

**INTERVIEW WITH ROBERT SCHWINGHAMER
INTERVIEWED BY STEPHEN P. WARING
16 AUGUST 1990
HUNTSVILLE, ALABAMA**

1. WARING: How would you describe the relationship between the laboratories and the program offices in the sixties?

2. SCHWINGHAMER: Well, I think that we have always been a matrix-overlay organization and not totally "projectized" in the sense that the projects depend on the Science and Engineering Directorate to get their engineering and scientific skills. Therefore, they do not staff up their projects with engineers and scientists because they draw on this big pool of science and engineering of which we are a part of here.

That matrix-overlay was already in place then and has persisted and continued since then. That worked reasonably well. In fact, I went away in 1967, in June, I spent a year at MIT on a Scoble Fellowship and interestingly enough, I decided to do a thesis. I got a Masters in Management, but part of that you had to do a thesis. I elected to analyze, if you will, I hope that is not presumptuous, but analyze the matrix-overlay arrangement at the Marshall Space Flight Center. I haven't gotten that thing out and dusted it off lately and looked at it, but there were some interesting things that came up. People spent far too much time in meetings, etc., etc., you know, the usual problems. But it did seem to work pretty well. As a matter of fact, it still works very well and pretty much in the same mold.

3. WARING: Do you think there has been any changes in that or you think that it is pretty much the same system? For instance, did the budget cuts in the 1970's change that?

4. SCHWINGHAMER: No I don't think that really the budget cuts influenced that fundamental principle of the matrix-overlay operation. What the budget cuts obviously did do, was trim the manpower significantly. Now that changed it to the extent that certain

luxuries left. Technicians got shorter. Engineers did a lot of their own technician work, which to this day they still do to some extent. I think the strength dropped from, I think our highwater mark must have been somewhere around 7,500 at that time. It is down to a little over 3,000 now. That was rather dramatic.

The thing that really has changed. Back in the 1960's and '70's, we had a few very well defined large projects. It has become increasingly more difficult to deal with more and a whole variety of projects. Some of them are quite large like the shuttle. But we have all kinds of projects going. It takes a certain ability to shift gears and change your thought pattern. Maybe I am speaking a little bit from my own personal experience, but everybody has to have more flexibility to do that. You have to have more storage capacity. You have to remember more things that...

5. WARING: People were more specialized in the sixties?

6. SCHWINGHAMER: Exactly. One could specialize. To some extent probe more deeply. Whether or not the depth of penetration then was superior to the depth of penetration today, I guess that is subjective. I wouldn't want to hazard a guess on that. But it is definitely more difficult when you have more projects under way. You have to remember more. Your memory capacity, whether we are talking computers on the base or your own memory capacity, has to be more exercised and more flexible.

7. WARING: How did people feel when a lot of the machinists and the technicians were laid off? How did that change the way engineers worked in the labs?

8. SCHWINGHAMER: As I say, engineers had to pick up more and do more and more of their own dirty hands things. In more recent times now, fortunately, and by necessity, we

have been able to supplement those resources a little bit with contractor help. We have done that to a significant extent and that has taken the heat off considerably.

You know, you can put engineers doing their own technician work, but it is a kind of a misapplication to the extent that you can get by people with, I don't mean to imply that they are any less necessary, but the engineers obviously can't do somethings that the technicians can. If you put engineers doing technician work, then you are not getting your models developed, you are not doing the higher order mathematical things that they are capable of doing. So that is a wrong split in the skill distribution. But we have rectified that to a great extent by being able to pick up some contractor help.

9. WARING: I have heard many stories about how in the sixties if an engineer or a scientist wanted a model or prototype built, he would go down to the lab and it would be done very quickly. Is it more time consuming, more troublesome in working with the contractor and having them do that sort of thing?

10. SCHWINGHAMER: Well, you know there is just a little more paper involved in the system. If you have contractors by necessity and by Congressional regulations or whatever, laws and rules, you have to keep certain kinds of paperwork. Its a little more cumbersome.

You know if you have a fewer number of people and that makes it more expeditious, you can overcome that disadvantage by doubling the number and still getting the job done and still meeting all the federal requirements relative to paperwork and so on. It is not necessarily solely because we operate that we do the whole thing has become bureaucratically bogged down, you can put a little more effort on it, you have got a few more contractors and still get it done. It's different.

There just are certain things that you just can't circumvent that the Congress checks and balances that they put in there. Many of them well-meaning in intent, but at time working negatively for us in terms of being able to execute things quickly.

11. WARING: Getting back to the relation between the labs and the program offices. In the very early years of Marshall the labs were definitely top dog. In '61 or '62, with von Braun's management, Marshall Management Policy Number 1, he elevated the status of the program offices. How did people in the labs feel about that? Did they just accept that as a necessity?

12. SCHWINGHAMER: Well you know that was such a gradual transition and done in such a manner that it never really became an issue. I think what you say is basically true. The project manager probably today has a little more freedom to exercise his own initiative and is a little less constrained. But it was such a gradual transition that I don't think that it really ever became apparent or that people perceived that as a problem in getting their job done.

13. WARING: So as I understand it, in the beginning the lab chief, lets say during the Saturn Project, had budget and schedule responsibilities, so as the program offices became more important, he lost that. But that was to be perceived as moving in the wrong direction?

14. SCHWINGHAMER: Quite the contrary, a lot of people back in those days, specifically, we had highly capability, not to imply that we don't today, but those guys grew up with rocketry, from Peenemuende and they were highly confident technically capable. A number of these viewed these administrative details as thorns in their sides. They were glad to get rid of that scheduling and program business so they could get on with the real interesting technical work at hand. That was more the rule than the exception, probably. You have to remember too, that in the very beginning, Redstone days in the late fifties, that team came and grew as a team. The people that von Braun had as lab directors at that

time were old and personal friends that had come through the whole Peenemunde experience and then Ft. Bliss and White Sands thing, then to Huntsville. It was just natural that in the beginning it should be set up that way. But, von Braun, himself, as you have already indicated moved in the direction of the matrix-overlay project office. I sometimes thought that maybe he did that deliberately to give these guys more opportunity to get more in on the technical and not be burden so much with cumbersome scheduling. So it was never a painful transition. Like anything else you can always find a few people that perhaps were personally disadvantaged by the changes. Then they are negative or maybe still sour about it. But across the board I think that it was a painless transition as far as I am personally concerned. That would be the consensus.

15. WARING: It was accepted as being necessary and good.

16. SCHWINGHAMER: Yes and it works very well today. A matrix-overlay is nice. You get economies of scale because you have people that are on top of the state-of-the art and they are really physically, and that is another thing that von Braun always called it. I was going to say physically working, but he called it a "bench-oriented philosophy." If he said that one time, he said it a thousand times. He absolutely wouldn't do without his own in-house laboratory capability, because he felt like a bench-oriented philosophy was necessary in order to be able to judge, if nothing else. Even though you didn't build it with your own hands, you had the judgement, the capability. Things like that help prevent overruns. They don't preclude them, but they certainly help prevent overruns when you have that capability. So, we have always had that at Marshall. Smoking fire and whatever. We like to do it enough ourselves so that we understand the problems. That is in contrast to a lot of other government agencies that do have to depend entirely on the contractor. I think it give us a little better perspective or vantage point in which to judge the relevance of what

they propose, sometimes, the contractors to do. In the long run, it saves the government money and that saves the taxpayers money.

17. WARING: Another important transition in Marshall's history was the movement from propulsion into manned systems, which took its...

18. SCHWINGHAMER: Never quite made it! I was involved there, too!

19. WARING: Could you tell me how Skylab changed the tasks of the center? How was the work different?

20. SCHWINGHAMER: Well, up until Skylab, I guess we really were never much into the manned systems aspect of it. That kind of got us into it by necessity, because once it was elected to build the Skylab, that stage was our responsibility, so we really couldn't be kept out of it. I remember, you know that von Braun was such a gregarious individual. Everything interested him. There was nothing that the man wasn't interested in. He got enamored of manned systems and human engineering. He said, "Boy if we are ever going to have space station and go on to Mars, or to the Moon, we are going to have to understand how these things work." He then initiated a few projects like the Ben Franklin Drift Mission. I don't know if you know anything about it. We had this submarine called the Ben Franklin. We launched it down in West Palm Beach into the Gulf Stream and it drifted on up to Boston. They did all these things. They lived together, made measurements and worried about Florida and etc. He was always into things like that.

Then there was Operation Take #Five down in the Virgin Islands. I don't know if you knew about that. We had an undersea habitat down there for some length of time. The length of time escapes me at the moment.

But he was interested in that because he felt like it was essential and crucial that eventually people would live and stay in space a long time. Then he and Stuhlinger went off to Antarctica and stayed down there just to understand what the complications of living in a cramped habitat and hostile environment. He did all those things.

21. WARING: Is my memory playing tricks on me, but didn't Marshall build sort of a simulated lunar base on one of the buildings out here, where a couple of guys stayed in there for a couple of weeks?

22. SCHWINGHAMER: I think that we had some contracts, notably I think, with General Electric at Valley Forge and did some of that work in that time period that you are talking about. But I don't ever remember that we did our own habitat here.

23. WARING: I will have to check that.

24. SCHWINGHAMER: But, he was very interested in that. In fact, he wanted to get deeper and deeper into that. I got personally involved in that because I just had happened to come back from MIT. He wrote me a note up there one time and said, "Well I guess you are about ready to come back from MIT." Herb Culpson, who happened to be writer for the Chicago Tribune and was very popular at that time. He says, "Culpson says that anybody that leaves MIT with a Master's Degree is a drop-out." But when I got back in, we were getting ready for this whole Skylab endeavor and he wanted to get in there deeper in the manned systems aspect of it.

So they were having great difficulty in developing some of the biomedical experiments. You know, part of it was due to the requirements, the very optimistic requirements the doctors wanted, they wanted it all. But he couldn't do that technology-

wise, you couldn't deliver everything that they wanted. The contractors were balking and they weren't getting their metabolic analyzer built. They were getting...

25. WARING: "They" meaning Johnson.

26. SCHWINGHAMER: Johnson. They weren't getting their special ergometer completely instrumented for tort and pulse [185] and all that stuff. They weren't getting their experiment support system. Then they wanted something called a lower body negative pressure device. This would seal around your torso and then pull a vacuum on the lower extremities which causes pulling. That is both therapeutic and diagnostic. You can tell cardiovascular speaking, how you are deteriorating, how your strength is staying up in the presence of zero g or low gravity. So they wanted all these things but weren't able to get them done, so he gets me in and I get the opportunity to go build that stuff.

I had to work with the doctors down there. That was like two dogs sniffing at each at the start. I think Houston was worried about us getting into their britches, but at the same time they knew very well that somebody had to help them or they wouldn't have all these biomedical experiments for the Skylab flights.

So I had double duty. I worked on the materials division at the time and I was worried about planning building materials that went in there and that sort of stuff. Still at the same time I was building these biomedical experiments. They even had some plans at one time to perhaps create a whole laboratory based on the manned systems.

He was absolutely convinced that if you are going to have to understand these things if you are going to have a space station. He was pushing that. He saw the Skylab as a space station as a matter of fact.

So we built those things very successfully. We had some interesting experiences. I hope you won't put this in the thing, I am going to tell you these little anecdotes.

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One of things that we worked on was a urine volume separation measuring system. Hell, I didn't know what capacity, how much you pee! So, I put these beakers in the restroom and I told everyone in the lab to fill up the beaker when they had to go. I did a means and a standard deviation to find out what the average guy... I added a hundred CC and we designed it, I believe, for a 900 milliliters or so.

Then this big astronaut, his name was Thorton came up here. We were so proud and we showed him this thing. He says, "Ain't big enough!" "What the hell do you mean it ain't big enough," I said, "I collected specimens for three months. I took the means and standard deviations and added a 100 cc." He peed 1200! We had to redesign it!

But anyway all this stuff is going on at Houston. It is just astonishing how finally they lost their fear about being taken over. I think Marshall backed away at the same time and decided to let them have it. It's their thing and they do it well. But we built biomedical experiments very successfully. I came in about six weeks ahead of schedule on them and under cost. That was pretty unusual. They all worked fabulously.

But then, one of the astronauts broke the bicycle ergometer, one of the shafts on the pedal. I had to redesign that, too. But when we finally got done, nobody could tear it up anymore.

But that was about the last attempt we really made to go forward in that direction. Now the strange thing, subsequently of course, in the space station was back in the life support systems again. Life support was always a Houston thing and we did vehicles and propulsion stuff. I don't know how that happened, who knows? On the space station we got a big effort again in building for a life support systems for the space station. So it kind of flops around.

27. **WARING:** That would be interesting in investigating that program. With these medical experiment, essentially Marshall was acting like a contractor?

28. SCHWINGHAMER: We were a contractor. I was sitting in a lab. That was kind of a strange thing to. I had the matrix-overlay, but that was one of the exceptions. I was cost scheduling and technical. I was my own project manager on these biomedical experiments. That rubbed a little the wrong way, incidentally with a certain project manager, but he finally got over it. But after it was all said and done we never got any awards for coming in under cost and ahead of schedule! They wanted the project managers to give out their awards, and he still hadn't gotten over it. Those thing happen. But it was a good program.

29. WARING: So this was really a very unusual form and it really hasn't been repeated.?

30. SCHWINGHAMER: Not to my knowledge. I had one-on-one Houston with Dockerson, the people down there. It worked fine.

31. WARING: You were also played a very essential role in the rescue mission. Could you tell me about that? What it was like during those hectic days?

32. SCHWINGHAMER: The whole lab did. That was hectic. My wife had never seen a launch and I had decided that would be a good one to see. So I took her down to the Cape, drove down at my own expense. But I still was on duty there, so this thing takes off, and my god, the solar arrays don't deploy. Everybody, all the rest of my compatriots down there were able to get on the Gulf Stream and fly back to Huntsville and start working on the problem. Here I had my wife down there, who doesn't drive very well, so I had to drive back to Huntsville. I got in that car and I started driving, and I drove and drove and remember coming through Atlanta during the rush hour. I finally got over here. Rocco Petrone was the Center Director at that time. He had everybody over in the HOSC [Huntsville Operations Support Center] already and was having a meeting. I walked in late. He glared at me. It was about 8:30 at night because it is a long drive from the Cape.

violent inhibitor. The first paint I put on it turned brown from the sun, but that marine epoxy just stayed white. So, to save time and I didn't want to process any paper work, so I gave them the money and they went downtown and bought a quart of red white and blue at the paint store, Campbell's paint store. They brought that stuff out and we spray painted that marine epoxy. The guys had to get a flag, we didn't know where to put the stars and all. So anyway, we did that day and night for three days. At the same time I took some of the paint and spray painted it right away. So we put velcro on the back and then put velcro on the bird and we stuck it on about a half a day before lift-off. So we would have an American flag. But it was made of aluminum. The last pictures that we have of Skylab, it was still nice and white! The marine epoxy was holding up.

Campbell's paint store. You know that is the funniest thing. I saw those guys about a week or so after things calmed down. I said, "Do you know your paint is in orbit." "Oh, is that right?" It was not big deal. I thought he would be pleased that his paint was in orbit with the Skylab and he says, "Oh is that right?"

33. WARING: Looking back on your career, do you think that couple of weeks on the rescue mission for the Skylab was perhaps the high point?

34. SCHWINGHAMER: It was a very high point. You know that is a thing... I will tell you a story about that. My father just happened to be visiting us at that time, when that occurred. He took his vacation time and came down. He told me while that was all going on, he said, "Bob, I don't know how you get those people to do what they are doing out there." He was fancy [?434] and built fine furniture, specifically chairs. He said, "We couldn't get our people to do what your people are doing, that day and night stuff." I said, "Dad, they just like what they are doing. That is the only explanation I have for it."

Yes, it was a very high point. Everybody tuned to. But we done [sic] that again several times since. The 51L, the post-51L thing was just like that, except it was sustained.

That lasted from the end of January to June. We had one day off in there, Easter Sunday. They wanted us to work then, but I wouldn't do it. But we did the same thing there. These people, I don't know, they just do. When you need it is there. No grumbling, no gripping, no complaining, they just turn to. But the thing that was so bad about 51L, under the circumstances, you were cast under a pall. It smelt bad all through the whole thing. But, the level of effort was equivalent to Skylab.

The Skylab, what was so nice about that, was you killed yourself for two, two and a half, three weeks, day and night. Then it was successful. It was such a pleasurable event. One tends to remember the pleasurable ones more than the unpleasurable ones. Its human nature. But the guys just did a yeoman's job on it.

I headed that SRM cable investigative team. See, they split it up according engines and tank, each major element of the shuttle. It turned out that I got the one that was the baddy. So I was over there where [?469] it was pretty easy to exonerate the engine space on the flight data and the tank and some of the other things. Finally you got down to the SRM. So I had to stay with that through the whole thing. But the people were just remarkable. It was just fantastic what they do when the chips are down.

35. WARING: I haven't read too much about that. I will probably come back and talk to you about that next summer.

36. SCHWINGHAMER: It was an excruciating experience.

37. WARING: Do you remember when there was an investigation of the failure meteor shield. Was there similar feelings here? Were you much involved in the decisions to put that on there?

38. SCHWINGHAMER: No, I was in the materials division at that time and that would have been in the structures laboratory. There was a mistake made. It just was invented and then it just explosively depressed until it went. You know it is interesting, because I guess it was ultimately successful in the, then the oversight seemed less damaging. But I just don't remember anything like the recriminations and the bad press and the attitude relative to that that we have, for instance with Hubble. Of course 51L is in a class by itself in that respect.

39. WARING: Well, NASA handled the investigation of the Skylab problem in-house. They had another Center director I believe.

40. SCHWINGHAMER: Think back though, to earlier times, with Apollo. But during the Apollo fire and after that, that was extremely excruciating for everybody too, but I don't think it ever got as vitriolic and as bitter, persistent as we have had in recent times.

41. WARING: My impression is, after interviewing some of the people in Houston is that, yes, it was hard on them, but it doesn't seem to have effected people in nearly the same way as the Challenger did.

42. SCHWINGHAMER: Yes, that hurt everybody. That was a tough time. In fact, if I see vapor trails from my location at the Cape during the flight, I believe its the end.

43. WARING: I can understand that.

44. SCHWINGHAMER: I don't want to go through that another time.

45. WARING: Let's turn to another subject that I am interested in during this early period. Can you tell me what some of the most important spin-offs from space technology. Space technology that worked its way into industry?

46. SCHWINGHAMER: You know the thing about that is, although I think very early there was a office to try to track that sort of thing. It's just so there is no way anyone can really quantify what come out of that. They learn things in executing our contracts and you know we are in a capitalist system. You use the good things you find. No one can really expect them to come back and say, "well, I built a better communication systems because you forced me to develop a transistor I never had before." That is all going on, but you just can't quantify that stuff.

I can tell you, I believe particularly in the early days, in the area of electronics, we really drove the electronics business. Too a much bigger extent than we do today. Part of that has to do with a premier or leadership position in the United States at that time in electronics in those early days as contrasted to today, where the Japanese have taken the lead role in the development. I think in early computers and basic electronics in general, transistors, power transistors, what have you.

47. WARING: Yes, I think you are right because computer technology was just so expensive there was little commercial incentive to get much involved in it. The space program provided an incentive for things like IBM.

48. SCHWINGHAMER: The same motivations that drive you to make it smaller and less energy. All those things are what ultimately were necessary to get computers reasonable. So that was one area that really profited enormously.

49. WARING: How about some of the metal forming?

50. SCHWINGHAMER: Materials. Oh, yes. We pioneered some new techniques of forming metals. I had several issued patents in that area myself. So-called magnetic hammer that I developed and patented that. It is still in use today. I wanted to build some hydrofoils and I think they use it in shipbuilding in Pasagoula. That was one of the significant spin-offs.

There are innumerable spin-offs. You just don't even know what they have done with the technology that they helped to develop. Which is ok, but it makes it a little hard sometimes to substantiate, because you don't know if you built a better transceiver because you forced them to build you a transistor you needed. You never find that out. It's a little hard to put your finger on sometimes. I think that quite interestingly, that metabolic analyzer that we build for the biomedical experiments, the Spain Rehabilitation Center down in Birmingham, seized on that. They use that extensively in analyzing the condition of their patients down there.

51. WARING: How do you spell that?

52. SCHWINGHAMER: I think it is Spain.

53. WARING: Just like the country?

54. SCHWINGHAMER: Its a rehabilitation center in Birmingham. It still uses it, or at least they were the last I heard.

So those are just some things that I personally am familiar with. Then materials, the aluminum industry in those days and I guess to some extent even today, we are a driving force in the development of smaller and lighter aluminiums, like the aluminum elithum alloy. We generally push harder on that then the commercials do. We got a lot of work

going to develop this. One of the two aluminum lithium alloys that will be much, much lighter and stronger than the existing aluminum. That will be a significant improvement. For instance, if we were to use this alloy and have it totally characterized, we could pick up about 8,000 pounds of payload on the shuttle. Four tons of payload just by switching. Ultimately we will do that. It may be four or five years away before we can do that. We may be the first ones to fly an all new aluminum structure of that kind.

55. WARING: Who developed that. Was it Marshall or NASA, generally?

56. SCHWINGHAMER: I would have to say NASA generally, along with the aluminum companies. See, the aluminum companies, or any contractors, they have a lot of good ideas. Then they have to find a sponsor or it just dies. In this case, for instance on the aluminum lithium, we are one of their main sponsors because we want it. We would like to have it. In some of the alloys that we formulated in-house and they are our own. In fact, we are working on one now that is insensitive to hydrogen environment than aluminum. Now that takes a little bit of explanation. But, it is unfortunate, but always true in engineering, that everything is a trade-off. You never have the strongest, the lightest and the most resistant, you have to give us something. You can't have it all. You can't have your cake and eat it, too. So we are working on this in-house, we formulated a new alloy. It is high strength, called a "super alloy." The super alloy in the space shuttle's main engine today, have a deficiency in that hydrogen makes them brittle. They are strong in air, but brittle behind [?639]. So in order to get that strength property, you have to use a coating over them to protect them from hydrogen. Then you worry about how good is the coating. Does the coating peel off or this that or the other. Or, you have to use the material at strength levels so low, stress levels so low, you aren't taking full advantage of the alloys capability. We have one going now, in-house in the lab here, that will have strength equal or slightly greater than the current super alloys and will be pervious to

Then things really got tough because we had ripped off the micrometeor shield we had lost our thermal control material and the temperature started rising. Then we had concern, and legitimate, about the toxic gas that evolved from the interior from the foam. Then we had to devise some greater tubes so the guys could actually make a measurement before they went in there to determine if it would be safe for them to go in. Then we immediately began to devise some schemes to save Skylab. Houston came up with a parasol idea that came out of one of the experiments days. But, unfortunately they selected a material that was not ultraviolet resistant. In the press of time and the urgency of things, they developed this parasol with this material that began to degrade rapidly with time on exposure to ultraviolet. We approached it a little differently in that we built, we called it a Marshall Sail. We sprayed a thin thermal control rubbery-like, silicon rubbery-like, thermal control material over that sail. Then I got some Navy Seals that were here, that were parachute regulars as well. They packed that thing up in a nice small space and I think in about 13 or 14 days we designed and built that thing, packaged it and then flew it up.

The grand scheme was that first we deploy the Houston parasol to give immediate relief because it was easy. You didn't have to go EVA, you didn't have to go outside. You stuck it out that egress port inside the Skylab, and they did that. Two things were happening then. Immediately the ultraviolet began to degrade that material, as I knew it would. It was a nylon material and as you know yourself, nylon is poor in ultraviolet. So it began to degrade. Now we had the thruster attitude control that would fly periodically that maintained the attitude of the Skylab. Every time it did that, it rippled that thing. It would have been one thing if it could have set there and not been disturbed. Then the ultraviolet deterioration might not have been so bad. But this was continually stressing and working the material. Heating and cooling and then the gas, the attitude control, we were actually blowing gas on it, rippling. So I got very concerned about that. We had meetings and meetings and meetings. Of course, Houston really didn't like it that we wanted to change from that scheme because it was their scheme and they thought it was a good one. It did

give immediate relief without EVA. But ultimately, the temperature began to rise. I think that it got up to 97 degrees Fahrenheit inside. [They] then finally decided, yeah they would deploy the Marshall sail. It just turned out then that an old friend of mine, Alan Bean... I had also early worked on this idea of neutral buoyancy. That was another thing with von Braun (I digressed). We used some scuba gear and I used an old explosive forming tank that we had done some experiments with forming metal over here. I invited von Braun over there and said, "Hey look, when you are neutrally buoyant, its almost like zero g." So at that time the Skylab was going to be a wet workshop. We were going to fly her up wet and then use [?325]. We subsequently decided not to. One of things that we had to do was remove the bolts from a large flange. I had scuba gear and showed him. So he liked that. Well, then I called Alan Bean, whom I knew very well. He came up and tried it in a neutral buoyancy tank. While he was in there, they wouldn't give us any suits from Houston because they thought we were trying to get into the manned business! So I got some old navy suits from the Navy but they were worn out, 84 Navy pressures suits. While I had Alan Bean in the tank, a big hole blew out from under his armpit. He is under 20 feet of water! I thought, "God, if we have killed an astronaut, that would be the last heaven!" But anyway it worked out alright.

Because we knew about all those things and had worked that way, when this thing when up and then we had this gas problem and we were going to deploy this seal, Alan Bean knew what our capability was in zero G already. So what we did was, old J.R. Thompson designed the seal and I developed the material and from my labs. He and I worked together on that. He did all the deployment, designed the wind booms and how you would deploy it. I did the design of the seal and different materials analysis with the ultraviolet exposure testing accelerate. I tested at ten suns' equivalent, to accelerate the testing so I would get some data before we flew. Then Alan Bean came up and we actually deployed a model of that in the Neutral Buoyancy Tank which we got because von Braun was interested in that. Which incidentally almost sent me to jail because we built it with

the wrong kind of funds! But we had it. So we used it that way. Then they deployed that thing over the parasol. If you look at the old pictures you will see that the seal is deployed over the parasol. It worked very well and brought the temperature down and allowed them to finish that mission. But boy, I tell you, it was day and night. I mean literally day and night. Petrone would come by and he would come in about 11 o'clock at night and we would all be doing the best we can. He would go to the front door and I would walk to the front door talking with him and he would look at me and say, "I'll be back later." You know, when in the hell is later! So you would stay up all night because he is coming later! I went about two night like that and my deputy could tell. We were dying. I said, "Gene, we have got to get off of this." So we went on two 12 or 14 hours shifts. I forget what it was. We had about 2 hour overruns. Finally we were able to get some sleep. I slept on my office floor on the rug. I ate apples and crackers.

Funny things happened. I used to smoke cigars back then. Petrone came in unannounced during that period and I had a cigar in the ashtray that it was still smoking. He sat down in my chair behind the desk. He took the ashtray, picked it up and threw the ashtray and the cigar in the garbage can. The whole works! I got the message, I never smoked around him again.

But we did pull that thing off and we actually saved that Skylab.

We had another interesting thing with the American flag. Three days before the launch of Skylab, Belew came in and said, "We don't have an American flag on that thing. We have got to do something." I said, "Boy that is pretty short notice." So he said, "One of the contractors has a flag and they want to stick it on with velcro." I said, "What's it made of?" He said, "Well, its just a flag. I don't know, its just nylon." I said, "Man, it will eat that thing up. It will as brown as your shoes in four days in ultraviolet." You know in the absence of any atmosphere. So, we got busy, I will never forget, and I said, "I think we will make it out of aluminium." So we got some, I believe it was 60 mils thick. Then I had this boat, a big old cruiser, twenty foot cruiser. I had found a marine epoxy that had an ultra-

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hydrogen. That will be a big deal. Mark what I am telling you. Not this year, maybe not 1995, but we are going to hydrogen element maybe because we are planning this from an energy perspective. We are going to drive hydrogen cars. We are going to fly hydrogen stages, etc., etc. Just environmentally speaking it is just important. Until we solve this materials problem, about the brittleness with the high strength alloys, we can't have good products made for cars. So we got that coming. In the first place we will use it in the main engine. But I think that as the conversion to hydrogen power goes on in the next decade or two, you are going to find more and more of that alloy is going to be used because it is going to be necessary to make the technology feasible. So I see that that is going to happen. The same way with the aluminum, we are going to fly in an aluminum ethilium tank. I think I will probably still be here to see that. I won't be here to see the other one. The hydrogen industry, or field of energy. Hydrogen is going to be longer in coming, but I think that it is on the way. So that is how that stuff comes off.

But nobody blows their own horn. Interestingly, a lot of the other agencies deal deep in advertising. You see Air Force. We can't advertise. We are forbidden by law to advertise.

57. WARING: Is that right?

58. SCHWINGHAMER: Yes, I couldn't put up a sign, "We have a hydrogen resistant alloy. Look what your tax dollars paid for." We are not allowed to do that. I never knew why.

59. WARING: That is back in the original NASA legislation. That is interesting. Well we have pretty much gone through the questions that I wanted to cover this time. You have told me a lot of useful information. Is there anything else that you can think of? Particularly about the sixties and early seventies. Could you tell me the story of how the

neutral buoyancy facility was built? People have sort of told us elliptically about this, but nobody has just directly told us. Can you....?

60. SCHWINGHAMER: I know better than to talk to a guy like you and say "don't print this!"

61. WARING: We will leave the names out, but...

62. SCHWINGHAMER: Well, that all played a little bit into this business about Marshall moving more and more in the direction of manned systems and the environmental control and life systems.

63. WARING: That was a threat to Houston?

64. SCHWINGHAMER: Yes, but von Braun was...[end of first side of tape]

The only thing that I could find was that we had a tank in the back that we had used for experimental forming of materials using explosives. It was big enough, so we just put a temporary tent over it and invited him over and put him in one of these old navy suits. Fortunately that one didn't blow up! He said, "Hey this is great! This simulates zero gravity. We are going to be fine!" So, being really ambitious at that point in the game, I sat down, just on one of these large tablets like you have on your desk, I sketched out how we could really do it up proud. I put in a safe haven in the bottom. You know, if the tank gets...it turns out in scuba if you go below about 33 feet then you have some special problems that you have to cope with. If you stay above that relative to nitrogen and stuff in the blood, you don't have to worry about it. But 33 feet, I knew wouldn't be big enough to handle something like the Skylab. We kept thinking space station even in those days. So I wanted it at least 40 feet. I had to design then a safe haven, so that you could maintain that

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in an airlock mode. Then if you really got in trouble and you didn't want to surface and run the risk of an embolism of a rapid surface rise, you would go into this safe haven. Then you could breathe, take your gear off. Somebody could come down and tend to you. So I designed this, and thought, "Oh boy, this looks pretty good." We talked about it. "Well, when are we going to do this thing?" Well, my first idea was that I wanted to put it out in the parking lot. Right down there next to 4712, right out in the parking lot. So they said, "Damn, we can't do that. If you do that, then it is a facility." If it is a facility, it goes through this tortuous facilities route and we will be four years getting it. We need it for Skylab before that. I got to go down to von Braun...To make a long story short, he looks at Dave Newly and says, "Dave, we can't go a facilities route. We will call it a tool." So we called it a "tool" and got it financed included in the building. Then we called it a "tool" because we knew we wouldn't get it in time to do any good for Skylab and that's when we needed it. So that looked alright, so they said fine, we will just call it instead of a facility, we will just call it a "tool." So we called it a tool. Then they got to investigating that after the damn thing was built. This guy kept coming to see me in my office every week, quizzing me, "Did you say so and so?" I would say, "I don't remember that. [?759] came for a year and my mind is a blank! I can hardly remember hardly remember what happened!" Then he [?had] a memorandum that I signed or something. I thought I was going to Leavenworth for a while. But you know it had a negative effect to this extent, that they finally restricted the amount of money that a center director could include on the basis of that. It proved its worth, it was necessary. We needed it. That didn't matter, somebody had transgressed!