NASA MSFC Oral History Interview
Steve Johnson Interviews – Apollo/Saturn Program

George von Pragenau
Interviewed by Steve Johnson
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Steve Johnson: I am talking to George L. [Landwehr] von Pragenau who worked at Marshall Space Flight Center from 1960 to 1991. He also worked with the Army Ballistic Missile Agency from 1957 until they moved to Marshall in 1960. Mr. von Pragenau, could you talk a little bit about your education, what prepared you to be in the Space Program?

George von Pragenau: Transistors, which I learned on the job in Vienna, Austria. In the 1950s, the transistors came out from Philips Eindhoven transistors. They got crazy as an electronics engineer, transistors, because of the freedom they had in designing circuits. That was of interest to the U.S. [United States] Army at that time because it was essentially to be used on American rockets. Therefore, I had the opportunity to go to [sounds like "Ratpat"] or come to Huntsville [Alabama]. A professor of mine, who I loved very much, surprised me with a phone call one day and said, "George, are you interested in coming to the United States?" I said, "What? I will think about it." It was a very terse communication, I was living in the Russian zone and he was in Vienna.

Johnson: This was the Russian zone in Berlin [Germany]?

von Pragenau: In Austria. It was surrounding Vienna. Vienna was my university. There was a train back and forth.

Johnson: Your university degree, what would that be in?

von Pragenau: There was an M.S., master of science degree, in electronics and electronics communications.

Johnson: You are in Vienna. You are in the Russian zone. Where do we go from there?

von Pragenau: I was actually very happy with the phone call. I put my name on the list with the embassy in Vienna, the special project team picked me up, and then they offered for me to come to Huntsville or go to [sounds like "Ratpat"] in Dayton, Ohio. I chose Huntsville for a very practical reason, I knew there was a German team, which I did not know personally, but they spoke German and in Austria we speak German too, though in a dialect, as you can tell. If any German would listen to this interview, they would say this guy is from Bavaria or Austria. That is the way I got rolling.

Finally, I got my ticket just before Sputnik was launched. Before that even, the Germans got their permission from the ABMA [Army Ballistic Missile Agency] here to check me out in Vienna [to see] if they want to have this fellow. They checked me out and said okay. Transistors were a brand new technology in the amplification in low frequency signals. I was an easy pick. I got the ticket to join the ABMA. I worked initially on transistor development and had great fun with it. At the same time, I had a bug for flying. I flew as a teenager in the war. When the war ended, I was eighteen years old.

Johnson: What did you fly in the war?

von Pragenau: I flew primitive gliders and more sophisticated ones. I loved flying. It was in my blood because as an eight year old, I saw the rich Austrians flying near my home village. On the Hungarian border, there was a hill, and the rich kids from Vienna came out to fly those things with a bungie cord. I was bitten by the flying bug quite early. When I was a teenager, the war had started, Austria was occupied in 1938. The school kids said, "Yay, no school." For three weeks, they had no school, but we were under occupation. Things changed drastically. I was in a village across a little river. Next there was a bigger city which had the national airfield and Hitler landed all kinds of planes there, bombers and even giant glider things, but also his Messerschmitt Bf 109, which were the successful German fighters. I had the opportunity to volunteer for the

German Luftwaffe, which saved me from going to the Eastern front, for example. I was eighteen years old when the war ended. Nevertheless, I had the opportunity to fly gliders because of that. That was fun.

Johnson: You were essentially a trainee pilot.

von Pragenau: Yes, there was primitive training and I flew the glider. By the rumor mill, I knew they wanted to train us for rocket planes. I praise God that never happened. The war was over.

Johnson: You wanted to fly. You were an expert in transistors, and you ended up with the Army Ballistic Missile Agency. What did you do when you first got to ABMA? As you got to transistors, what were you doing?

von Pragenau: I was developing the circuitry. I think Raytheon has some copies of those. They were elements of PNP [Positive-Negative-Positive] and NPN [Negative-Positive-Negative] transistors, and I had to build the frequency standard with transistors, temporarily compensated to frequencies stayed constant, and I was a builder of high voltage generator, of these transistors, which was really the crown of my actions. (Laughs)

Johnson: Were you trying to figure out ways to replace vacuum tubes in these same type operations?

von Pragenau: Not directly.

Johnson: The circuitry you were designing would replace more cumbersome circuitry?

von Pragenau: Absolutely, more reliable was the transistor than any tube.

Johnson: You were with ABMA for three years before you moved to Marshall. Why did you choose working in the missile program to working on space travel?

von Pragenau: I did not have a choice. The whole group who worked under Dr. [Walter] Haeussermann, who was on the German team.

Johnson: What was Dr. Haeussermann's first name?

von Pragenau: Walter.

Johnson: Walter Haeussermann. You were working for him.

von Pragenau: Not directly. I was in a branch and he was the lab director.

Johnson: The lab moved?

von Pragenau: The whole lab was moved to NASA [National Aeronautics and Space Administration].

Johnson: You go to NASA. What are you doing?

von Pragenau: I was still in electronic circuitry development, but then, I told you about the flying bug I had. That summer I wanted to work on advanced rocket configurations for space flight. There was a Dr. [Heinz-Hermann] Koelle from the German team.

Johnson: What was his first name?

von Pragenau: Hermann. He also was the one who checked me out in Vienna. He was an inspiring type of a person with new stuff and I wanted to join him. My lab director said, "No, I need you right here. You cannot move." Then he said, "You can move over from electronics to flight dynamics," which I did.

Johnson: Very quickly, explain what flight dynamics are.

von Pragenau: Flight dynamics talks about hydraulic actuators, which move the rocket engine, will swivel the rocket engines, for example, and how you filled it electronically to make sure the rocket is stable going up. This was the Flight Dynamics Branch.

Johnson: Then you got into the kind of work you would do during the Saturn V Program.

von Pragenau: I could not resist using mathematics. I love math. The Germans had started to make tests on the Saturn I space vehicle, which is still standing at Marshall. It is the very first 100 million pound size vehicle. We had beat the Russians already. They put them on cables to have all degree of motions. The cable system was not so good. At that time, I opened my mouth and said, "If this springs off into an axel direction, this vehicle will never be stable because you cannot test like this." I gave them the stability calculation. From then on, I was appointed director of dynamic testing. Then there was the big Saturn V. The big Saturn V had six million pounds of lift off weight. To jump right away to the end result, I could put six million pounds per head because, by the grace of God, I could invent this dynamic launch pad. It is like a launch pad on the Cape [Canaveral, Florida] except this one permitted all kinds of motions.

Johnson: We are basically talking about how you controlled the gimbaling action of the rocket nozzles to aim the rocket, so to speak.

von Pragenau: Yes. I told you earlier that my master's degree was in electronics. How does a guy like this fit into rocketry? I was not educated in rockets. My education in Vienna had fluid dynamics, atom physics, stress analysis, mechanical engineering, everything in there. I had a broad education and I could use every bit of it when I was facing rockets here. My fiercest situation was on the Saturn I. The Saturn I is eight H-1 engines, four of them are gimbaled, four of them are stationary. In the center they are stationary, on the outside they are gimbaled. The gimbaled H-1 engines were of great interest because they stabilize the rocket. We had them sitting on the launch test tower and the rocket engine, even cold, was unstable. I could keep the handle, it was ratting around. Even though I was not a rocket expert, I looked at the data and could identify what the problem was. The German team made the corrections, stiffening certain things up. From our hydraulic people in the Astrionics Laboratory, they made corrections on the actuators to be sensitive enough to the angle of motion. This was my first, let us say, feather in the hat of a rocketeer (Both Laugh), to identify a problem as a rocket engineer.

Johnson: Figuring out a way to stabilize a rocket is awfully important. Did that same work continue as we move to the Saturn V?

von Pragenau: That is right. I went to bigger pieces. The first big piece was to invent this dynamic launch pad with four elements like on the Cape, except this was a special one where we made all motions, up and down, friction free, left and right and up. We had to simulate free flight on the ground with six million pounds. It was a tough, tough job. By the grace of God, everything worked, the slide rule was used for sizing all the elements.

Johnson: No computers, slide rule.

von Pragenau: I had a 1965 computer, but initially it was the slide rule and every part was designed at the Martin Marietta Company, built that thing in no time. In one year we had that thing up and running.

Johnson: Did you have to do a lot of live fire testing to test the gimbals and the processes you came up with?

von Pragenau: I was involved a little bit with tests, but the hot test, I was not much involved in it except when I left NASA.

Johnson: Essentially, you came up with the ideas and the test guys tested your equipment.

von Pragenau: The test guys put the Saturn V in the biggest test stand they have. With big cranes, they set the first stage down, the second stage, and the third stage down, the capsule and everything, to be configured. The prototype you have in the Davidson Center is the vehicle which we used for testing. It was essential because it was involved with Langley [Research Center] because Langley had built some scale models of the Saturn I. You are losing some fidelity when you scale down.

Johnson: You are talking about scale models that can actually be fired for testing?

von Pragenau: No, this is all cold, all dynamic test models. The rockets have several models. There are wind tunnel models, they are rigid, nothing is moving there. They are scaled down, you learn about the shock waves and the vent forces, and you can know how to scale them up and scale them down by the theory behind it. You also have scaled models in the dynamic area. It was a brand new thing to do, dynamic testing for big space vehicles.

Johnson: Could you explain the phrase "dynamic testing?" What we are talking about?

von Pragenau: Dynamic testing is setting up a vehicle on the ground but simulating free flight in its stable orientation. It can freely move. The free flight quantities would not be changed the way we have it on the test stand. That was the idea. Then you put shakers on it and shook it, scanned the frequency range, and found out the bending resonances so you could build accordingly to control loops without regenerating those simulations.

Johnson: Dynamic testing, I am assuming the methods of doing these things and the designs you came up with were proven by the testing.

von Pragenau: By the testing, that is right.

Johnson: Did the testing proceed? Was this the kind of thing where you test it and we are done or did testing continue over the Saturn V years?

von Pragenau: No, before the first liftoff, we completed the tests. There was no retesting, except the upper stages were tested also when they took the first stage off. The second stage was used in the same test equipment, which was used for the total thing. It was not six million pounds anymore. It was in the order of one million pounds. The second stage has five.

Johnson: In all the different stages when you were figuring out how to make the rockets do what they were supposed to do with the gimbaling, what was the main challenge to making things work the way you wanted them to?

von Pragenau: I think designing the testing was the biggest challenge because you wanted to do it frictionless. When you do something frictionless, you are crossing the border over to unstable because zero damping is the weapon in unstable and stable. Stable vehicles always posit the damping. This was the challenge, to design a test which would be sure to disturb the vehicle so much, by its weight, for example, because the piece that was used on the dynamic test had weight. I was proving before the analysis with a report which was published in 1966 at the AIAA.

Johnson: AIAA, what is that?

von Pragenau: American Institute of Aeronautics and Astronautics.

Johnson: Did you have to develop any new tools or materials as you came up with these processes?

von Pragenau: It was new stability criteria to have to come up with, which I tried to prove to my boss, I told him the system was naturally stable. He did not buy it. He was a professor type, Dr. Haeussermann. I would give him proof, so I came up with proof that when you put the two systems together, they will still be stable. That was a new step. The other new step was with thermodynamics, which still has to be published yet, but I still have to do some more in that area. In thermodynamics, we are still amiss today, thermodynamics model for the compression of gasses in one dynamic model. The analysis is fudging quite a bit today and I was inventing a new way to represent the thermodynamics of a gas in the compression. This is what is being said in the subtitle here. (Gestures)

Johnson: By the time the Saturns were flying, you had essentially finished that work. What did you do after that?

von Pragenau: When the Saturn flew, I got quite a bit early involved in the shuttle.

Johnson: By the time the Saturn V flew, you were already thinking about the shuttle?

von Pragenau: No, I forgot one important thing. On the very first flight of the Saturn V, we identified a pogo situation. Pogo is a vertical bouncing of a person sitting on a pogo

stick, a kid, you are pumping your body against the springs. We used the same name for an undesirable phenomenon with liquid rockets. When the LOX [Liquid Oxygen] tank is getting empty, those systems become sensitive to the oscillation of the LOX level and the thrust is responding to it in exciting resonances.

Johnson: We have some vibrations that are not doing good things for rockets.

von Pragenau: On the very first flight of the Saturn V, we knew that we had a pogo problem. I was running the tiger team to work the pogo problem for the first stage and then later on the second stage of the Moon rocket. That was highly interesting for me, being an analyst, loving math. We had to distinguish multiple feedback loops. The most exciting one was actually the second stage.

Johnson: What made that more exciting?

von Pragenau: On the first stage, we had the opportunity of using prevalves on the feed system for the engines. They had lots of volume. When you put helium in there, like an accumulator putting a cushion for the flow of LOX passing by, going through this prevalve. We could attenuate and kill the pogo effect for the first stage. On the second stage, time was short and we needed to go to the Moon. At least I had the analysis. I

showed them, look, the same thing is unstable, but it is not really a heavy issue. They were trying to reason it out, but you cannot. When something is unstable, you had better pay attention to it. We did have instability phenomena. Fortunately, when the LOX gets low before it is completely burned out, it comes out. We did not have any destructions in flight until Apollo 13.

In that case, the second stage was going at sixty Gs [G-force], at twelve Hertz cycles per second. I would say the German team had the sixth sense of intuition. They put each engine chamber pressure, gave them an instrument, pressure gauges in each engine on the second stage as well as the first stage. When we had this, the chamber pressure went so low that the airline cut it and cut the same engine off and saved the day. We could fly with four engines. The German team, they had the sixth sense of a backup, a safety net, to say we can still make it with four engines to orbit.

Johnson: Just burn a little longer.

von Pragenau: That is right. That saved us on Apollo 13, but there was another problem lurking on the Service Module behind the capsule. It nearly killed the crew. Praise God they came back. That was something extraordinary.

Johnson: You have already sort of mentioned this when you said we had to get it done because we were going to the Moon. In the Saturn V days, was it made clear we have to move this right along in all this work we are doing?

von Pragenau: Sure. The success of the Moon flight had several ingredients. Number one were General [John Bruce] Medaris and [Major] General [Holger Nelson] Toftoy. Those generals had a vision for this wonderful nation of ours. They came up with the conclusion that we had to have rockets. That is the reason the German team came over here. The German team was definitely capable, but without the push from General Medaris, they would have gone nowhere. The Moon flights were drawn up under General Medaris in the ABMA. What wonderful things came out of it! We could prove to the rest of the free world that we do not have to have fear of Communism. We can accomplish extraordinary things. That came to Austria. I appreciated it because I was under Russian occupation. I had no sense for Communism. It was my pleasure that I could be a part of that program.

Johnson: With some pressure to get things done, were the hours long?

von Pragenau: The hours were long. The job was number one and you had to do it. That happened on the shuttle too. I would work nights through when they had emergencies.

Johnson: What was the work environment like? With people working long hours, was it still a good environment?

von Pragenau: It was a tremendous environment. The work environment was great because we were all so excited to work on the brand new project, a fantastic project.

Johnson: Was it one of those things where everybody was happy to work these long hours, long shifts?

von Pragenau: It was never discussed. I worked among wonderful Christians in the Army. Those fellows were the most enduring under all the pressures we were put under. Even with my cumbersome English, they still liked me. (Both Laugh) They all influenced me with their wonderful, peaceful attitude amidst the pressure.

Johnson: Let us talk about Dr. [Wernher] von Braun. Did he take an interest in what you were doing in the different areas, first with the dynamic testing and then later working on pogo? Was he involved with all this?

von Pragenau: I am sure it was his concept which came down the echelons that we have to have dynamic testing full-scale. This was enforced because I told you about Langley saying we can make it much cheaper. We scaled the Saturn I vehicle, which is not the Moon vehicle, but they wanted to prove to us the Saturn I model was good. That was in Langley to see what they were doing. All of a sudden there was a reversal of the deflection where the [sounds like "rachars"] were seated in the model. That was bad news because we had done the instability in the vehicle and then it became infamous at the same time. Here from the scale model, we had the prognosis of instability, we cannot fly. I was husting along with the full-scale model here, suspended on cables, not on the dynamic support we had for the Saturn V. The cables were resonating, messed up the data, and I said, "If we put string gauges on it, we probably can eliminate those resonances from the cables to confuse the data, and delay the shot of the first Saturn I two weeks." That was the reason for it and I still could not prove it. (Both Laugh)

Johnson: These rockets, there was a vibration that resonated, there was a lot of movement in something that appears to just be going up. There is movement in there.

von Pragenau: Not to the naked eye, but there are resonances which can be fatal, like pogo.

Johnson: Basically the fuel is vibrating.

von Pragenau: The fuel is vibrating in the vertical direction. That is the reason we call it pogo.

Johnson: Up and down. When you were working all these different things, did how much things were costing ever come up?

von Pragenau: Costs, no, we did not have to prove the costs.

Johnson: You did not have to worry about how much money you were spending?

von Pragenau: It never came up. We just did our best with the money we got, that was it. There was a certain amount of money there and we did our best. There was a whole city of contractors surrounding us to support us, but the big difference was the whole team at NASA knew what they needed, so there was great direction there, no wishy-washy. It was clear we needed to do this, this, this, step by step. We were polarized for

success, let us say. There was a team which knew about bigger rockets and we had to follow suit.

Johnson: Were there dead ends in your work, things you tried that did not work and you had to start over?

von Pragenau: With certain inventions. For example, I told you for this vehicle we had to invent this fantastic support to fight the resonances. I was working to come up with a control method, which is insensitive to the resonances of the vehicle. I actually aggravated my supervisor by saying we did not need to dynamic test. If we had a different kind of logic, a control system, this was under Brooks Moore, my lab director, I made a reanalysis of the attitude of the Saturn V to prove what the new method would look like, but it was not didactic. They preferred the way it was in the mill. On the pogo, I had an academic joy of coming up with new stability criteria in sensitivity. In pogo, there was something else. I came up with a new stability criterium because we had to consider multiloop feedback. It is not a single loop, it is multiple loops. I could help out on that. There was always work forward-looking, get the next difficulty overcome with new inventions.

Johnson: You have already mentioned the fact that you were supported by contractors. Over the years, especially during the Saturn years, did you find the experience of working with the contractors a good experience?

von Pragenau: Yes, I had an excellent team in Baltimore [Maryland] from Martin Marietta, and I enjoyed working with them. Gordon Scholls [Spelling?] was the project engineer and Dr. Heshbeth [Spelling/First Name?] was also there, a genius. I enjoyed talking to the genius at Martin Marietta. In short, there were some people who would throw papers against the stability, which I had, but they did not know what was going on.

Johnson: Talk about the integration of all these different systems that had to come together to make the Saturn V work. As an engineer, as a scientist, was it amazing to see all these different aspects work to make this incredibly complex vehicle do what it was supposed to do?

von Pragenau: I was not at a high level. I was an engineer and I resisted any invitation to be a manager. Engineering was my favorite. I was heavily focused on what I needed to do, and the joy of working together with the contractor, it was always fun to work with the contractor. This was absolutely necessary. At the same time, there were people

coming into the organization from outside, consultant types. Those would check me out on my work, but there was nothing on the hydraulic test stand, nothing came back off that. Those people always talked to me about, for example, the first stage, second stage and the common bulkhead between the LOX tank and the hydrogen tank. They told me I should pass it on, this is a very sensitive technology, so I passed it on. We did not have the things, so we invented them to get over it. That was my approach. I appreciated the supervisor I had who let me invent new things.

Johnson: How did you feel when the Saturn V finally flew? Let us talk after pogo when you had fixed the resonance problem and the Saturn V flew and it was a successful flight. How did it feel to know you had been a part of that?

von Pragenau: I did not have too much time to think about it. My dear wife, she is upstairs, we started a new family in 1962 and there was a lot going on. We were having another girl, so there was a lot going on in the family. My dear wife had very little of me being so much tied down on the job that was fascinating for me. She wanted to [inaudible, sounds like "double two"] when I came home. There was a lot to do at home and that took a lot of time to do work at home to follow through with the things I envisioned to do.

Johnson: What you are saying is you were busy.

von Pragenau: I was busy. Then I was called to the tiger team for the space shuttle because of the hydrogen pump on the orbiter main engine.

Johnson: After the Saturn V days, you moved over to work on the shuttle in the early days, what were some of the first problems you encountered working on this new spacecraft?

von Pragenau: From my experience from the Saturn V, I was looking at the orbiter thrust frame with the three engines attached.

Johnson: Those are the Space Shuttle Main Engines?

von Pragenau: The Space Shuttle Main engines, and I had a big concern about the softness of it. I mentioned it to my supervisor at that time, which was Mr. Bob Ryan, division chief for the dynamics, vibration, all of these things. I changed from my Astrionics Lab to 4610, which was the mechanical engineering group. I did not join the aerodynamics guys even though I had some business with the wind tunnel, but I did not join them. I worked with the vibration guys and there I had the encounter of

wonderful analysis I could do. For example, on the Solid Rocket Motor, the Solid Rocket Motor was a thrust vector control and they had a very ingenious way to suspend the nozzles. It was invented, I think, with the rocket company. I was able to analyze it with the help of a computer. That was important because I could identify what the irritation point was for the nozzle because it was not visible. It was an open throat. There was a rubber package suspended in sheets. I learned a lot. At the same time, we had explosions in the Space Shuttle Main Engines. I had to fly out with the team to Rocketdyne to investigate those explosions and identify what was going on.

Johnson: Did your work on the Saturn V help you with your work on the shuttle?

von Pragenau: Only in the orbiter's thrust frame. When it came to dynamic testing, I was replaced by another gentleman, Jack McPherson [Spelling?], to supervise the dynamic testing using the aerodynamic support, which was built for that and used for the space shuttle. I loved to work on the space shuttle because it was dynamic and the most challenging thing we ever built, with all its many clusters of things.

Johnson: Did you like the design of the shuttle? As an engineer, did this design seem appropriate to you?

von Pragenau: I do not want to be high-minded. I just had a thing for space vehicles. Remember, I asked my German boss if I could move to the advanced system guys, dynamic design, and he did not let me. When I saw the shuttle there, right away I tracked it to a few points. The Solid Rocket Motors were a big concern for me, so I made proposals. Before the shuttle was built, I made a proposal to get those engines close together, the Solid Rocket Motors, so they would not have such a big turnover moment in yaw. Then the control guys, they got crazy when the project team suggested we should not have thrust vector control on the Solid Rocket Motors. It was not my responsibility, but I am glad I had an influence and moved the Solid Rocket Motor people to put thrust vector control on the Solid Rocket Motors.

Johnson: So they could actually gimbal?

von Pragenau: They could gimbal them. They are forty feet apart. The cast is cast only once in the solids and they have to have a little tolerance. Too much and they have a terrible moment. The thrust vector control can cope for that safely. Those things occurred tangentially. They moved me to make suggestions for reconfiguring the shuttle before it was even built, and moved the Solid Rocket Motors closer together. Those were laid out just before the *Challenger* accident. I was already working on getting more payload out of the shuttle.

Johnson: Learning to get rid of some of the weight and replace it with payload.

von Pragenau: Yes. For example, the Solid Rocket Motors, they give thrust all the way up below the LOX tank of the External Tank. The thrust frame in the inter tank is lodged in the External Tank. When it dropped the Solid Rocket Motors, you cannot drop the thrust, it is already stuck in there. We lost 25,000 pounds of payload because of the design, because of the way the thrust was generated. In other ways, the shuttle was very efficient having parallel staging, but at the same time having hidden thrust frames in the External Tank lost us lots of payload. That is what I learned. Then it came up just before *Challenger* on how to improve the payload situation.

Then the *Challenger* crashed. I could not believe it. I was sent to Washington [District of Columbia] to get the Inventor of the Year Award for stabilizing the LOX pumps in the Space Shuttle Main Engine. Director Jack Lee knew about this. When I got this award, I already had a proposal for the upgraded shuttle to pass on to astronaut [Richard H.] Truly, who became the administrator because of the *Challenger* crash.

Johnson: What did you do after the *Challenger* disaster?

von Pragenau: I gave them the proposal for the updated shuttle to gain more payload, to limit the failure chain from the *Challenger*, like the chilling of the Solid Rocket Motors. Not only this, I also came up with a replacement for the rubber seals. I flew out to Thiokol to present them with the twist seal, which avoids rubber seals.

Johnson: Did you help with the redesign work at all?

von Pragenau: I had a unique design, which I presented. I analyzed it, that the twist seal would work and would be a solid seal, not a rubber seal. Thiokol came up with their own design changes and that is what they did, using rubber seals again. However, the double clutch prevented the hot gasses from reaching it. They appreciated what I did. I would have liked to have more input than that, but that is the way it goes. You do your best.

Johnson: You continued your work on the shuttle after we returned to flight?

von Pragenau: Yes, absolutely. I was involved in the recertification of the Space Shuttle Main Engine. We stayed out at Rocketdyne for two weeks to make sure the Space Shuttle Main Engine was okay. We had to ask them because the Solid Rocket broke loose and blew up the LOX tank.

Johnson: Compare, if you could, how the work felt during the Saturn V years as opposed to how it felt during the shuttle years. Was it the same at Marshall? Did it feel the same, or did it feel different to you?

von Pragenau: As I told you, I was such a busy guy. (Both Laugh) In the shuttle days, I reached a point where I finally decided to retire.

Johnson: You got tired of being so busy?

von Pragenau: No, that was not it. As I told you earlier, I was interested in flight configurations and that took hold of me somehow. I am still busy today. Today I am proposing the limited Shuttle.

Johnson: You are still involved in the future.

von Pragenau: NASA has not picked [it] up yet. This was the proposal submitted to Headquarters. I am jumping ahead too much here. I retired twelve years ago from NASA. The main reason was the upgraded shuttle was my proposal to improve lots of the space shuttle fleet, flexibility, much better payload, and a few launching to Space Station.

Johnson: Sounds like there might have been a little frustration that you could not get.

von Pragenau: The frustration was I worked on the seal, which really saved the day when we chewed by the ball bearings in the LOX pump on the test stand. Rocketdyne was running 3000 second tests in tandem on the West coast to prove the Space Shuttle Main Engine could do it, not knowing the ball bearing was already ingested, was gone. Remember the damping seals, the damping seals were damping bearings. They took the function over from the ball bearings and carried the rotor safely. The ball bearing was gone, did not cause any fire, was chewed up and passed away on the pump. Before I left, I made the proposal of why not fly without the ball bearing, we do not need it, we can use the damping seal. On that note, I left NASA. I went to work on the United Space Fleet, I called it, and wanted to present it to the AIAA and was forbidden to do that. I knew it was time to leave.

Johnson: Did you realize working on the Saturn V, and even the space shuttle, that you were part of making history? I know you were busy, but did you understand that history was being made?

von Pragenau: No, I only understood that I grew in proficiency, that I was able to discover new things, that was my reward. My reward was to come up with the hydrodynamic test stand and come up with a new law in thermodynamics, which in this very day is not being employed. I need to work on that. I wish I could have more input with NASA, with Marshall, they could pick it up and make it a big thing. Efficiency in thermodynamics means a lot of Cadarache savings. We could do a lot.

Johnson: You are basically saying the more efficient we are with thermodynamics the more efficient our rockets would be?

von Pragenau: Not just rockets, the whole industry will benefit from it.

Johnson: The space industry?

von Pragenau: Not just the space industry, everything with thermodynamics.

Johnson: Working with heat.

von Pragenau: Heat, that is right.

Johnson: You did not quit when you left NASA, but when you look back at your NASA career, what jumps out at you? What is the part that you think "that is what I feel best about?"

von Pragenau: The damping seals and the support for the Saturn V. There were a lot of things in there. Real progress was made, even if not fully recognized.

Johnson: Does it ever seem a little amazing to you that a guy who started out working on transistors in Austria became such a big part of America's going to the Moon and building an International Space Station?

von Pragenau: I have to give honor to God because I came from a country which is traditionally bound and the relation ritual means everything. I grew up among Catholic sisters and they prayed for me. That inspiration, miraculously healed, loving the whole world when I woke up in the morning. Something happened to me, but the bigger thing that happened to me was when I came to the South, I found people who worked in the heart, not in their head. That really touched me. Because of this, I was encouraged to stay on regardless of difficulties. I appreciated the immense blessings the Lord gave me to invent things. There is this tremendously important mixture which I would recommend to everybody, do not get tired, but think about the Lord helping you along

with getting things done and enjoy it while you are doing it. I wish a few things would have gone differently, but I am just one man. Interestingly enough, I started a one man company in 1995 called Provident Technology. Under that I got contracts with NASA working damping seals, testing again. I had two contracts and the last contract was a purchase order. I could report on it and revive what I did forty years ago in my old age with the help of computers.

Johnson: Things have changed a lot from the beginning to now, have they not? (Both Laugh)

von Pragenau: They surely did.

Johnson: Slide rules were the thing and you moved into the computer age. Did it change everything?

von Pragenau: Yes, I would make one comment, the creativity issue, the independent thinking. We can do tremendous things with computers, no question, but the thinking is still left to us personally. There is a great temptation because of computers to think to play computer games is an accomplishment.

Johnson: You need to remember how to use a slide rule.

von Pragenau: I do not use a slide rule anymore, no question, but let us not forget that we need to deeply search at the inset of us to bring some creative thoughts out. That is what I mean. We cannot neglect it. Each person is so important and we appreciate each one of them. Sure, we bring computers into it, but this is not everything. We are blessed with computers, tremendously blessed. At the same time, let us not dry up our creative moments. You still have to be ready. For example, in the bigger organization, what is happening is we are getting directions from NASA Headquarters and there needs to be a certain independency in the center to really come up with independent research, and they do. When it came to launch vehicles, I think we slipped. I can only say this because I was intensely involved in it. When I made proposals, I got support from certain areas within Marshall, but the bosses they thought they had the power to give the input that counts.

Johnson: That was a change from the Saturn V days.

von Pragenau: In a sense because von Braun, even though they knew what they needed to do, he was open to changes, especially when Langley came up with the proposal to

change the Moon staging, flying directly to the Moon, he was open to it. There was an appreciation of someone else's ideas.