ORAL HISTORY 3 TRANSCRIPT

ALECK C. BOND
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is July 15th, 1999. This oral history session with Aleck Bond is being conducted at the Johnson Space Center, Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Rebecca Wright. Thank you, Mr. Bond, once again for taking time to participate in our project.

BOND: Thank you. I appreciate the opportunity to do this.

WRIGHT: Well, your career with NASA spanned almost 3 decades, with the first days being at Langley [Research Center, Hampton, Virginia] with the Space Task Group. You arrived here in Houston in 1962, and then you were assigned to head up the Systems Evaluation and Development Division. Now this was a very large Division, and the task of this area had not even yet been identified, and now that became your project. Could you show—tell us how you were able to identify those areas? And what resulted with your leadership?

BOND: Well, the Space…Evaluation Development Division [SEDD] was conceived—it was really part of the Flight Systems Division that had existed under the Space Task Group. And that was back when we were still back at Langley. I was Assistant Division Chief of the Flight Systems Division, and we had many of the same elements that were finally put into SEDD, which included structures and mechanics and materials; propulsion and power elements; the communications activities that we were involved in at the time; and another big activity that we were given was the responsibility for the design and development and subsequent operation of a number of major test facilities that the Engineering Develop[ment] Directorate was responsible for.

At the time, in—I was officially transferred to Texas in about 19—in February of 1962, and our organization totaled somewhere in the order of 130/140 engineers. These were people that had signed on to the Space Task Group back at Langley, and at that time we were also given the responsibility for building up, hiring, interviewing, hiring people that had the qualifications and background to be able to help us in our mission for the design and development of spacecraft and the final test and evaluation—and certification—of spacecraft for flight.

…We had quite a number of the people that were assigned to SEDD at that particular time finally were assigned to other major positions. A number of them became Division Chiefs themselves. When we finally split up SEDD into several Divisions—Structures and Mechanics, Propulsion and Power, Tracking and Communications, and Space Environment Test and Development Division, and then eventually the Crew Systems Division—those were Divisions that people from SEDD finally were reassigned to as we began to expand and get more people on board to handle the issues and areas of engineering that we were responsible for in not only a continuation of Mercury, but also the Gemini Program that came on the heels of Mercury. And then subsequently, the assignment to do Apollo was really the instigation for the expansion and development of the final E&D [Engineering and Development] organization that I knew back in those days.

WRIGHT: Well, tell us how E&D evolved and how the Apollo Program did have an impact on its future?

BOND: Well, a lot of the reason for it—the development of E&D, Dr. Max [Maxime A.]

Faget, who was responsible for the concept of the Mercury-type of vehicle, the idea of seating the passenger in a forward-facing position going out and then in a rearward-facing position coming in, in order to be able to withstand the forces of gravity [and] the multiple forces…created by the rocket thrust and also the deceleration that was experienced during reentry. He came up with the idea that that was the only way that we could fly a man safely into space and then bring him back in the reentry process.

And he worked many hours I guess, with Dr. [Robert R.] Gilruth and convincing the powers that be up at not only [NASA] Headquarters but all the other scientists around the country that were, you might say, a lot of the [opposition]—we were newcomers to the whole idea of getting into spaceflight—well, that is, NASA. And we had a competitor. The Air Force was a big competitor at that time… They had a program, the Man In Space Soonest, that was competing with the civilian space program that President [Dwight D.] Eisenhower wanted set up. And so, we had a number of detractors along the way. A number of political issues that were continually coming up. A lot of criticism in the early program.

Particularly when we had a few failures in Mercury. And these critics didn't let us forget that we were [the new kids on the block]—we had a hard problem. But in spite of that, Dr. Gilruth, who was chosen to head up the whole project, persisted; and he didn't let things like that bother him. And in fact, he—the man amazed me at times about how he could keep his eye on what the ultimate mission was and make sure that we progressed and didn't let things like that bother us.

And E&D was, like I said, was one part of the Manned Spacecraft Center [Houston, Texas], which Johnson [Space Center, JSC] was originally called that when we first [were] established, and then subsequently was renamed as Johnson Space Center. But there were a number of elements. E&D was only one part. We had several Directorates that had to make up [the Center's overall organization]—Flight Operations, Administration, and so forth, that made up the activity. But with Max Faget being the lead engineer and he had, of course, made many contributions to space systems design, he was chosen to head up the Directorate and more or less lay out what the various requirements and job functions and responsibilities would be for the evolving organizations.

WRIGHT: And what was your role at this time that the E&D was beginning to evolve?

BOND: As I said, I was assigned as Chief of the SEDD. And our responsibility at that time was early systems design and development in the spacecraft area. But then additionally, we were assigned the responsibility for conceiving and doing the early design and development of many of the test facilities that you now see here on the site at Johnson Space Center. So, we had a big job ahead of us, not only to do the flight programs but also to establish a Center and provide all those kinds of implements and tools that we were going to be able to do our job with.

One of the things that still has remained with me all of the years of my career is the fact that, Dr. Gilruth—all of us that came from NACA were hands-on type of engineers. We got our hands dirty. We got involved with the hardware and equipment. And that was Dr. Gilruth's background. And he insisted on having all the necessary tools to be able to do a complete job, not just sit down and write contracts for others to do the design and development. He wanted us in from the initial point of conception up through the time that we verified and certified an article for a flight, and then the completion of the flight program, as we have done over the years.

And his admonition to me at one time, when we were designing facilities, he told me that he wanted to be sure that we did not create any white elephants in our process of coming up with all these different facilities that we thought we were going to need. And that stuck with me. In fact, it made quite an impression. I wanted to be darn sure that we didn't come up with a bunch of facilities that were going to be so far out that they were not going to be useable. And I had particularly wanted to maybe say something about several of the rather unique, major test facilities that we did develop back in those days that are still in use today.

There are some five major facilities. The first of those is the Space Environment Simulation Laboratory (SESL). That consists of two very large space chambers that were specifically designed to test all the Apollo hardware. But in addition, it was also designed to be able to accommodate human beings in the space environment during the time of testing. The facility consisted of two large chambers. One of them was 65 ft in diameter—the large one was 65 ft in diameter and 120 ft in length, in overall length. This would accommodate the Apollo hardware that had to go to the Moon.

And it was designed so that we could test the command module with the occupants, the three astronaut occupants, in the command module for the full duration of the flight activity that was going to take place—8 days or 8-plus days. These astronauts were to live, sleep, eat for that whole period in that command module while the command module was subjected to the complete environment of space, which is practically no air molecules within the chamber, and also with the radiation of the Sun striking the spacecraft so that we could do—simulate the thermal heating from the Sun. But in addition, space has another property; it's very, very cold in space whenever you're not facing the Sun. When a body is in space, it radiates to all the surrounding areas and, essentially, it sees a temperature that is of the order of around 4 Kelvin—which is just 4 degrees above absolute zero.

So, we had to be able to produce that kind of an environment. But at the same time, since these chambers were designed to be man-rated, we had to be able to re-pressurize, go in and do a rescue, if necessary, if any of the inhabitants were in any kind of a problem. We had to be able to re-pressurize to a breathable atmosphere within 30 seconds, and then within one and a half minute, bring down the—bring the pressure back up to 14.7 psi, which is the pressure that we live with on Earth. So, that was quite a challenge, to be able to design a chamber or two chambers of that very large size when at that time the technology says the farthest we had gone was to—or people had gone were to develop chambers that could produce hard vacuum that were only the size of bell jars. Only maybe a foot or two in diameter and maybe a couple of feet in length. And when we took that on, it was quite a challenge.

We did have a lot of help along the way. We had a number of companies that had been working with vacuum at that time. But there was a lot of new pioneering work that we had to go through. The second chamber in that facility was a smaller chamber that would accommodate the lunar module for testing and, at the same time, would allow for accommodating or testing the astronauts to EVA activities and also lunar surface kind of environments.

And now the second facility that was in that particular group was the Vibration [&] Acoustics Test Facility. And it exists here on the site, and has been used, I think for quite a number of other kinds of projects since that time. There are two towers in the facility: one which would [accommodate] the full Apollo—the part that housed the lunar module and the command and service module. And we were able to—we designed that to be able to subject that whole package to the vibratory environment that the vehicle would see during the initial light-up of the rocket engines and the subsequent travel into space with the rocket engines functioning. But along with that is a very intense acoustic kind of an environment that's involved. And we [tested] that separately. The second tower that the facility has was to be able to provide the very, very severe noise environment that the vehicle has to see whenever it sets off on the launch, and then subsequent travel during the propulsive part of the mission. And again, we were able to provide this kind of an environment for testing the Apollo components in that particular kind of environment.

And we did find problems along the way. We had various pieces of equipment that failed or were near-failure; and were able to make those kinds of design changes along the way before the actual test article[s] were flown…without occupants and be able to verify that we had solved all of those kinds of problems on the ground before we undertook [manned] flight.

Another facility is a large anechoic chamber… Anechoic means that it is completely noise-free. We were able to design a large chamber, again to house major components of the vehicle and test them in a noise-free environment so that we could test and verify the early concepts of the communication systems and then finally the—certify the communication systems that were used on the actual flight articles.

Another facility, the fourth facility, was the Thermochemical Test Area. And it has been invaluable in the kinds of testing that—capability that it has provided here on the Center. One of the—it had separate test facilities. Each separated from each other because of—hazardous operations were conducted in each of those. So, we separated the facilities by some space in order to be able to make sure that, in the event we had a mishap in one, it didn't give problems to the other part of the facility. And we had the ability to test pyrotechnics; to test fuel cells where oxygen and hydrogen were brought together, and so forth; to test propulsive systems, fluid systems, and so forth in that facility. And, like I say, is has been invaluable throughout the years—and is continually in use at this day and time.

And a final facility that we developed was an Arc Jet Test Facility, where we would be able to test and certify thermal protective materials. An electrical arc jet is used to produce the very high energy that is injected into a supersonic—it's really a wind tunnel with high thermal capabilities, with the energy being produced electrically that we inject into the stream for the testing of materials that are used for the nose cones, leading edges of the shuttle, the thermal protective material, the TPS [thermal protection system] that's used on shuttle these days, and also was used early on in the testing of some of the ablative materials that we used back on Apollo—although it didn't come in, in time, to do extensive testing there. We did use—we used another facilities in order to test out the ablative materials that we used on Mercury and then subsequently Gemini and Apollo.

But those five facilities and along with, oh, a lot of the other laboratories, the standard laboratories, that were created to give our people the hands-on capability to be able to test and verify the designs that were being conceived and eventually developed and used. One of the admonitions again from Dr. Robert [C.] Seamans [Jr.], who was an Administrator of NASA at the time, was that we would make extensive use [of these facilities.]… He, of course, and Dr. Gilruth [being] of the same school… [had a philosophy of] making sure that you did all your testing on the ground to the fullest extent that you could. And he said, "We will do all of our testing on the ground to the fullest possibility, make sure that before we go into flight, even unmanned flight we will have tested and verified the capability of the hardware to do what they were designed and conceived to do."

That way we would be able to make sure that we had the ability to very confidently go into space, knowing that we had done the testing to our fullest extent. To be able to verify and certify the designs before—certainly before we ever put man—subjected man to fly on those articles.

And that more or less became one of the philosophies that we used. We more or less did what we called "man-rating." Man-rating was a term that was, I think, coined by the Air Force back—and I think NASA in the early days when they were going through the supersonic airplane developments, back in the 1950s and so forth. And it envisioned a—it was a philosophy that says, again, that you will do everything that you can do technology-wise and knowledge-wise to be able to assure that you have designed a safe vehicle to put man into. And before you do it, you want to be able to certify that you have done everything in the design that promotes safety.

So, that was more or less the marching orders that we had, whenever we set out to design a lot of these facilities. And I felt like over the years, I guess in a lot of the exposure, the publicity, and so forth, the engineers in the Engineering and Development Directorate were not given the proper, I guess credit because there was so much publicity that was focused on—of course on the astronauts—and certainly they deserved the publicity and the exposure—but also the other element of the organization, …Flight Operations people. They were always in the limelight. Whereas the engineers from E&D, even though they worked those problems and solved them and came up with solutions for in-flight problems that—like we had on Apollo 13.

The engineers of E&D were responsible for working out, "How do you retrofit the environmental system on the command module to be able to extend its capability—the capability of the environmental system on the LM [lunar module] to accommodate three passengers instead of two that it was originally designed for?" It was things like that that the engineers did. They, like I said, I didn't think they received the due credit that they deserved. And many of the other kinds of problems of design and development along the way that allowed us to proceed on meeting schedules and making sure that the programs were able to maintain the progress that was desired by the management.

And, well, for instance, back in the days of the Skylab. The engineers that were responsible for making the fix to the initial Skylab problem, where the thermal protection material was ripped off the part of the vehicle that contained a lot of the stores, and we were beginning to find that we were going to be—we'd be damaging all the storable materials that had been taken up, some of the medications, the food, the water, etc., unless we did something rather quickly.

Now the whole Center, of course, really came together and—but a lot of that testing that was done was done by a lot of unsung engineers in the back 40 that had to work around the clock and come up with those solutions and how we were going to be able to save the day. Which did happen with the parasol that was finally put over Skylab to protect it from—and also the solar elements that were damaged in that early flight.

WRIGHT: How did you learn that there was a problem on Skylab?

BOND: Well—

WRIGHT: Were you among the first?

BOND: Beg your pardon?

WRIGHT: Were you among the first to know that there was a serious problem that needed to be corrected?

BOND: No, I don't think we—I was among the first. It was pretty evident, very quickly, that something had gone wrong and that the temperatures on a lot of the thermal-sensing information that we were getting back indicated that something drastically wrong had happened. And it was very quickly conceived just what had happened. And it was a matter of very quickly trying to come up with, "How do we protect this area that was so vital?" And the idea of a parasol was suggested, I guess by several people. It was—and we all worked together, too.

But the material of the parasol and how it was going to be verified and certified that it could function for this length of time was done by a lot of our people who had experience in materials. We—people from our Structures and Mechanics organization suggested several materials. We went to work exposing those in the vacuum chambers, round the clock. And we had the ability to do what we call accelerated testing, this thing had to last at least three months. So, we were able to, in less than four, five, six days, to certify material that was going to be able to hang together to stay together and still function after the three-month period.

WRIGHT: Quite a remarkable feat in such a small amount of time, to save such a large project. And I think your remarks are wonderful for us to hear, because these engineers have left quite a legacy for others to follow.

BOND: Well, thank you. I have always felt that, you know, that the fact that, you know, a lot of these laboratories and facilities are still operating full tilt in this day and time is really—speaks well for the ingenuity and thought that was put toward trying to pull all these requirements together and develop them.

WRIGHT: And that leads me to my next question. Each one of these facilities has its unique and very important purpose. Could you share with us how you and your coworkers developed the plans to build them? And how did you decide which one would come first?

Or were they all done parallel? Give us some insight on how you were able to take these facilities from the plans and make them into the realities that they were.

BOND: Well, actually the idea for test facilities, like I said, the people that came from Langley were people that worked in test facilities and with test facilities. And a lot of the test facilities that were developed back at Langley were developed by the you know, the engineers that were to operate them back then. And the whole idea of creating a new Center and what we were going to need, one of the first things, of course, I'm sure Dr. Gilruth thought of, he says, "What facilities are we going to need?" And there was a lot of thought given to that, and a lot of people had inputs and requirements. We—

Back in 1961, I guess, when it was first determined that we would become a Center, some—several people were asked to contribute inputs and thoughts about, "Well, what kind of facility will this new Center require in order to be able to do that program?" And even back then I guess there was some thought, well, of going to the Moon. So, back in 1960, '61, I guess at the time there were some early studies of a lunar mission. And so, the idea of, "Well, what kind of facilities will we need?" Not of just going into space, but going to the Moon and beyond that?

So, these people submitted their thoughts and ideas. They were all pulled together. We had some groups that Dr. Gilruth pulled together and said, "Well, now, let's do some general [jaw-boning] sessions here and find out, well, what do we think we really need?" Because whenever you ask people for inputs and ideas, of course, you get a whole conglomerate of stuff that engineers think they do need. But this was all sifted through and, gradually, it finally came down to a number of major kind of facilities that I've just talked about. But then there are those standard kind of laboratories.

For instance, Structures and Mechanics. Joe [Joseph N.] Kotanchik, who was my Assistant Division Chief in SEDD, came from the Structures and Mechanics—from the Structures Laboratory at Langley. And, of course, his background was testing structures and, "What do I need for testing structures?" He says, "Well, one of the first things we're going to put in the Structures Laboratory is what is called a strong back." And all a strong back is, is really a very, very strong structure of—made up of very, very high [strength] I beams that are embedded in concrete for quite a number of feet so that it—even though you put very, very large forces on the strong back, it doesn't deflect and so forth. So, one of his first requirements was, "We will have a strong back," he says, "because I know we're going to be testing some structures here, if we're going to do anything of that sort."

So, that was one of his requirements. And then coming from the testing field myself, at Langley we had some jets—free jets, heated jets—that we did some early testing in. And so, one of the first thoughts was, "We needed an arc jet." So, that was where we conceived the idea that we ought to have a testing facility that would be able to test materials under the very high, intense heat that you see on the reentry.

A lot of the other people, like the Communications people, thought they needed this anechoic chamber because, "Hey, if we're going to get into space, we're going to have large expanses that we're going to have to communicate over. And so, we need to be able to test these communications systems in an environment where we can make sure that we don't have any clutter from outside noise," and so forth. The Propulsion people say, you know, these are kind of propulsive facilities [that will be needed].

At one time, we thought the—we would have a test facility that we could do a lot of the kinds of testing that we did on the lunar module engines, here at JSC. And then after we looked at the territory and the proximity of the residential areas to us, we said, "No, we can't really do that. Not here at JSC. That's got to be someplace else." And we looked at several sites. In fact, Matagorda Island [Texas] was one of the sites that was looked at for possibly a propulsion test facility where we could do that medium-size engine testing. And we ended up with White Sands [New Mexico], and the facility was sited out there.

And at one time, E&D was responsible for developing that particular facility. I was glad to [when]that responsibility was reassigned to another group and we said, "No, it will be an independent, separate facility at White Sands." But E&D was required to look in on it occasionally, from time to time, because we had other people out there that were—more or less wanted to make sure that we were coordinated and following along the same provisions and concepts. So, for a while I traveled to White Sands a number of times for reviewing the activities out there. But I was glad to, then, have my responsibilities just remain what we had here on site.

WRIGHT: I'm sure there was plenty to keep you busy here, without traveling back and forth to New Mexico.

BOND: Well, back in those days, I remember when we first came to Texas, I came without my family. They didn't come down. I came in February of '62 and they—after my wife sold the house back in Virginia, she and my two daughters came down in July of that year. And since there was no family to have to come home to every evening after work, we continued work. And Joe Kotanchik and I, we lived at the Bachelor Officers' Quarters at Ellington [Field, Houston, Texas]. And so, we worked six to seven days a week and, many times, 12 to 15 hours a day. A lot of times, I'd have to grab a hold of Joe and say, "Joe, it's time to go get some sleep. We've got to recycle for tomorrow."

But those were the really—they were the fun days, but they were also the hardworking days. And for several years, we did work through a very, very tough schedule of trying to develop the Center here, maintain our responsibilities for the Mercury and Gemini Programs, and then get involved into what Apollo was going to be all about. Those were really the real high-activity days. And like I say, it wasn't unusual to work 12 to 15 hours a day a lot of times. And most weekends a lot of times.

WRIGHT: The way that the missions and the programs were structured, there wasn't a lot of time off in between. So, did you ever have much time that you were able to go off and spend with your family during those days between Mercury and Apollo?

BOND: During those days I accumulated a lot of leave that I think paid off handsomely when I finally retired! Every now and then, we had to take off a bit. And I was able to, every now and then, take off a couple of weeks and go off with my family and kind of get reclamated a little bit there. But you couldn't keep up this kind of activity indefinitely without becoming burned out. And so, it was necessary to take off every now and then. But I did accumulate a lot of leave.

WRIGHT: Well, let's stop for just a moment and then we'll come right back.

BOND: Okay. [Recorder turned off.]

WRIGHT: Mr. Bond, before you joined NASA you were a member of NACA [National Advisory Committee for Aeronautics] and spent many years there. Could you share some of the nice memories that you have working with this pioneering organization?

BOND: I'll be glad to. The NACA—I attribute NACA for really training me how to be an engineer and a manager, I guess I might say. I graduated—after getting out of the service in ’46, I went back to school for my Master’s degree at Georgia Tech [Georgia Institute of Technology, Atlanta, Georgia]. And upon completing my Master’s, I was hired by NACA in March of 1948, [when] I reported for duty. And in the course of being interviewed, I had gone up—I guess my majors in Aeronautical Engineering were in aerodynamics and structures. And I did my Master’s thesis on fatigue in airplane structures. And so, at that time when I first went up to be interviewed, I thought that, well, maybe I would like to go to work in the Structures Laboratory and do some fatigue work.

But I had been told about Pilotless Aircraft Research Division [PARD], and I went over there for an interview and I was interviewed by Dr. Gilruth himself. And I was so impressed with the kind of work they were doing, the freedom of activity, and the ability to more or less express our ideas about how to—what kind of research we wanted to get into, it just—I was sold on that almost immediately. And the other thing that sold me, of course, was Dr. Gilruth himself.

He just seemed to be such a—very much a down-to-earth type of an individual. A very warmhearted man, very capable. I had—was quite aware of all the things that he had done, and his career up to that time and quite impressed with the man. And I—to be able to work for a man like that was just something that I immediately decided that I wanted to do. That was where I wanted to work.

And Dr. Gilruth had come up with the concept, a number of years before, of flying rocket-propelled models designed according to whatever configuration you wanted to investigate; and flying those to get aerodynamic data in free flight. Wind tunnels had a certain limitation on what they were able to do, particularly when you get into higher and higher speeds and going through the velocity of sound, then some funny things happen in wind tunnels that—but we were not hampered by that in free-flight flying. We could actually go through the speed regimes without any kind of problem at all and do whatever aerodynamic testing that was necessary just with using free-flight models.

And initially I had—was assigned to a couple of projects. Eventually, I got into the testing of one of the major missile systems that was being developed by the Air Force at that time, and that was the *Navaho*. And gradually aerodynamic heating of reentry ballistic missiles became one of the main focuses of the Air Force.

The ballistic missile penetrates the Earth's atmosphere and comes down almost vertically into the atmosphere. But as it gets into the atmosphere, of course, intense heat and the very high velocity—intense heat is generated on the surface of the vehicle. And the problem was the nosecones were burning up or encountering severe heating problems. And the issue was to try to solve, "What are the materials, what are the configurations, and so forth, that we can solve that kind of a problem?"

The Air Force, of course, was working on it. It had a number of companies GE [General Electric] was one in particular that was working on the problem. But at Langley and PARD, we were free to work on problems like that. And it was—it came to my mind that we ought to do a little bit of testing and work—investigation in that particular area. So, in the—about the mid-1950s, I began to do some work on various kinds of materials that could withstand reentry heating. And ablation was—an ablation process is where the material itself is consumed gradually on the surface, but the heat pulse through the material doesn't come through the material. It doesn't burn the whole layer of material at one time. It gradually creates a surface reaction that is much—at a much lower temperature than the energy that the airstream imparts to it and actually provides a protective layer across the face of the material.

Anyway, I had—we had a couple of facilities there at Langley that were being developed to do ablation or high-temperature materials testing. And one of them was a jet—provided a small jet stream where you could test very small models. And I tested a number of materials in it. It had its drawbacks because it was a facility that depended on heating zirconia pebbles up to high heat and then forcing the air through it to pick up the heat. In doing that, it also picked up the particles of zirconia; and in the airstream you also had the other problems of trying to figure out, well, how much did the impact of these particles have to do with whatever your test results showed?

But the University of Chicago had a—was developing a facility in an old streetcar barn that had at its disposal a number of electrical generators in which they could use to impart the energy to an airstream. And I ended up going to the University of Chicago several times with test models to test up there.

And in the course of time, I had tested a number of different ablative materials and was sort of becoming a test expert at Langley on materials performance in those kinds of environments. So, when the idea of Mercury started, I was invited by Max Faget, who had been my boss and colleague at—in the first several years that I was at Langley, invited me to come over and talk to him about doing something on a project that was going to be a man in space project. And when I went over, he told me that there was an idea for doing a flight verification of a shield—a heatshield—that would go on the Mercury capsule. And he asked if I was interested in being the project engineer.

Well, at that time I had flown a number of rocket models to investigate aerodynamic heating at Wallops Island [Virginia]; and the idea of doing testing on an Atlas certainly seemed like quite a challenge, to be able to go from some of the smaller models that I was testing at Wallops to something big and monstrous like the Atlas missile at that time. So, I asked him to let me give it some thought; and he gave me 24 hours to think it over. And I went back and talked to my wife, and we were very comfortable living in Virginia at the time. I had a job that she could set my comings and goings by the time that I left and arrived back home. It was a 8-to-5 kind of a job, and really wasn't a whole lot of pressure. And we talked it over, and then the idea that this new organization would probably be moving to another location that was going to—that was not intended to stay at Langley.

So, we were kind of cool to the idea. And I came back and told Max that 'I thought it over, but I didn't think that that was what I wanted to do.' And when Dr. Gilruth heard that I was not interested, he began to twist my arm a little bit, telling me this was a natural and so forth, and something I was going to have a big opportunity to get in something real big. And I guess with all the urging by Dr. Gilruth, I went back and talked to my wife; and she said, "Well, if they want you so badly, well, why don't we do it?" So, that was how I got into the Space Task Group and I was one of the first 35 that was selected to work on the Mercury Program then. And my job was to be project engineer of the Big Joe vehicle, which was to be the proof and verification of heatshield material for—of a heatshield design for the Mercury spacecraft.

And I was given the opportunity to actually select the material and do the design of the shield that was going to go on the prototype vehicle. And I had been in touch with the General Electric Company off and on in their activities on ballistic missiles, and I had been invited up to see a recovered nosecone that had recently flown. And it was with a glass-phenolic combination that we ended up using on Mercury. The difference between the ballistic entry—ballistic missile entry and for a manned entry vehicle was quite different.

The ballistic nosecone would come in very, very quickly and steeply and would enter the atmosphere. And there would be a short time for the heat pulse to actually get through the material. But in the case of the manned reentry, because of the G limitations that we could subject a man to, we had to come in and more or less graze into the atmosphere gradually so that the g-forces did not build up too high. We had to maintain something less than 3G's for the reentry portion. So, that meant that the entry was then extended over a much, much longer period of time; and the concern at that time about ablative materials was whether this extended time would then cause the heat to penetrate through the material and actually impair the structural integrity, and whether the material would actually fall apart after it heat—it had heated through.

So, the problem was: "Let's test it and find out," under those particular conditions. And so, we designed the trajectory of the Big Joe, the entry module, to simulate then the conditions that we had selected for Mercury. And there was an alternate material that had been also selected; a beryllium heatshield had also been conceived. And the reason for selecting beryllium was that, it is a lightweight metal, and it also has a tremendous, tremendous heat capacity. And you can soak a lot of heat into it, and it contains it without melting. And copper is another such material. But copper would begin to melt earlier than beryllium. So, beryllium was suggested as an alternate to the ablative material in the event the ablative shield didn't work.

Actually, there were two of the ablation—excuse me, of the beryllium shields were actually built. It was a very expensive material at the time, and it involved manufacturing that did involve some considerations of safety from the toxicity of beryllium. And the—but the ablative material worked so well that we never had to use a—we used the beryllium on a couple of development shots that needed a heatshield, but it was not required to actually have a heated entry. The other concern about beryllium was, what would happen to it in a heated condition after it was heated to, maybe, 1000, 1200, 1500 degrees and then suddenly was plunged into the cold water of the ocean? Would it actually cause a minor explosion? Would it—and how it would affect the spacecraft?

So, we were just as happy whenever the beryllium shield did not have to be used and the ablative process was shown to really work fine. And it allowed us then to turn over the information to the McDonnell Company, who was building the actual production versions of Mercury. And they, in turn, took that information and designed the production shield that was subsequently used.

Gemini used an ablative process also. The material was changed slightly. Improved. And Apollo used ablation in its—for its reentry shields.

WRIGHT: It seems, from your very first day, you've had one challenge given to you after another. Looking back through all the years that you spent with NASA, was there a time or a task that was given to you that you would consider the most significant challenge that you had to overcome to turn it into success?

BOND: Well, of course, Big Joe was a significant challenge. You know, coming from a kind of an environment where we used small rocket motors and—well, much smaller than the Atlas. We did end up eventually using some fairly large motors, but nothing of the size of the Atlas. But coming from that kind of activity, going into using the Atlas as a booster was quite a challenge, and was—I considered it a little bit awesome to begin with. And then it began after we got down to the brass tacks of designing and developing the Big Joe that became, more or less, just a real tough job that we had to do and do well. And I might say that, back in those days, we were not encumbered by a lot of restrictions and requirements that we have imposed on the designers today.

We were able to design, develop, and actually test and prepare the vehicle in less than nine months and put it on the Atlas vehicle. And as I recall, when I was down at the Cape for the flight of Big Joe, we—during one of the testing phases, we noticed that there was a problem with one of the instruments that's—it was called a barostat, that's required—sense the atmospheric pressure as the vehicle comes into the atmosphere, and it determines the time whenever the parachutes were to be deployed.

We sensed in one of the testing sessions that we had a problem in one of the barostats. And so, Scotty [H.] Simpkinson and myself, we went up onto the gantry, removed the barostat, brought it back down to Hangar S, where we were housed at the time; and we took the barostat apart, found the problem. We made the fix to it, and I believe Max Faget and Chuck [Charles W.] Mathews, a couple of the other guys that were with us, we all kind of conferred on the fix and so forth, and went through the process of actually testing it and checking it out to make sure it was okay. Took it back up on the gantry and reinstalled it. It worked fine in the flight.

Those things you couldn't do this day and time. And to be able to do a test vehicle in nine months and—from concept to flight was just unprecedented—I mean, is unprecedented these days.

WRIGHT: And how did you come up with the name of Big Joe?

BOND: Well, that wasn't difficult. Max Faget, well, he had already named Little Joe. And Little Joe was a composition that was a cluster of four rockets that were put together; and, since—and if you're familiar with the game of dice, the number four, when you come up with a four, is called a Little Joe. So, when Little Joe came up and then the idea of a bigger vehicle, he says, "Oh, I've got the name for that. Big Joe. We have to—" So, it was very quickly decided that ought to be the name.

WRIGHT: And it has lasted through history.

BOND: Right. The other challenge that, I think, was a major challenge in my career was the Space Environment Simulation Laboratory. And I think I've hit on that already. The idea of being able to design and develop and operate such a facility that had all those requirements of man-rating and providing the very severe environments of space was extremely challenging at the time. And since no large chambers were even—Tullahoma, the Air Force Base in Tullahoma [Tennessee], they were in the process of developing a facility of somewhat similar size. But it was not going to have the man-rating capability that we envisioned we needed in ours.

And we, of course, we used whatever expertise and information that was available from that facility to put into the design of our Space Environment Lab. But that was a really a major challenge to be able to design and develop that facility and then have it operationally ready to be able to do the Apollo Program in time. And I sweated many nights over the problems that we encountered there. But, of course, along the way there were other kind of challenges as we got into operations to support Apollo and the Shuttle Program subsequently. And always many interesting things that I considered myself to have been very privileged to be able to come along at this time and work with the many, many, many notable and capable people that I was able to rub elbows with and work with and—

George Low was really, he was—we were colleagues, I guess at the time. He worked back at the Cleveland Laboratory [Lewis Research Center]. And he was also involved in some heat transfer work. And so, we had kind of a common bond at that time. But George was a fantastic engineer and manager. And I learned a lot from George, working with George. It was really a privilege to be able to work with that man.

And, of course, Dr. Gilruth. I don't think enough could be said about Dr. Gilruth and his ability to psych out problems. And he was very low key. He was very low key type of individual. I think everybody loved the man. He was really a real human being. And he cared about his workers, and their families! And just—it was a privilege to work with him and Max Faget and quite a number of the guys that worked with me and under me in the Engineering and Development organization.

Chris [Christopher C.] Kraft [Jr.] had, of course—we were close colleagues at the time when we formed the Space Task Group. Chuck Mathews. There were quite a number of those guys that made very, very large contributions. And I felt very, very privileged and fortunate to have been able to work with all these guys. And to work on the manned space program from its very beginning.

WRIGHT: Well, the program certainly has had many historic firsts. And tomorrow, in fact, we are looking at the anniversary of one of those. And it's the launch of the Apollo 11 crew. Share with us where you were 30 years ago when the excitement of what was going on here at the Center and help us understand, from the folks that helped create this historic event, what it was like here.

BOND: Well, I'll tell you, it was very exciting. It was very exciting. I guess the—no, this was the culmination of all the activities, the inputs, the work that had been put together by so many hundreds and thousands of people. You know when you think about it, the manned space program employed, I remember the number it was something like 250,000 or 300,000 people from all over the country. Not just this area. And the flight to the Moon at that time was—this was going to be it. This is what we'd been working so hard for. This is—

And like the—back in my days at Wallops, whenever I would take a vehicle up to be tested and we'd run down behind the sand dunes, and there was a lot of excitement to watch this thing go off, you know. This was it, you know. This was the time that you said, "Well, did you do everything right or didn't you?" And, golly, it was just fantastic to see [Neil A.] Armstrong step down out of that lunar vehicle and make those famous words about, "This is a small step for man but a large step for mankind."

I get a kick out of Pete [Charles] Conrad's [Jr.] remark. And I was sorry to, you know—very much touched by the fact that he had that accident and passed on just recently. But he, you know, Pete was always very much of a witty, comical individual. He always had something to kind of set you off. But his, you know, his remarks were, "It might've been a small step for Neil, but it's one big step for me."

WRIGHT: Were you here on the Center when the event happened? Or were you home?

BOND: I was on the Center and at home, and then back at the Center. I was back and forth. I think I went home to be with my family when we were watching part of the lunar activity, the—and then, of course, a lot of us would have to be available in the Control Center in the event we had some problem or issue that had to be addressed. And as I remember, I was back and forth. And it was really an exciting time. So, I don't think that I've ever experienced as exciting—I mean, as that particular occasion.

WRIGHT: Many, many individuals, as you said, made that happen. And then, of course, just two missions later, you were all very closely working together to save a mission. And you mentioned early that one of the test facilities was very, very instrumental in dealing with the issue with Apollo 13. Could you elaborate a little more on your participation? On how you were able to help solve some of the problems with the Apollo 13 mission?

BOND: Well, the—of course, the fact that we had an explosion on the spacecraft was devastating. And at that point in a mission, whenever the vehicle's headed toward the Moon, there was nothing else that you could do except to let it go around the Moon and then head it back, if you could. And, of course, the people in the Control Center were frantically trying to figure out what had happened.

Our engineers were—we always manned, in Building 45, a comparable activity where all the systems people were made privy to—all the information that was coming in was also available in Building 45 at various stations for all the various systems of the spacecraft. And, of course, we had E&D people, who were the systems managers and engineers, that were responsible for the—a lot of the detail work of the systems. And also, a lot of the company representatives; their systems people were brought in with us.

And so, they were in the—you know, going through the job of trying to figure out exactly what had happened and determine what to do. But the E&D people, the Crew Systems people, were really called upon to figure out how we could retrofit the canisters of the command module to fit into the lunar module to extend the stay time and also to extend the capability to accommodate three individuals in the LM, which was originally only designed for two, and still provide them a breathable atmosphere. But then in addition, all the other systems people that had to do with power consumption had to figure out exactly what could be powered down and what could leave only the essential stuff operating.

So, that went on behind the scenes. The—you know, the communications people, the people that had to do with the fuel cells, all of those people would huddle together and review the information and determine just what we could do, how to power down, and so forth. But after the flight, we had to ascertain what was the real cause of the problem. And as I mentioned, the Thermochemical Test Area had a facility in which we developed fuel—

did the testing and development of fuel cells.

And in that facility, we were able to reproduce the problem that had caused the explosion. And we did this. There was an investigating committee that was set up; and, I believe, Ed—Edgar [M.] Cortwright of the Langley [Research Center, Hampton, Virginia] Laboratory had been sent to—assigned to head that up. And we were able to brief him and actually simulate and reproduce that—the cause of that malfunction, where some switches actually, because of a wrong process having been used at the Cape, actually was the cause of those switches actually fusing and continuing a continuous buildup of heat in the system until there was so much heat that generated that the fuel cell exploded.

WRIGHT: I guess it was such a relief to everyone that this was not the normal practice, of having to come up with the answers to these problems that most of your missions were very well orchestrated and people sat and reviewed the accomplishments, not all the problems.

BOND: Well, there were always problems. Always problems that had to be solved. I can enumerate any number of problems along the way in Apollo and—that had to be solved before the mission could actually—or the vehicle design could continue. We had problems with the environmental system. With the air-conditioning system.

We had problems with metallurgy, with what was called—some materials, whenever they're being processed, if they're in the presence of hydrogen you can get what's called hydrogen embrittlement, which weakens the material and eventually it can actually begin to fail.

We had chemical—chemistry problems, like I say, in the environmental control system, where the control system had been put together by a number of dissimilar materials and eventually, with the fluids tending to pick up the ions from these different metals, would—caused a problem. And we finally had to introduce other constituents in the cooling system in order to gather up those excess ions that were causing the problems.

We had problems with titanium tanks. We were buying hydrazine from—through the Air Force, and it was—it came with a certain specification. And this is kind of surprising: the Air Force went through a process of making the hydrazine more pure. It took out some of the impurities that were in it, and that was—it turned out that those impurities were actually protecting the titanium tanks. Once that was taken out, we began to have problems with them. So, we had to reintroduce the material—the impurities in order to stop that process.

Now some unusual kinds of things like that, but these were problems that were sorted out and solved by many of the engineers in E&D. And along with that, you know, the company engineers also participated in these kinds of investigations. But it was a process of excellent engineering and understanding of materials, so a lot of times that we found whatever materials were used that there wasn't a good understanding of the capabilities. That's where we had problems.

So, one of the advices that I've always given my young engineers, "Know the materials that you're working with. Know what they can do, what they're capable of doing, and how they've been tested to be able to accommodate that. If they haven't been fully tested for all the conditions that you're going to see, well, don't use it. Or else make sure that you do test it under those conditions."

WRIGHT: It sounds like sound advice. Very sound. We've spent a lot of our time visiting today about your Apollo time. But you also moved on through and worked some with the shuttle era as well. Could you give us a brief review of some of the things that you did that affected that time of NASA's history?

BOND: Well, yeah. It's—well, the shuttle, of course, was another big challenge for the Center and for many of us. The shuttle concept was initially envisioned by, oh, several engineers. Dr. Faget had a big hand in the shuttle concept. And in the early days—well, in the latter days of Apollo, Max did set up an organization that we installed in the back 40. It was a group of engineers. I think Jim [James A.] Chamberlain was one of the—was head of that group. And Jim was one of our Canadian engineers that had come down with us back in the early days of Mercury. And he was assigned to come up with a preliminary conceptual design of a shuttle kind of a vehicle.

And these guys were set off in the back 40—I think there were, I don't know 30 or 40 of them—and asked to do their work quietly and, you know, come up with what they thought a usable kind of a vehicle would be like. And once they went through a lot of—there were a lot of evolutionary changes that went along. And then, of course, people at [NASA] Headquarters got involved. John [F.] Yardley, who was formerly with McDonnell, of course, went to Headquarters as an administrator up there. And there was a lot of going back and forth, and—but Max was quite involved. He had ideas for a delta-wing—excuse me, for a straight-wing shuttle. And others had an idea of the delta. And the delta finally won out.

But Max still got a lot of his ideas incorporated into the shuttle. It, you know, we were quite excited starting off on a new kind of a test article. And there were other issues and problems to be addressed. Again, the material that you would use for thermal protection. That was one of the big items that we had to make sure that we solved and solved properly. If it was going to be a reusable vehicle, the thermal protection material, the TPS [thermal protection system], had to be able to sustain repeated use without having to have major retrofits, and so forth.

The leading-edge material. The nosecone material. Though each of those were different kinds of—I mean, the nosecone and the leading-edge materials were different from the TPS that would go under the grosser parts of the vehicle. And so, there were major developments there. And our Structures and Mechanics people participated with Rockwell [International Corporation] in designing and coming up with materials and selecting materials, and then testing them to make sure that they did meet the bill. Then there were issues about, you know, whenever you had moving surfaces, how did you protect certain areas where the airstream could get in and maybe create zones of impingement of hot gases and so forth?

So, there along the way, there were many of those kinds of problems that had to be solved along with the communication systems. We came up with the SAIL, Shuttle Avionics Integration Laboratory, that put all the control components together and exercised them as a integrated system. And, there, many kinds of problems were deduced and corrected and so forth. And so, yes, it was a major challenge again but in a different kind of way. But many of our engineers, again, contributed to the solving of these problems and putting together a system that is working today—and working very well.

WRIGHT: Yes, it is. Yes, it is. And hopefully will continue for a long time as the new ideas are thought up.

BOND: Well, there's a major upgrade that's going to be going on, on shuttle, too, that I think will extend its time—its useful life—for another, I believe, 10 or 15 years, if I'm not mistaken. Something like that.

WRIGHT: So, the years that—your contributions will still be making impact for many more years to come. And we certainly have enjoyed listening to the ones that you shared with us today. And I know that you have many more; and hopefully in the future, we'll be able to visit with you again.

What we'd like to do now is take a break. We know that you brought some photos for us, and we're going to ask you to go through some of those and give a brief kind of like a photographic history of what those photos are and how you had the—your contributions made a difference in those as well. So, we'll stop for now, and thanks for—

BOND: Well, thank you. It's been a pleasure, and I've enjoyed doing it.

WRIGHT: Thank you.

VOICE OFF CAMERA: Okay. We are ready, sir.

BOND: [Photograph One] We're looking at a photograph of the Big Joe vehicle. It's the—includes the—on the top part, of course, is the Mercury prototype test capsule mounted on the adapter that attaches it to the Atlas booster.

BOND: [Photograph Two] In the Big Joe capsule, the key individuals that worked on Big Joe composed a letter that we sent to Dr. Gilruth. And the letter has been—in this particular scene, the letter has been retrieved and is being read by Dr. Gilruth as the—it was a first. It was the first mail from space to Dr. Gilruth. And I believe for many years, he had actually framed and had this in his office for some time.

BOND: [Photograph Three] This scene shows a picture of the recovered Big Joe. And one of the things that's particularly noteworthy is the letters "United States" are still showing up very good, even though it has gone through the reentry heat phase and also in the Atlantic Ocean for a while, that there was still—the letters show up quite a bit there. This is part of the crew that worked on it. The fellow standing on the left is Scotty Simpkinson, who worked directly with me on putting the Big Joe instrumentation together. A couple of other guys: Marty Eiband is on the other side, opposite Scotty. [G.] Meritt Preston on the left, myself in the middle, and golly, it—another guy, I—it escapes—I know his name like I do my own, but I can't remember the name just now!

BOND: [Photograph Four] This shows a view looking in directly toward Chamber A. We can't see all of Chamber A because the chamber is so very large. But we do see the 40-ft opening door, and we can see a test article in the chamber. It was a satellite article that was subsequently tested for one of the other agencies of the government. But one of the things we wanted to point out here is that this chamber has been useful for many different kinds of tests, even beyond those of test activities that—for support of JSC programs.

BOND: [Photograph Five] This again is another shot of the large chamber in the Space Environment Simulation Laboratory. And we see, inside the chamber, we're looking through the 40-ft door. We see inside the chamber the Apollo command and service module as it was tested back in those early days of Apollo. And the individuals that you see in front of the door are the key individuals that were involved in running the facility. The middle fellow is Kurt Strauss, who was the head of the organization. And the other individuals were very key in running the test organization and test activities that SESL undertook.

BOND: [Photograph Six] As mentioned earlier, the—one of the tasks that was undertaken in the Space Simulation Lab was to test the Apollo command and service module for the full duration of the mission—some 8-plus days. And these were the three crewmen that were subjected to that testing. We're looking through the hatch in the command module, and they're all looking out; and they were in there for some 8 days, eating and sleeping and carrying on all the mission activities as they would in an actual mission going to the Moon.

BOND: [Photograph Seven] This is just another shot of the crew, looking into the command module. The crew was quite relieved, of course, to get out of that thing after lying on their backs for that many days. It was unlike going to the Moon actually. In the zero-g environment, of course, the astronaut has the ability to get up and stretch and move around and so forth; whereas in the one-g environment, they were essentially on their backs for quite a bit of the time that they were in the command module. But they did everything they had to do. They had that space mission odor that astronauts have whenever they get back after being cooped up together. Of course, they didn't realize they smell bad because they all smelled each other. And it was—but the people in the facility, of course, understood it as soon as they opened up the hatch.

BOND: [Photograph Eight] This is a shot of Chamber B. Actually it's hard to really discern that there is a chamber under all that mass of equipment that's installed around it. But it was the smaller chamber of the facility, and it was used primarily to test the lunar excursion module, the LM, in its entirety as well as to accommodate—test and accommodate the astronauts to the lunar surface kind of environment with tests that simulated those kinds of conditions.

BOND: [Photograph Nine] This is a shot looking directly into the Chamber B, the smaller chamber. The top has been lifted off. And we can—the lunar module has been installed into the chamber. After all the connections and everything had been made, the top would be put on and we would proceed into the testing—achieving the test environment for the lunar module.

BOND: [Photograph Ten] This is a photograph of Eugene [A.] Cernan being fitted up for an excursion into Chamber B, where he was going to actually undergo some training using one of the pieces of equipment that he used in EVA [extravehicular activity] on one of the subsequent flights.

BOND: [Photograph Eleven] And this scene shows the astronaut in the chamber with the hardware that he [Cernan] was being tested with. And the chamber is actually—has been pumped down to space conditions; and the test is being carried out to give him some exposure to what kind of conditions that he would be seeing in the space environment.

BOND: [Photograph Twelve] This is just another scene of an astronaut in the small chamber, being subjected to the thermal conditions that can occur in the Moon The cage that you see around the astronaut is actually a thermal cage that provides a simulation of the kind of heating that he would see whenever he's in direct sunlight. Sunlight on the lunar surface. And he is using the backpack, the EMU, extravehicular maneuvering unit, for his breathing supplies, as he would on the lunar surface.

BOND: [Photograph Thirteen] This is a composite photograph of the Vibration and Acoustic Test Facility that you see. You can see the building in the center part of the photograph. And it has several photographs around it that show the various test articles that had been tested in the facility. Of course, it provides both the mechanical vibratory environment that the vehicle sees on its—during its launch—the launch process, and also the acoustic environment that it has to endure when the rockets are firing.

BOND: [Photograph Fourteen] This is a photograph of the lunar module test article in the vibration facility. The little nodules that you see all over the vehicle are instrument locations. It's been very highly instrumented with vibration pickup so that we can ascertain how the structure will respond to the vibratory environment that it has to see on the—with the rocket firing.

BOND: [Photograph Fifteen] This is a photograph inside the anechoic chamber. The anechoic chamber is a noise-free—provides a noise-free environment, free of any electromagnetic radiations from the outside. And here we're—we see two astronauts seated on the lunar rover, in which they were testing the communications systems that were on the lunar rover that communicated back to Earth.

BOND: [Photograph Sixteen] This photograph is another shot inside the anechoic chamber. And here we see a scale model of the orbiter [shuttle] vehicle being tested, communications-wise again, for its systems that had to do with communications back to the Earth.

BOND: [Photograph Seventeen] This photograph is really an architect's rendering of the layout of the Arc Jet Facility that was built, and is presently functioning, here on site. And it included two test positions for the testing of reentry-type materials. The nosecone material and the thermal protective material that's used on the shuttle were tested there, as well as some of the ablative materials that were tested in subsequent programs after the Mercury

Program.

BOND: [Photograph Eighteen] This is a composite photograph of the Thermochemical Test Area [TTA]. There's an overview—an aerial view in the top center photograph that shows the central control system with the five individual laboratories that make up the TTA. On the left-hand side is a fairly large vacuum chamber that is housed in that facility that was used for testing fuel cells and other kind of equipment that required exposure to hard vacuum.

On the upper right is the Fluid Systems Test Facility, where we were able to test different kinds of fluid systems that were used in the various control rocket systems and so forth of the various vehicles that we—had been developed. Pyrotechnics was the—were a big entity, of course, throughout our space program, one we used on all the programs. The lower left test facility was exclusively used for testing and developing pyrotechnics.

The middle photograph is the Propulsion Test Facility, where the small rocket motors used in the RCS system, reaction control systems, on both Apollo and then subsequently the shuttle orbiter have been tested. And the—on the right hand we have the Space Power Test Facility that, again, tested certain power systems that were used.

BOND: [Photograph Nineteen] This is a composite photograph of the Crew Systems Division. And the Crew Systems Division had several medium size to small chambers that were used for different kinds of testing activities in developing suits and developing certain pieces of hardware and so forth. We had—20-ft chamber was developed, and I understand is presently in use, actually, to expose a number of volunteers to the kinds of conditions that they would have to endure on a long-duration mission to Mars.

The 8-ft chamber was just an ordinary—not a space chamber, but just a vacuum chamber for—the Air Force actually gave to the JSC for just exposing occupants to the reduced atmospheres that you see in flight, high-[altitude] flight, and so forth. Then the—on the lower left-hand side, we have an 11-ft chamber and also a 10-ft chamber. And these were used extensively in the developing and testing of spacesuits.

BOND: [Photograph Twenty] This is a photograph in the Structures and Mechanics Laboratory and it shows the people that were in Structures and Mechanics involved in the Apollo-Soyuz along with the Russian engineers that had come over and spent quite some time with us in several different tests during Apollo-Soyuz. The Russians passed out red hats for everybody to wear. And it was a—they were quite interested in this docking facility. In fact, they were quite interested in all of our facilities, and carried back a lot of information on details that we were able to make available to them, public information that they could take back with them and use in their thinking.

WRIGHT: Thank you.

[End of Interview]