right, and you got the parts back to see what kind of quality and this whole thing didn't work out very well.

Dannenberg Right.

Neufeld: This was when, in late '42, early '43? Somewhere in that time?

Dannenberg It would have been basically in the '43 area, when the production really got under way. And as you said, there was initially an attempt to also produce a large number of V-2's in Peenemünde, and that's what Rudolph was supposed to do. But after the bomb raid of course it was also something that went out the window. It was immediately decided not to set up any production in Peenemünde. We still built a few hand-made V-2's, so to speak, for certain development purposes. But real production took place only in Mittelwerke.

Neufeld: So you were assigned to working on the production drawings for the power plant, for the engine, including the turbo pumps and the whole system?

Dannenberg Hm mm. At that time I was (crosstalk) in charge of all the drawings. I never knew too much about the electronics items points, but they were part of the overall set, and I also had to get these drawings out of the electrical people, and that was a big job to really make them put down on paper all the things they wanted to have done, and then deliver them again to Mittelwerke, for the manufacture.

Neufeld: Okay. So where was your location then?

Dannenberg I was located in Peenemünde.

Neufeld: I meant organizationally, where were you in the organization?

Dannenberg I was Riedel's deputy, Riedel III's deputy. He was the head of research and development, and as I said, he finally really also took over the production, because it didn't work with making new production drawings, and Riedel was probably the one who convinced von Braun not to make a new set but use the R&D drawings. And of course there was also very strong drive to get the drawings out, to get the drawings to the production people, so that they could really start the production. And then of course parallel to all these efforts, we also made still research and development firings. We found out many problems which still had to be solved. And the army also got into the act, and the army shot about a hundred or so V-2's in Heidelager. You may have heard about Heidelager. And at that time we found out that many of the V-2's didn't come down the way they were supposed to come down, head first or at least tangentially to the trajectory. Many of them came down sideways, and when that happened we had the air bursts, and missiles broke up, and that was one of the biggest problems towards the end, and there was quite an effort. People finally insulated the fuel tank and the LOX tank, and they used glass fiber, long fiber, glass fiber, and shorter fiber glass fiber which could be easily obtained. And I don't think scientifically it was ever demonstrated that either one of the two solved the problem. But we had to make a decision, and so it was finally decided to insulate them all with long fiberglass wool and that finally of course went also into the production drawings.

Neufeld: So you worked for Walter Riedel III?

Dannenberg Right. I was his deputy.

Neufeld: For the rest of the war, pretty much?

Dannenberg Practically for the rest of the war.

Neufeld: Can you describe him as a personality? What was he like?

Dannenberg Well, he was certainly a very good engineer. That's why von Braun on the one side picked him up. He worked at the University of Berlin then he came to Peenemünde and he finally spent practically all his time in Peenemünde. So he was an excellent engineer, there's no question about it. He was very familiar with orbit propulsion problems, and in a way he was a very pleasant boss. He had some problems though with people like

Walter Riedel I, and so not everyone might agree with what I said right now, that everyone really liked him and went along with him. He had very firm, his own firm opinion, and if you didn't agree with him, he didn't agree with you.

Neufeld: I gather he pushed very hard.

Dannenberg Yes, he pushed very hard, and I think he was a pretty good manager. After the bomb raid, the whole research and development agency was really distributed not only over the island of Usedom, but also on the mainland. Our lab, for example, was located on the mainland, and Riedel was also in charge of that, and he really could still pull all these organizations together. So in that sense, I think he was a pretty good manager. Besides being a good engineer.

Neufeld: Do you think that dispersion had much of an effect on efficiency?

Dannenberg I'm sure it did. I cannot quote any numbers, any percentages of decrease in efficiency, but I'm sure that it's not the best way to do it.

Neufeld: Which brings up a related question. The concept that seems to have evolved right from the beginning in the late thirties was of a large laboratory with a big in-house capability.

Dannenberg Right.

Neufeld: Did Dornberger--it seems to me now that Dornberger was probably the most influential person in that concept?

Dannenberg Right.

Neufeld: Did you, I'm trying to think of how I should ask this question, was that a philosophy that you came to agree with when you were there, that it was much better to be able to make things in-house, at Peenemünde, as opposed to having it contracted to some company?

Dannenberg Well, I never thought too much about it. During the war it was awfully difficult to go to a company and tell them, "Here's my drawing, build it." All sorts of companies were so busy with wartime production that they just turned you away. So I think to a degree it was even necessary to have this facility and to be able to do a lot of things there. When the mass production started, that didn't work any more, ja, because we could not build these thousands of parts. We could build a few of the parts for our own use. But for the mass production, it was a different story. And that's in a way, I think a part of the story where many of these problems came in. As I said, the

drawings we had were probably not complete. Our chief engineers in the shop, they knew how to do it and they didn't have to see it on the drawing. They knew what they had to produce and therefore it worked. If you then finally made a drawing and gave it to somebody else to build it, they might not have had all the information.

Neufeld: Right. You don't have a completely specified drawing.

Dannenberg Yes, and of course, it goes into all the details, not only the dimensions of the part, the material, the heat treatment of the material, all our valves used rubber type gaskets. We didn't have real good rubber so we had to use synthetic rubber, and there again you had to specify exactly what kind of rubber you wanted to have. That was not always very clear on the drawings. So I think in a way Peenemünde was forced into this kind of operation, particularly in the beginning, to do a lot of things in-house. Toward the end, of course, I don't think we did any mass production work. Not any small parts and certainly not the bigger parts.

Neufeld: You started importing more and more things from the companies even for research and development vehicles that were made?

Dannenberg Well, we normally used production vehicles and modified them for our purposes, so they were towards the end strictly production vehicles, and really our main capability at Peenemünde was to take them apart, modify the parts, and put them together again. So we still had that capability. And we probably could have built also completely brand new missiles, if we wanted to, but towards the end, we even wanted to test the production missiles. We wanted to find out, if they were really good enough? Do they do what they're supposed to do? So that was a part of the research effort in Peenemünde at that time.

Neufeld: Now, as far as the management and organization is concerned, I never got to ask you when you first met Wernher von Braun what your first impression of him was?

Dannenberg I mentioned earlier, I think I went up for an initial visit, and I don't think I met him at that time. I talked at that time only to Thiel. But of course as soon as I finally came to Peenemünde, I met him, first, second, third day, I met him quickly. And Peenemünde was still a relatively small organization at that time. We had about a thousand people at the time when I got there. I was in the same building as von Braun, so my office was there. Thiel's office was right next to him. So I don't recall the exact time when I met him, but it was certainly very shortly afterward.

Neufeld: What was your initial impression of him?

Dannenberg Well, of course, all the people up there, they admired him, and they all always thought very highly of him. And he's also the personality-- I don't know, have you ever met him?

Neufeld: No. No. Of course he died 12 years ago.

Dannenberg So his whole appearance, his whole behavior really showed to you that he was somehow an outstanding personality.

Neufeld: Was it manner of speaking?

Dannenberg Also his pronunciation, in English, you may have heard some of his recordings, it was not the typical English. And that goes also for his German. He did not speak the normal English that most Germans speak. He had a very accentuated, a very specific pronunciation, and that probably was somewhat tied to his upbringing. He of course came from an outstanding family in the first place. And he always showed that. So you always got that impression right away.

Neufeld: Yes. Of course he was an aristocrat, officially a baron.

Dannenberg Yes.

Neufeld: A Freiherr.

Dannenberg And somehow you noticed that. So somehow you got that impression right away even if you didn't talk to him, if you just saw him.

Neufeld: Was it in his bearing, the way he stood, the way he talked, is that what you're saying, that he appeared to be sort of aristocratic, very cultured?

Dannenberg I think you can say that. And also, well, as the aristocrats apparently all do, he had a little bit of military appearance. He was standing straight up. In that sense he didn't look like a scientist, although I think he was a good scientist, but he didn't look it. Even in those days some scientists had long hair. He never had long hair.

Neufeld: I gather that he did not wear this aristocratic background obviously in the sense that he was a snob about it or anything like that?

Dannenberg No. No. No, he got along with all the people really well. He went very often into the shop to talk to all the people on the lathes and the drilling machines. There is something that

many of our new bosses here don't do to the same degree that he always did it, starting in Peenemünde and even later on in this country. So he had always a real good contact with the whole working level. And of course also with all the people who worked directly for him.

Neufeld: So in that sense, he was able to be an inspirational leader, is that it?

Dannenberg He was really a good leader. I think that sums it up exactly in the best and simplest fashion.

Neufeld: Were there any disadvantages to the way he operated? Were there aspects of him that were not helpful?

Dannenberg No, I can't think of any. He was a good engineer. He was a good manager, which you probably have to be in order to be a good leader. He could convince people that his ideas were right, so even if the people didn't always agree with him, he could still convince them that maybe we should even try this first. And in that sense he was not snobbish at all. He gave everyone a chance to say his piece, to talk to him about it, but then he made the decision, and he said, "That's the way we are going to do it. After I have heard all your stories, this is the way it's going to be." And again that's of course typical for a leader.

Neufeld: And you virtually always agreed that his decision was the right decision?

Dannenberg I think in all cases I have to say that right offhand I cannot think of any single decision which he made wrong. He didn't always get his way.

Neufeld: Because he could be overruled from higher up?

Dannenberg As I said, he was not ready to really turn the V-2 over to mass production. He would have liked to have had another year of development work, research work.

Neufeld: When was that, that he objected? In late '42?

Dannenberg That must have been late '42, at the time when the decision was made to really go ahead and build it in large numbers.

Neufeld: So at that time he thought this was a mistake to rush into it. I know that one of the things that's been mentioned to me in a few other interviews that I've done is, Dornberger sometimes criticized him for wanting to go off in all directions, or having so many interests that he wasn't always focussed on what needed to be done here and now, (crosstalk) at least that

would seem to --

Dannenberg I have not heard that Dornberger made that criticism. I don't think von Braun really had that characteristic. He saw always the whole picture, and his overall idea was probably many times much wider than what Dornberger wanted him to do. After all, Dornberger was in charge to develop the V-2. And von Braun of course was thinking already about space flight and future applications at some time. So I can imagine that Dornberger might get that idea. As I said, I've never heard that he expressed it that way. On the other hand, maybe other people have heard him make that statement. But von Braun on the other hand was also always very realistic. He always had a policy to go one step at a time. And he was not of the opinion that you should start from scratch again and come up with completely new ideas. He was always of the opinion that you build on what you have, build on what has been shown to work.

Neufeld: So he wasn't necessarily pushing you to do something that was really radically innovative?

Dannenberg No.

Neufeld: That might go wrong.

Dannenberg And I think typically in this country, it's the design of the Redstone vehicle which is really just an outgrowth of the V-2, it, some people even call it a younger brother of the V-2, and I think that's correct, and again von Braun had a strong hand in making that relatively small step. If he wanted to he probably could have made a bigger step at that time. And also of course getting started finally with the Saturn series. He really built on the Redstones and on the Jupiters, and he clustered the tanks and the engines, and he had on relatively short motors, relatively, at that time the most powerful launch vehicle.

Neufeld: So, I want to return to the German period, but I've heard the opposite about Redstone, that he or other people were a little frustrated that at that point you were still only building a new V-2.

Dannenberg Well, some people left our group. Riedel may have been one of them. Some people said that he was even too conservative. So contrary to what you said earlier, ja, some people, Ehricke, you probably--you may even have met Ehricke, before he died.

Neufeld: I haven't met him, no.

Dannenberg He left the group because he felt von Braun was too conservative, and he didn't go ahead fast enough, and that's why Ehricke finally went to General Dynamics and developed the first

liquid hyrdogen propelled vehicle, the Atlas-Centaur, upper stage. And I also had the impression that some other people may for that same reason have left, because well, some of them just wanted to build bigger missiles, and of course the army had been limited to 400 mile range missiles, the Pershing.

Neufeld: After Jupiter.

Dannenberg Right. Jupiter was the last big army vehicle, and then the army couldn't build big vehicles like that any more, and that's when some people became restless and left the group. Again, I think von Braun made the right decision. He was at first reluctant to join NASA. It wasn't an easy transfer. He first had a strong inclination to stay with the army. But when this limitation came, that the army can only handle missiles up to the Pershing size, that of course did it for von Braun. He didn't want to build short range missiles all his life.

Neufeld: Right, he wanted to get on, use Saturn as a space launch vehicle.

Dannenberg Also many people, and some of them even left for that reason to private industry, many people felt we should really not be working for the army, or for NASA today, ja. We should really be a private company and do really what a private company likes to do and then try to sell our product to the government. And I personally think von Braun made the right decision, not to leave the government. I think it was advantageous for him to stay in the government and really to have control about the overall program. If he would have left NASA, he would not have had control about the entire Saturn V. He might have built one stage, like Boeing did or North American, but he would not be in charge of the entire thing. So I personally think he made the right decision. You probably can still argue about it.

Neufeld: I haven't studied that period in great detail so I don't have a lot of detailed questions about it right now. But I'm curious about, before we return to the German period, I'm curious about this whole issue of in-house capability developed here at Redstone Arsenal versus contracting out. Was it von Braun who was very influential on that?

Dannenberg I think von Braun was convinced that this is the right way to go, and also Medaris was really a very strong pusher in that direction, and he wanted to have a very strong arsenal, maybe after consultation with von Braun, I don't know who was the stronger voice in that area, but they both firmly believed in the arsenal concept, that the army at least knows all the tricks of the trades, that they know how to build these things. And if you really go into mass production I think none of these two would object to give it to private industry. But the basic, the early research and development should be done in-house.

Neufeld: Do you agree with that?

Dannenberg I personally agree with that.

Neufeld: But do you agree with those people who said that it was a mistake essentially in the Marshall years to--and it may come later on in fact--to give up most of that in-house development?

Dannenberg Well, in a way we were forced to give it up. We were told not to do everything in-house but to give much larger slices to private contractors. And of course the private contractors pushed that way, and they have the bigger voice, the bigger ins into the Congress, so the Congressional committees finally pushed von Braun, NASA in general, not to do as much work in-house as we used to do.

Neufeld: When did you notice that changing quickly? Was it during Saturn V that pretty much you moved to--?

Dannenberg --To a degree, already during Saturn V. So the upper stages were not built here, they were built by North American and Douglas. Grumman built the lunar landing equipment. So it became apparent already at that time, but it of course was much much stronger after the end of the Apollo program, with the Shuttle.

Neufeld: Right. Now, as far as the influence of the Germans on that period is concerned, you felt pretty much that you wanted to retain the same concept as Peenemünde, Redstone Arsenal, how were you organized and a strong in-house ability?

Dannenberg ... Most of our people did not worry too much about the management. You talk about the management aspect. After all, most of our people who came over here with von Braun were technical people and they worried about their technical problems, and how this whole thing would finally work out, I think people normally didn't have too strong an opinion either way.

Neufeld: But you were used to having in your development laboratories here, more at Redstone because at Fort Bliss you weren't occupied with new developments much, but you were used to having your own capability in-house to produce the prototypes, right?

Dannenberg Hm mm.

Neufeld: So in some ways even without thinking about it, you would be accustomed to that kind of organization.

Dannenberg It just happened that way.

Neufeld: Yes. It fitted well with the army arsenal concept in

the United States. Now, to backtrack to where we were before we got started, you talked about von Braun and his role, and I was wondering finally about that management role at Peenemünde, to what extent you saw him at that time as being in any way generating new development ideas for A-4 or Wasserfall, and to what extent he was really just the manager on top of the whole system who was tracking what everybody else was doing and trying to coordinate it?

Dannenberg Well, he always stayed with his feet well to the ground, so he never was just the top management manager working through his subordinates. He really went, as I said earlier, into the shops to talk to the people, and I think that's still true for the final mass production days of the V-2. He visited many of the companies who built the parts, who built the components. He made a number of visits of course to the Mittelwerke, assisting Arthur Rudolph down there, and getting things straightened out, and what was actually your question?

Neufeld: Well, really I was trying to get at, to what extent do you think that he contributed original ideas for specific equipment or specific developments? You know, in that instance, you can attribute some aspect as you say basically, Thiel should be given the credit for it.

Dannenberg I think Thiel was at least up to his death really in charge of the power plant. Von Braun didn't worry too much about it. He spent much more time on guidance and control. And I think there we have to give him a lot of credit, that he came up with the basic concept, the basic principle, and of course the early A-4's were relatively simple. They were really just an automated pilot for an aircraft, and the aircraft just flew a little bit differently in this case, and that created a few new problems. But he had many basic ideas in that area. I think he also basically innovated, really conceived the basic guidance of the whole system, where you measure where you are, and then of course you have to use your controls in order to do what you really want to do, to control your engine flight. I think he had a pretty strong hand in for example the engine. We haven't talked about that. It shuts off in two stages. There's an 8-ton stage, in order to have a greater shut-off accuracy. I think von Braun had a pretty strong hand in making these kinds of very basic, very principled decisions. So he really again looked at the overall total project. Then after that had been done, then he turned it over to Thiel, and Thiel had then to come up with some valves which do that, with the basic system, the basic prinicple. And of course after Thiel died, von Braun dug also much, much deeper into the propulsion systems. So I had in the later years more contact with him on propulsion than I had in the earlier years.

Neufeld: Schilling replaced Thiel?

Dannenberg Schilling was basically in charge of the test section, the test department. Now, of course testing shows you all the problems, the development difficulties, so in that sense you can say to a degree. But Schilling never really dug deeply into the engine, for example, into the power plant. He tested it, and due to that activity, of course, he got involved. But to my knowledge, he never influenced any of the basic decisions.

Neufeld: So as far as engine development was concerned, after the air raid in which Thiel was killed--

Dannenberg --It more or less stopped.

Neufeld: You didn't really--I mean, of course there had to be Wasserfall development going on, but there wasn't, you didn't have a clear figure any more who was centrally interested in it, is that correct?

Dannenberg And of course it was also decided to not fiddle around too much any more with changes. So the decision not to introduce any new changes really stopped it, in a way it really stopped the development. And well, if Thiel would have been there, maybe he would have pushed for the introduction of the mixing nozzle instead of this one here. On the other hand, I think maybe it would have been too late. Even he couldn't have made that change because it was not working properly. If it would have worked, he might have been able to somehow squeeze it in.

Neufeld: The problem was of course that by the time you get to 1944, it's almost too late to change the whole production line.

Dannenberg Right.

Neufeld: When, you know, Hitler and the system was calling for as many V-2's as they could after they began to launch, as fast as possible.

Dannenberg You couldn't make changes any more. It was impossible. And that in a way of course really stopped the development right then and there. Important things, like the long fiberglass wool that I mentioned earlier they still had to be done, but no other changes just to improve the performance of it.

Neufeld: I wonder to what extent there was still Wasserfall development? It seems to me it's hard to find much about Wasserfall. So far, maybe in the archive reports and other places there will be, but so far, I haven't found much on it.

Dannenberg There are not too many Wasserfall people over here. They are basically all V-2 people. So right offhand I couldn't

think of any single person who really would know an awful lot about Wasserfall. Of course the designers in Riedel's office designed also the Wasserfall parts. But I think that was in a way really more a sideline, so Wasserfall was never one of the more important projects. Whenever there was a little problem with the V-2 it had priority, and all the people had to solve that first.

Neufeld: Okay.

Dannenberg The Wasserfall also had in a way its own crew. That's when the air force people came in and the air force had several hundred people at Peenemünde at that time, and I think only very, very few of these people are over here. And that's probably one of the reasons that you can't find out too much about it. And although the Wasserfall was also theoretically in my area, and the drawings were made in the Technisches Buro, for the Wasserfall, but I really didn't have the time to worry too much in detail about it. We had seen so many V-2 problems that they had first priority. And we also built another smaller vehicle, the Taifun. I don't know if you heard about the Taifun?

Neufeld: Yes. I've heard about that. That was at the very end of the war.

Dannenberg Right. Yes, that was really for emergency use in there.

Neufeld: Where did the idea for Taifun come from and who was involved with that?

Dannenberg Well, the fellow who pushed it mostly was again in the air force, Officer Schaeufelen, Klaus Schaeufelen. I don't know if you have heard the name?

Neufeld: It sounds slightly familiar.

Dannenberg As far as I know he's still living in Germany. He went back to Germany. He was here only the first, I think he left shortly after Fort Bliss. No, he was a short time at least also here in Redstone but not very long.

Neufeld: His name was Schaeufelen?

Dannenberg Schaeufelen, Klaus.

Neufeld: Okay. So he was an air force officer?

Dannenberg Yes, and he I think had the basic idea of the Taifun. And in a way of course it was a response to the Russian Stalinorgan. You probably heard about the Stalinorgans? And this was a similar system, launching a lot of--in some cases solid

propelled, but Schaeufelen dropped mostly liquid propelled rockets which didn't have a great accuracy so they were really a target area weapon, with which you could combat an army that was approaching you.

Neufeld: The Taifun was supposed to be launched against bomber formations, right?

Dannenberg No, it was really against army, it is a ground to ground vehicle. It was not a ground to air vehicle.

Neufeld: Because I've seen it described as a ground to air vehicle in some of the things I've been reading.

Dannenberg Maybe some advanced Taifuns in this country. The Taifun was picked up again, and I think the Taifuns in this country were used or intended to be used for that purpose. But in Peenemünde as far as I know it was just like the Stalinorgan. No accuracy, had no guidance system. It was a very simple weapon. It just carried a payload over a certain distance. And having no guidance system, it would be awfully difficult to use, at least the old Taifun from Peenemünde, as an anti-aircraft vehicle. You need a fairly sophisticated guidance system for that.

Neufeld: Yeah. Well, I got the impression that they were pressing that into production and it never was produced, with the idea of just shooting masses of them at a bomber formation, kind of random idea that you would explode them in the middle of--

Dannenberg Well, if you had enough bombers coming at you, you might be able to succeed in that area. On the other hand, the bombers will all be so high, the Taifun does not have a very great height of its trajectory.

Neufeld: It gives you the definite impression of being a desperation move.

Dannenberg It was.

Neufeld: At the very end of the war. So you can't tell me much about Wasserfall, unfortunately.

Dannenberg No. I can't.

Neufeld: If you ever think of anyone here who might have worked on Wasserfall, I'd be interested in talking to them. Because I don't have much information. Now, Dornberger, I never asked you about Dornberger and some of the other army people, did you have much dealings with them?

Dannenberg Not too many, between Dornberger and myself was of

course von Braun and sometimes even Thiel, on top of that, so I never dealt too much personally with him in Peenemünde. I had probably more contacts with him here in this country. Of course he came often here to Huntsville, visited often. I visited with him at Aerospace a few times. I visited him there. And of course normally his decisions were passed on to me through von Braun. I was in a number of staff meetings with him, after the bomb raid, for example, I remember that meeting, when we had to decide, where do we go now from here? What do we do next? And then of course we decided, we really have to disperse the whole facility, and as I mentioned earlier, we were finally spread all over the island of Usedom and even over the mainland. And of course Dornberger came to many of the firings. He was normally there for any important firing, whenever a new system, a new vehicle was being tested, he was there on the launch site and also very often at the test stands. Again at that time you don't really have too much of a chance to talk to him.

Neufeld: Okay, so for you he was always kind of a fairly distant figure.

Dannenberg Right. He was really the boss, the boss in Peenemünde.

Neufeld: And you got the impression of him as what?

Dannenberg Well, he was certainly a good engineer, I think. He had the basic idea of using rockets for artillery purposes. I think he gave a lot of good inputs into the V-2 system. Of course he was more involved with the final deployment, to make it mobile and to use it not only from the bunkers that were initially scheduled. In fact, I even think he was always opposed to that idea, because he saw coming what finally happened, that these bunkers would be bombarded and they are gone, you don't have them any more. While for mobile deployment of course you have a lot of flexibility. And I think he was the one who really recognized that and pushed it quite a bit. And also von Braun was in favor of that. And one of the fellows who really pushed that was Klaus Riedel, the other Riedel, and he was initially, before he died--he was in an automobile accident, and before he died he was really pushing the mobile deployment of the V-2.

Neufeld: Do you recall whether in the beginning von Braun was in favor of the bunkers?

Dannenberg Well, of course, in a way it was a military decision. Von Braun could give his consultative advice and could tell them, well, that's really not the way to do it. I think as I said, I think he was never too much impressed with it. I think he always preferred the mobile concept.

Neufeld: Who was pushing the bunkers?

Dannenberg That was basically the army and maybe even the party to a certain degree, but I think it was basically an army decision.

Neufeld: Because I got the impression, I mean, I certainly know that as some people have said, Hitler was in love with gigantic concrete structures.

Dannenberg He may have been the one who finally pushed it and finally made the final decision, that's definitely a possibility.

Neufeld: But I had the impression that perhaps early on, earlier on, before the mobile system was really demonstrated that it could work, that some people at Peenemünde also felt that with such a complicated vehicle, you had to have some kind of preparation underground, a protected shelter, to prepare the vehicle for launch. I gather you probably were not involved in those issues at all?

Dannenberg No, that was a separate group, and Hueter, and he died in the meantime, he's not here any more, and they worked on these concepts after Klaus Riedel had died. He was really in the beginning the one who was really pushing it, and then Hueter took over from him after he had died and he was in charge of ground equipment, as we called it, and George von Tisenhausen was in it, do you plan to talk to George?

Neufeld: I have heard of him.

Dannenberg --He worked on ground equipment and he worked even on submarines, on the underwater launches, not necessarily submarines. They would probably just be towed by submarines. And he may know quite a number of these things also, if you have a chance to talk to him.

Neufeld: Yes. I only have probably one more week in January after this week. That's my problem, I don't really have the money or the opportunity, unless I continue to work with the Air and Space Museum. If I get a job there I might be able to do more of this.

Dannenberg Is there a chance?

Neufeld: There's a chance. So I don't know whether I'm going to be able to do more than this week and then a week in January, and maybe some time in the future. Now, let's see, we've covered virtually all of the things on the war that I can think of offhand. So you stayed with the production drawings issue, and basically you stayed in Peenemünde the whole time?

Dannenberg I stayed to the end in Peenemünde.

Neufeld: You didn't do much traveling during that time period?

Dannenberg Well, I went every once in a while to some of the manufacturers, when we had special problems, when the drawings were not too clear. I went several times to Mittelwerke in order to deliver the drawings. Very often they were so urgent, we made the blueprints and I grabbed them under my arm and flew or used the train to Mittelwerke. But otherwise I did not travel around too much. I, for example, never went to Heidelager. We mentioned that earlier. Many of the people who worked for me went to Heidelager, but I myself never went there because I had so many other urgent problems that had to be taken care of. And during the war, travel was not pleasant.

Neufeld: Yeah.

Dannenberg You tried to stay away from it whenever you could.

Neufeld: When did you first notice the SS getting involved in--starting to interfere at Peenemünde?

Dannenberg Well, I don't know when Himmler was at Peenemünde. Hitler never made it. But Himmler came to Peenemünde, and I think that was after the bomb raid, so it must have been in late '43, maybe even '44. And that of course gave many of us the first inclination that the SS and the party really would be interested to take over all of Peenemünde. And of course Himmler had taken over many, many of the other activities. He was initially just a police officer, and then finally he built up the SS to what it finally became. So he was apparently a very ambitious man, and I think many people suspected him, that he really would want to grab Peenemünde. And he finally of course made an overt grab. That's when they put von Braun in jail. I think it was not so much his activities that he worried about future space flight, apparently Himmler felt if von Braun would be gone it would be easy for him to take over Peenemünde.

Neufeld: I gather that von Braun was, according to his story, was called to Himmler's headquarters in February of '44, and asked if he'd go over to the SS, and he said no, you know, I'm happy with Dornberger, I'm happy with the army, and the arrest came three weeks later. It seems like it was a punishment as much as anything for not--

Dannenberg Yes, a punishment, or even he wanted to take over Peenemünde after von Braun had gone, because he apparently felt that von Braun would be a very strong influence in that decision, and he wanted him to be out of the way.

Neufeld: Yes.

Dannenberg So it was in early '44, you say?

Neufeld: The arrest was on March the 15th, '44. But according to von Braun he had been called to Himmler's headquarters in February, '44. So that--

Dannenberg --And of course there were inklings already that the SS would be interested to take over Peenemünde before that time. So this was really the first official step, you can say.

TAPE 2, SIDE 2

Dannenberg ... Rees. He was quite a bit involved in all these political decisions. He was von Braun's deputy and he was was--he kept very, very well informed about what von Braun, even in a separate meeting where Rees was not present, but he passed on this kind of information very well.

Neufeld: Okay. ...Do you remember the Zanssen affair at all?

Dannenberg What specifically do you--?

Neufeld: Zanssen was removed as commander, base commander of Peenemünde, in May, '43, and the SS was behind that.

Neufeld: I see. No, I hadn't even heard about that. That's news to me. I knew that Zanssen had to go, but I don't know the details there. Again that was a political decision that was way over my level.

Neufeld: Yeah. The accusation was, Zanssen was connected to some oppositional Catholic priests, and some other charges. It seems basically like a frame-up. And one of the--did you ever know Lieutenant Colonel Stegmaier?

Dannenberg Yes.

Neufeld: By the way, do you know what his first name is? Because I haven't seen it anywhere in the record.

Dannenberg I think it's Heinz but I'm not really sure. Again Rees would be a good source, and he has a fantastic memory.

Neufeld: Do you remember anything about him?

Dannenberg Well, of course he was in charge of the Peenemünde operations, while Dornberger was very often away. I had a number of meetings with him, because, well, it again was involving getting the V-2 ready to go, getting the drawings out, and I always thought very highly of him. He was not the kind of person as von Braun or Dornberger was. So he was a good administrator but he was in that sense not a leader.

Neufeld: Can you describe him physically, personality-wise, say more about Stegmaier? Because I don't even have a good picture of what he was, who he was.

Dannenberg He was an average person. I might even have a picture of him. Shall I look?

Neufeld: Yes, maybe after.

Dannenberg At the end of the tape.

Neufeld: At the end of the interview, yes.

Dannenberg I might have a picture of him. He was really in a way an average person. He was wearing glasses. I even think Krammers, you know the one without the bows that you just--

Neufeld: --Stick on the end of your nose.

Dannenberg Stick on your nose. I think. I'm not too sure about that. Maybe the picture will show it. He was a pretty nice and pleasant fellow. He was not as tough as Zanssen. Zanssen was a pretty tough--he really showed you he was a commander, while he was up in Peenemünde, and many people were mad at him, and maybe that's another reason that they finally removed him.

Neufeld: So there were a lot of people who were unhappy with Zanssen.

Dannenberg He was a typical military commander, ja. He made up his mind. He didn't necessarily talk to all the people before he made his decision. He made the decision on the basis of his information, and boy, you'd better follow it up, whatever he ordered! So for that reason, he was not too popular. I personally have nothing against him. In fact I visited him once or I met him once after the war in the Bremen area. He lives in the Bremen area now.

Neufeld: Actually he died some years ago. By sheer coincidence, by rather much of an accident, when I was in Hamburg in August, I was introduced to his daughters.

Dannenberg I see.

Neufeld: And I spent an evening with the daughters, the two daughters of Zanssen and their husbands and had a long discussion about these issues. That's still an issue.

Dannenberg Were they of the opinion that he was booted out by the SS?

Neufeld: Well, I have documents which show in fact that the SS,

the Gestapo sort of framed him up. And I also have documents which show that Stegmaier was the man behind a lot of it.

Dannenberg Really?

Neufeld: Stegmaier had the highest contacts with the SS leadership, through Gottlob Berger.

Dannenberg Maybe that's even one of the reasons that he was put in charge there, due to his SS contacts.

Neufeld: But you have no knowledge of that whatsoever?

Dannenberg No, neither of the Zanssen affair or that Stegmaier was involved in this area. As I said, I always thought, well, not as a big leader, but I thought--

Neufeld: --Competent?

Dannenberg --highly of him.

Neufeld: So most people liked Stegmaier in terms of?

Dannenberg I think most did, more than Zanssen.

Neufeld: That's interesting. Rudolph said that he had terrible disagreements with Stegmaier.

Dannenberg Yes?

Neufeld: But that was over Versuchsserienwerk, that he didn't get along with him, so I have no reading and I'm only getting a few opinions so far. Obviously you just get along with some people and don't get along with other people, when it's often just quite coincidental.

Dannenberg How did Rudolph feel about Zanssen, did you talk to him about that?

Neufeld: I think he was friendly with Zanssen. I don't remember real well what he said about it, but he didn't get along with Stegmaier.

Dannenberg Well, I'm in a way surprised. Stegmaier was normally fairly easy to get along with. But of course there may have been some very basic differences in the Nachbau question, and maybe Stegmaier even had his orders and he had to pass his orders on to Rudolph and Rudolph didn't like the orders. So I can see that these things can develop.

Neufeld: Right. I mean, of course, the whole problem of going into production was a real controversial situation. As far as SS

was concerned, all you knew about it was that there was something going on there.

Dannenberg Right.

Neufeld: Kammler of course came into the picture, after the air raid, as the man responsible for building the Mittelwerke and producing the prisoners.

Dannenberg And again he was so high up in the hierarchy, I had no contact with him at all. I knew about him of course but I never talked with him. I don't recall meeting either with him and so I really have no personal judgment.

Neufeld: So he was not someone that you met at meetings or anything?

Dannenberg No.

Neufeld: Later on?

Dannenberg I met Sawatzki fairly frequently when I went to Mittelwerke. He was normally the one to complain that he didn't have all the drawings. So then I had to find the drawings and take them to him. So I had pretty good contact with him. But that was about the top level that I had my contacts with. Rudolph probably had many more contacts. He may even have had some contacts with Kammler and people like that.

Neufeld: I imagine. I didn't ask him about it. So I mean, officially of course, Kammler sort of gradually gathered all these various strings together, by the end of '44, and was officially over you and everybody else?

Dannenberg Yes.

Neufeld: But you didn't notice much actual presence of SS and so forth? I know the facility was (crosstalk)

Dannenberg --Then of course the push was always on. There was always a lot of pressure, and as you indicated earlier, they wanted to build large, large numbers of V-2's and they couldn't even use them. They built many more than they finally could launch. And well, I certainly felt the pressure. Also getting the drawings out, of course. Many of these orders came from Kammler.

Neufeld: Yeah.

Dannenberg But I didn't get it from him, I got it through people like Rudolph and Sawatzki, and people who were more on the working level.

Neufeld: Right. Do you remember when the facility was converted into a private company, Peenemünde was converted--?

Dannenberg --As the Elektromechanische Werke.

Neufeld: --As really a government-owned company.

Dannenberg I remember that it happened, but I don't remember the date. Do you have the date?

Neufeld: August 1, 1944.

Dannenberg '44, that late?

Neufeld: August of '44. It came immediately after the coup against, immediately after the assassination attempt against Hitler.

Dannenberg I see. Are they connected somehow?

Neufeld: I think so. I don't know if anyone has the evidence yet, but it appears pretty clear that the army, of course, was humiliated by that. After that, the army was seen as the enemy by many people in the party and the SS, and in order to keep Peenemünde from being taken over directly by the SS, I think, this is--I don't know if the exact proof is out there yet--Speer was behind convincing somebody to make it into a civilian corporation owned by the government.

Dannenberg Yes, it sounds logical. I hadn't heard it. It's a new story for me.

Neufeld: From the standpoint of what you know, did it make much difference when you changed labels from the army?

Dannenberg Actually not an awful lot. Of course our letterhead paper had to be changed. But that was more or less it. The operation was the same. The bosses at Peenemünde stayed the same. Of course we had an extra boss, Mr. Storch. But otherwise it was not a great difference.

Neufeld: Did it make any difference in terms of converting the status of people from civil service to--I mean, did your salaries change or anything like that? Do you recall any difference like that?

Dannenberg I certainly don't recall it. On the other hand, money was of secondary importance at that time. You needed cigarettes and eggs in order to really buy something. You needed some money to make it legal but we had plenty of money so money was not the big issue, and I don't really recall it that my salary, my pay was changed.

Neufeld: Ration coupons were the important things.

Dannenberg Right.

Neufeld: Not how much money you had in your pocket. Whether you had access to goods. In that last year or so, at Peenemünde, was there a deterioration at conditions, noticeable, due to shortages of materials, due to shortages of food, dispersion, whatever?

Dannenberg Well, of course, particularly in production. I mentioned earlier, we had to make many design changes in order to accommodate the new materials. The food, of course during the war was always short. So you never had really all the food you would like to eat. Now, in Peenemünde we were probably better off than most people all over Germany, because the fishermen in Peenemünde would still go out to sea and catch some fish and even some eel, and eel were very desired because they were fat. You probably, I don't know if you have ever eaten eel? Most people resent it even and don't like it, but in those days we really liked to get a good piece of eel, eat a fat eel. So in that sense we were not too bad off, and if we had met some of our commitments, like delivering drawings, having tests run on time, we even got some extra booze rations, so we were normally not too short in booze. And I worked with Mr. Heller who actually was my first boss at Peenemünde, and he was a chemist and he knew how to take our ethyl alcohol and to make it into pure alcohol so you could make all the booze you could think of, and we normally made moonshine or something like that. We added a lot of taste to it, and so we had plenty of booze all the time. So in that sense we were not too bad off in Peenemünde. It was probably much worse all over the rest of Germany.

Neufeld: What was the effect of the air raids that you went through there? Of course the first one is well known, the first major air raid.

Dannenberg And that's really the only one I have in mind. I know there were some others, but they apparently didn't do too much damage. And even the first one really did not disturb the test area. The test stands are built for explosions, so you had to replace a few steel girders but that was a very minor thing. The assembly shops, they were badly damaged, so you couldn't use them any more. And also the living and the working quarters, where the engineers were located, and where people lived. They were badly damaged and that was of course in itself a relatively bad incident. After the first bomb raid, the one in August, '43, up to that time I lived on the base. We had a house of living quarters there, House 30, and Rees lived there, I lived there, von Braun lived there. He may have lived in another different building, but a number of people lived there. But the house was destroyed pretty badly during the war so we had to move out of it and move to the rest of the island of Usedom. I lived after that

time in Kolpingsee, another small little village, and that's where we also had finally our design offices. Design offices and also the blue print machines in order to make all the large number of blueprints. And that of course delays the whole thing, ja, to make this move, to set up the new equipment. We had to get new equipment. We couldn't salvage all the old equipment. That was a delay of several months, I would say. No, not so much in the production. The production was going, and maybe with the exception of some drawings that people didn't have, they could proceed and they could do whatever they did on their own. But for the personal lives, it was quite an interruption. As I said, I had to move to another location. The officers had to move. And so I think it delayed the research and development part of the work for several months. I mentioned earlier, the biggest loss in my opinion was really the death of Walter Thiel.

Neufeld: Yes, I think in that raid they really intended to attack the settlement. Therefore were too far south to drop much on the test stands.

Dannenberg Hm mm.

Neufeld: So you didn't notice those other raids? I gather in 1944 you had some daylight raids from American bombers?

Dannenberg Well, we had raids all over the country all the time. Yes, it was nothing unusual. You went in the bunker, you waited until it was over, and everything was back to normal again.

Neufeld: Was that disruptive in terms of work load, the air raid warnings?

Dannenberg Well, of course, during the daytime raids you had to go in the shelter, and people normally were encouraged to do that, not to stay at their design boards or in their offices. So in that sense it was an interruption. On the other hand, I don't think it had a major effect. Because again, the production work was going on somewhere else anyway. So we didn't do all the new developments, all the new work that we otherwise possibly could have done. But I don't think that that ever affected the whole project in any major way.

Neufeld: Okay. ...

Dannenberg Did I mention Prasthofer earlier? I think you don't have him on the list right now. He first went to France and worked with the French for a while, after Peenemünde. And he was just a design engineer in Peenemünde, so he may not have a lot of specific information you are interested in. I think Heimburg has some pretty good overall information. And von Tiesenhausen you mentioned earlier in the area of ground equipment. He worked in that area, and he's also a pretty good and pretty fast talker.

Neufeld: Okay. Now, as far as the question of finishing this up, did anything stand out about the last few months at Peenemünde? Then late '44, early '45, was it more difficult to operate at that point than ever?

Dannenberg It became more and more difficult, particularly also in the production area. We also had very often shortages of parts, and of course even if just one part you don't get in from all the thousands of parts you need, you have to hold up your production line. And that happened quite often, and it was not too bad in Peenemünde itself, where I was still located and stationed at that time. Of course we didn't get an awful lot of new research and development work done, so that was certainly also slowed down quite a bit, and towards the end of the war, I even think starting early in '44, most people became convinced that Germany had lost the war. And that of course really depressed the spirit, and people planned more for, well, what are we going to do next? What are we going to undertake once the war is over? And there was finally an arrangement, I think it was basically even arranged by the SS, to take 500 of the key people and move them south, move them to southern Germany, to Oberammergau, Garmisch-Partenkirchen, and that happened in--let me see, my son was born in March, and I could not go on the train because I got permission to pick my son up in Jena. He had just been born in Jena. He was only a week old or so, and I moved him with my wife whom I picked up and she also worked in Peenemünde. In fact, she was Thiel's secretary when I met her and later on she was also Riedel's secretary after Thiel had died. And she was therefore also on this list of people who were supposed to come down to Garmisch-Partenkirchen, so I got permission to buy an automobile. I got gas rations, I think they were rations from the SS, gasoline rations I mean, not food rations, so that I could buy the necessary gas to drive down there, and then I joined the group again in Oberammergau, and the other people had in the meantime moved on by train, a train which transported about 500 people down there, 500 of the key people, and the intent was of course, it was known that the Russians would take over Peenemünde, and the Germans never were too much in favor of Russian contacts, so there was a very great desire to get out of Peenemünde and to join this team. So really you didn't have a lot of a problem to get the people on the train and to ship them down. Of course some people were living in the Peenemünde area. They were farmers initially in that area so they were not too anxious, but I think most people moved down, once they were on this list. And then when the war ended we were located in Garmisch-Partenkirchen and the initial intent was even to set up a new design and even production facility in southern Germany. The SS wanted to make a last stand in the Alps. Festung Alpen, the Alp fortress. And of course we all realized that was hopeless. There was no chance to even start the design work. I was still in charge of the design group at that time, so I went around to Messerschmidt who had a plant in that area to borrow

some drawing boards and some paper, and we finally got some of these things. Well, of course we never really got to the point where we really did some meaningful drawings.

Neufeld: So then you never went to central Germany first, because the initial--

Dannenberg --Well, we, all travelled through central Germany--

Neufeld: The initial evacuation was from Peenemünde to around the Mittelwerke area.

Dannenberg Many people moved to that area of course, also partially to support the production going on there. They needed skilled labor, skilled people who knew about it, and so many of them were for that purpose moved on to Mittelwerke. I think there was never really a planned move like the one to the south of Germany to go to that area. At least I hadn't heard about it.

Neufeld: Well, that was my impression of the way things worked but it may have seemed different to you at the time.

Dannenberg Many people moved to that area because they were needed in the Mittelwerke. And also von Braun had, we have now a problem, he had established a Fertigungsaufsicht group of people who went to the companies, who were sure they had the right drawings, they built the right parts, they were responsible basically for the acceptance of these parts and for the shipment to Mittelwerke, and many people were in that group, and in most cases they worked finally out of Mittelwerke, so quite a number of people may have been moved down to that area for that reason, for that purpose.

Neufeld: But as far as your experience was concerned, you stayed behind in Peenemünde long enough--

Dannenberg Right.

Neufeld: You eventually went straight to Bavaria?

Dannenberg Right.

Neufeld: Without stopping off or being based?

Dannenberg Well, I certainly didn't spend any long time. I probably drove through that area, just right from the path from Peenemünde to southern Germany, I might even have had a few duties, to deliver a few more drawings or something like that. I don't have any special recollection of it. Then I picked up my son in Jena, which is also in that general area, a little bit

farther south.

Neufeld: I've been there, yes.

Dannenberg And then I traveled with both of them to Oberammergau.

Neufeld: This would have been in April, I assume? Okay, we'll finish then. So your recollection is that it was in March that you left?

Dannenberg It was definitely March. My son was born on the 25th of March, and I was shortly after that in Jena. Well, it could have been really early April.

Neufeld: The first week of April.

Dannenberg Yes, that could be. That could be.

Neufeld: And you went then directly to--

Dannenberg To Oberammergau.

Neufeld: To Oberammergau.

Dannenberg And of course at that time we were still not under confinement, so to speak. Later on we were put in a German army barracks, they were not really barracks, they were pretty fancy buildings, Kasernen, but the first month or so we were on our own, as I said. We were supposed to establish new design offices, eventually even new manufacturing facilities, and that was the purpose of this, the announced purpose of this move down to southern Germany.

Neufeld: You were not up then in the hotel where von Braun--

Dannenberg --That was a very small group. That was only von Braun and about another five or six people or so. Von Braun's brother. Lindenberg was with him, Dieter Huzel, who wrote the book, and two or three others, so it was a relatively small group.

Neufeld: Yes, so at the end of the war you were still in Oberammergau.

Dannenberg Right.

Neufeld: With the design group that was sitting there. Was it tense at that point, in terms of, you had to worry about the SS and what they were going to do at the very last days of the war?

Dannenberg And our big problem was of course we had lots of SS

papers. As I said, my gas coupons were being issued by the SS. So all the people down in that area, they all thought we were SS troops, and at some time, a number of us were already lined up on the wall and people wanted to shoot us. Americans even. The Americans had taken over already and they wanted to shoot these bad SS people. And then at the very last minute somebody showed up and said, "Well, don't kill these people, they are from Peenemünde. They are the rocket people, and we want to talk to them first." So we were not shot at that time. Schilling was in that group with me. And Zoike, I don't know if you've mentioned the name Zoike already. He was running the valve laboratory at that time. So in a way, to answer your question: yes, it was tense, it was very tense, but actually after the war finally really ended, you really didn't know what was going to happen. We didn't have rations in Peenemünde. You didn't need rations. We could eat in the cafeteria. So we didn't have an awful lot to eat, and my wife with a little son just two weeks old, she didn't get enough milk, enough all the good stuff you need for little babies, so that was a relatively tough time. And then after the Americans had taken over, some of them apparently were even pretty hateful, which you can understand, at the end of a war, and they even collected all the food which was available in that area, and you probably know they make a lot of pot pie and cheese and things like that, they pile it up all in one big heap, pour some gasoline on it and burn all the food. That made the people of course really mad. We didn't have enough to eat in the first place, and now they even destroy these few parts, these few pieces we still had left. So that didn't exactly help for good relations. But apparently that was one of these incidents and I think in the long run it disappeared again. I think from the very beginning the relationships with the Americans--and that I think were even French troops, French colored people. The French had a number of colored armies and they did this, so we probably were even more mad at the French than at the Americans. But the Americans finally came to the places where we worked. We were initially not in the--because the army--you know, we were distributed all over the country, but we were finally picked up by American jeeps and then taken over to Oberammergau to Garmisch-Partenkirchen where we had the army barracks where we finally were housed, and where we finally got the information that we would be offered a contract. Now, I myself went first up to Cuxhaven, you probably heard about Operation Backfire, so I was picked up by the British in Garmish-Partenkirchen. They took us by trucks to Cuxhaven, and we launched three V-2's there in Cuxhaven for the British. And then at that time, the contract was written with the Americans, and my wife signed for me because I was in Cuxhaven, when the contract was offered, and maybe that's where you got the idea that a lot of people were living in Nordhausen. The initial army contacts were made in Nordhausen. I think also the contracts were signed in Nordhausen. My wife was living at that time close by in Eschwege, which is not too far from Nordhausen, and she finally was contacted by von Braun

and she signed for me that I was willing to come over here, because she knew that I would be interested, so she didn't even have to check with me.

Neufeld: Why would you be interested?

Dannenberg I was always interested in rockets, and there was not much going on in Germany at that time. Germany was kaput. And I didn't have a job. My job was really in Peenemünde. Even the VDO where I was working before, they probably had to start from scratch again. And I was basically interested in rockets, as a number of people were who came over to this country.

Neufeld: And you didn't really feel at that time, it's hard, you have to think back, negatively about the United States as such?

Dannenberg Well, in a way, when, in the last days in Peenemünde, we already philosophized quite often, well, what is going to happen after the war? And one of our favorite subjects in the discussion was to eventually come to the United States and to keep on building bigger and bigger rockets here in the United States. So we really, we were certainly not antagonistic, and I think in a way our early dreams even really finally got being fulfilled. And also von Braun, I think von Braun had very well planned the whole thing through. Although the transport was arranged by the SS, but von Braun went along with it, and many people have told us that really the main purpose of the SS was to use the Peenemünde group, the von Braun group as a negotiating token, so that the SS people could save their own lives by making this group available. Now, again von Braun was always a pretty good negotiator. He finally got completely out from under the reach of the SS, so we made the contract with the Americans directly, directly from von Braun, his brother who spoke really the best English of the whole bunch at that time. He really had most of the discussions. And the SS was not a part of it at all. Dornberger? was also with von Braun, as you mentioned earlier.

Neufeld: As far as your discussions then about possibly going to the United States are concerned, when you were in the last phases of Peenemünde, was that a discussion that had to be kept in a fairly tight group?

Dannenberg Oh yes. You talk only to your very closest friends about that.

Neufeld: That's the kind of talk that lands you in a concentration camp.

Dannenberg Right. Definitely. So you didn't talk to strangers about it at all, and even among our closest friends we were very careful about talking about these things.

Neufeld: How small was the group that was discussing that, or was it just a bunch of, small group of friends talking to each other?

Dannenberg Individuals, I would say. Individuals talking to one another.

Neufeld: Not any kind of core group around that was involved in that.

Dannenberg No. No.

Neufeld: So it was just a--so that's interesting in terms of seeing just where the idea came from and to what extent von Braun was planning to try to use that.

Dannenberg Well, von Braun certainly did quite a bit of that planning, and it fortunately worked out all right. Again, I think it shows you a little bit the wisdom of von Braun, even in these non-technical areas. He normally knows which way to go and ultimately makes the right decisions.

Neufeld: Okay. Is there anything else we should cover? I guess it's late enough, though, we should just stop at this point.

Dannenberg Right offhand I can't think of anything else. If I can maybe I can still contact you?

Neufeld: Yes.