ORAL HISTORY 3 TRANSCRIPT

CALDWELL C. JOHNSON
INTERVIEWED BY ROY NEAL
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NEAL: All right. For identification this is Roy Neal with Caldwell (call him "Cadwell") Johnson, and we're going to talk about some of the early days of the space program. Our location this morning is the [Johnson] Space Center in Houston, Texas. And if you're ready, Caldwell? I think we're all ready to go, okay?

JOHNSON: Most—most everyone calls me "C. C." I—the reason being is that the given name was hard to pronounce and people solved the problem by just saying "C. C." And they didn't have to worry about it.

NEAL: As a matter of fact, the given name was so hard to pronounce that it's spelled "Caldwell" and pronounced "Cadwell."

JOHNSON: That's right.

NEAL: How'd that happen?

JOHNSON: Beats me. But my father has the same name, and it's pronounced the same way.

NEAL: Well, with your permission we'll make it "C. C." if you'll make it "Roy" coming in this direction.

JOHNSON: All right. Fine.

NEAL: Very good.

JOHNSON: Fine.

NEAL: Let's go back to the days of something they called the Space Task Group [STG]. Now somehow at that time the manned space program had a beginning. That you were a key man in that early design and test phase. Can you tell us how it all happened? How it all went together?

JOHNSON: I think it started with the Pilotless Aircraft Research Division [PARD] at Langley [Memorial Aeronautical Laboratory; later Langley Research Center, Virginia]. After World War II there were many surplus solid propellant rockets around. It was ordnance. They were not made for spacecraft or rockets of that sort. It was—it's pure ordnance. Robert [R.] Gilruth got the idea that he could investigate the transonic speed range, which was virtually impossible to do in wind tunnels. But using rockets to propel the test models in free flight, equip them with a small radio transmitters, called telemeters at the time, and collect the data that way. He formed a division; it was called the Pilotless Aircraft Research Division. Max [Maxime A.] Faget was there, Robert [O.] Piland, Bill [William E.] Stoney, myself, and there was maybe 50 or 60 eager young engineers now that had come there. And this was a whole new technique of getting data; and it was wide open. You could do anything you wanted.

They either purchased or leased or the government had land at Wallops Island, off the Virginia coast, just near Maryland on Eastern Shore. And it was set up as the launch facility, and it was a terrible place. There was nothing but a marsh and a strip of sand, and they had a few Quonset huts on it and so forth like that. And it was kind of living in the raw when you'd go up there to test things. But anyway, that's what started it.

The first thing, you know, these things that were supposed to explore the transonic region were getting hypersonic. And we had some vehicles that were getting close to escape velocities. And so the first thing you know, people started saying, "Well, if we just made it a little bit bigger and had a few more things, we could put a man in it." Ever so, we were playing Pinochle at lunchtime talking about this and, you know, bullshitting. But it—more and more people got to thinking about it. And I think that—that's what started the whole business of the space program.

NEAL: You were flying under the banner of NACA [National Advisory Committee for Aeronautics] during most of that time—

JOHNSON: Yes.

NEAL: —weren't you?

JOHNSON: Yes.

NEAL: Before NASA?

JOHNSON: Yes. And then—

NEAL: The [National] Advisory [Committee for] Aeronautics—

JOHNSON: —the transition was (when?) 1958 or something like that.

NEAL: ’58, yeah.

JOHNSON: ’58, yeah. And—

NEAL: And suddenly there was something new called NASA.

JOHNSON: Yes.

NEAL: The National Aeronautics and Space—

JOHNSON: Yes.

NEAL: —Administration. Wasn’t that a grand name?

JOHNSON: Yeah, that was a grand name. Of course, we were very excited and also worried because the Air Force was in that game, too. And the politics, didn’t know for sure which way it was going to go. But the President finally decided it was going to be a civilian outfit.

NEAL: And actually you married the military, in terms of getting some of those early boosters, didn’t you?

JOHNSON: Yes.

NEAL: Both—

JOHNSON: Yes.

NEAL: —Army and Air Force now that I'm remembering it.

JOHNSON: Yeah. And in fact, most of them are Army.

NEAL: Yeah.

JOHNSON: Army.

NEAL: Well, let's go back over those beginnings, because now we see the Space Task Group. Here's this—

JOHNSON: Yes.

NEAL: —new organization. It's NASA. You've just changed, and not your allegiance—but you've changed the flag under which you're flying. And so now the Space Task Group is getting organized. There you were, at the very beginnings. What role did you play at that time, and how did it work?

JOHNSON: I was a designer of the—of these test aircraft. And roughly the Agency was set up in an administrative department, the research department, and then what was called the Technical Services. Now all the people like the—the Fagets and the Gilruths were in the research department. I was in the technical services. It was our job to perform a service—an engineering service—for the research people. This included the shops, the instrument people, and all that sort of thing. And so, in a sense, I was brought from the organization I really worked for to help these people. So, that's how I became connected with the organization.

NEAL: Did they give you a title at that time? Because everybody in government service has a title.

JOHNSON: No, it wasn't all that formal. I was a section head and I was called that, but—and there were a bunch of young fellows—I think one of the things that made it go, too, is that we were all young. All the older people were in those wind tunnels. And this was a new game, and fortunately it had a bunch of young people because you can't teach the old guys a new game.

And the wind tunnels, we—they were like the battleships. And you remember in the services how the battleship were all having a big fight with the aircraft world? And the old admirals didn't like these airplanes; and the wind tunnel people didn't like those of us with these pilotless aircraft doing the research work. And I think that had a lot to it. That it was young blood. We didn't have enough sense to know that it was, you know—it was going to be a difficult thing to do.

NEAL: It seems to me, though, C. C., that at that time something big happened. You had been working with pilotless aircraft, and suddenly the mission had to do with sending a human being—

JOHNSON: Yeah.

NEAL: —up into space. An unknown area.

JOHNSON: Yeah.

NEAL: An unknown ocean, if you will. And how did that beginning come together? How did you begin to design something for a human being?

JOHNSON: I don't know except that obviously, sooner or later, whatever you do, you're going to put a man in the thing. No matter what it is. I'm sure the—it's almost no point in doing things if a man is not involved sooner or later. And of course, by "man" I mean "mankind," "humans," or something like that. And I'm sure it must've first been speculated about monkeys, if for no other reason they're smaller. They only weigh 12 or 15 lbs and—as opposed to 150 lbs or something like that.

NEAL: A good idea, maybe, to test hardware on animals before you put human beings in the loop.

JOHNSON: Yeah. In fact, there were a bunch of jokes about that in Mercury days. In fact, I think I remember making a cartoon that—something to the effect that—do you remember Sam? The monkey Sam? And he more or less just went along for the ride, but I wrote a memo and suggested that as long as he was there, if you could teach an astronaut to do this, you could sure as God teach a monkey to do this!

NEAL: I noticed you said you wrote a memo. You have a lowly opinion of memoranda, don't you?

JOHNSON: I know! Well, that one was kind of a joke. And they—the crew people didn't take it as a joke at all.

NEAL: I wonder why.

JOHNSON: Yeah. I wonder why.

NEAL: Where did the name Project Mercury come from? Were you—

JOHNSON: I don't know.

NEAL: —do you remember that?

JOHNSON: I don't know.

NEAL: Out of left field. Suddenly.

JOHNSON: I don't know.

NEAL: The messenger of the gods.

JOHNSON: Yeah, I guess so.

NEAL: With wings on his heels.

JOHNSON: Wings on his heels.

NEAL: Well, then along came the astronauts. Seven test pilots were chosen.

JOHNSON: Yeah.

NEAL: They came into the picture. By that time, where were you in the design phase, by the time that the men came into the loop?

JOHNSON: Well, let's see. 1958. I have a drawing at home of the—a drawing I made of Mercury, the first performing model. We put together a little paper and explained the systems, and I made the overall configuration images. And that was dated June of 1958. And see, that's just about when NACA became NASA. So, we were that far along before there was a NASA. And see, that was quite a bit before any astronauts came aboard.

NEAL: What do you remember of that first design that you put together? Can you visualize it for us?

JOHNSON: Well, in the first place it was a pencil drawing. It was not made with a computer. I can tell you that much. And it was—I still have the original. For some reason, I kept it. And it's remarkably like Mercury turned out to be. It's a man in it. A retrorocket. It did not have an escape rocket system. (That came along later.) But otherwise, it's the same parachute arrangement, and it's the same shape.

NEAL: Did it have a window?

JOHNSON: Yeah. It had a little window. Yeah. And, so, it's not true that we didn't put a—have a window in it.

NEAL: The process of putting a spacecraft together has always been fascinating, and most people haven't the slightest idea of how you do it. So, here's your chance, C. C. Tell us: How did that Mercury spacecraft come into being?

JOHNSON: Firstly, the guys in the research division (in the Pilotless Aircraft Research Division) had found out that, of course, that there's a lot of energy has to be dissipated when a spacecraft enters back into the atmosphere, that the blunt body was the most efficient way to do that. Everyone else had always assumed that things should be pointed. And it turns out that the blunt body is really the better way, if you just want to brute force something, you can decelerate yourself with the least amount of trouble with that blunt body. Now with the blunt body, it turns out, that the force vectors are such that a man can lie on his back and across the craft. When he's at the point, you cannot—it's hard to fit a man into the little thing that's got a point.

Second place, it was obvious from all sorts of tests the Air Force had done that men can sustain accelerations better, more or less, what's called eyeballs-in—that the force is in—if you're lying on your back. You put that together with the blunt body. Then there were parachutes available that were quite dependable parachutes. We had had a lot of experience with these solid propellant motors that you could do the retrofire business, to slow yourself up so you could reenter the Earth. So, suddenly we had all the fundamental elements that it took. Now then it's just up to someone to shape these things together, package them, and arrange them geometrically so that all these things fit.

Well, that was essentially my job, was to package all these separate elements that other people had worked out and selected. I never selected a rocket motor for it. I never selected the kind of parachute. I didn't design the initial heatshield for the thing. Other people did it. But I took all of the things they did and put them into a package. There's a—there's an English word that's difficult to pronounce. It's called: concinnity. C-o-n-i-c-c-i-t-y [*sic*]. Something like that. And it means an artful arrangement of things. I would use the word more often except it's so difficult to pronounce. So, that's what I tried to do: make an artful arrangement of systems.

NEAL: Once they came aboard, did the astronauts have anything to say about all of this?

JOHNSON: Well, I—they were probably as—they were probably in a state of shock, too, at the time. I'm not quite so sure they—they must've looked at this thing and thought, "My God! What have we gotten ourselves into?" But it was the first place, it—you know, it doesn't look like much if you look at Mercury. It doesn't look like much of anything.

NEAL: Not if you're used to flying high-performance jets.

JOHNSON: That's right. But they didn't come in roughshod and try to throw their weight around.

NEAL: The image that has been presented in books and motion pictures gives somewhat of that idea. You're contradicting it.

JOHNSON: Oh, that's not so. They were sensible enough to know that different people have different skills, and their skill was flying airplanes. It was not designing airplanes. Not that they couldn't—they could've learned to do that, too, I'm sure, because they were very intelligent, capable guys.

NEAL: Well, Mercury of course was designed to put a man in orbit. But you also designed it so that it could be remotely controlled. You could eliminate the man from the system if you had to.

JOHNSON: Yeah. That was a running battle throughout the program, that there were those of us that say, "Why should we waste 150 lbs and learn about all the safety of a man when with a quarter of that weight you could automate the system?" On the other hand, people would say, "Well, what's the sense of doing all of this if the man is not involved? Sooner or later the man's got to be there. " Unfortunately the system got polarized. I don't mean within the Mercury Program itself. But if you remember, NASA finally divided into two camps: the manned and the unmanned systems. And, you know, there's a place for the merger of the two. There's some things that men do wonderfully, and some things they're not very good at. The instruments can do things quick, but some things they can't do worth a damn. They can't think, for one thing.

NEAL: The Russians followed a different tact. They said, "Okay, we want this automatic control." And to this day, they still have it—

JOHNSON: Yeah.

NEAL: —as they fly their cargo vessels up there to replenish the *Mir* space station. Do you think, perhaps, that might've been a better path to follow in retrospect?

JOHNSON: Well, it would seem like it's a sensible thing to do, since it—there are many missions that if—there really isn't any point in having a man there if it's simply a resupply mission. Or let's say, to turn it into the reverse. It—it's just a Shuttle type of thing going back and forth; it's routine. And that's one thing that the men don't do very well. All the routine things.

NEAL: So, there would be a place for unmanned cargo aircraft?

JOHNSON: Oh, I—yeah, I would think so. I would certainly think so. For instance, the docking activity. You know, it's easy to automate the thing. The total navigation system. It's just—well obviously we have all sorts of unmanned satellites doing all kind of things in space.

NEAL: You were working with Max Faget, were you not?

JOHNSON: Yeah, oh, yes. Very closely.

NEAL: He was designing. You were taking the design and putting it, as you say, into "artful form." I understand that you even designed portholes (no windows) in the original Mercury. Is that right?

JOHNSON: It was a port, yeah. I suppose. I'm not quite sure the difference between a porthole and a window, except a porthole is generally small and a window is larger, somebody might say. But, and if you remember, Mercury ended up with a thing called a periscope. And it turned out to be not a very satisfactory device. But, you know, it was clear that the man; he's got two eyes—the best instruments there ever were. Two—those two eyes. And to deny they—those eyes the—a port to look out is kind of silly. That same thing came up in Skylab years later. It's that same argument.

NEAL: A lot of navigation aids also called "stars."

JOHNSON: Yes. That's right.

NEAL: If you can see them.

JOHNSON: Yeah.

NEAL: The Mercury interface between the capsule and the rocket was a big contribution. I understand that was a matter of some concern for you. Was it?

JOHNSON: Yes. Yeah.

NEAL: Can you tell us about it?

JOHNSON: Well, at that time the only candidate launch vehicles were things like the Redstone rocket and the Atlas, neither of—neither one were designed with the idea of putting the Mercury on the end of the thing. So, they were designed to their own particular requirements. We had a heatshield that was vital to the thing that really wasn't the best thing in the world to be the interface with something. And, so it took a little finagling to make these two completely separately designed objects take the loads, make certain they separated when it was supposed to, and not separate when it wasn't supposed to. And, so there was a lot of mechanical engineering involved in the thing that you might say had nothing to do with the spaceflight business itself.

NEAL: It had a lot to do, though, with the way that thing flew.

JOHNSON: Yes. Yeah, yeah.

NEAL: How'd you come up with that design?

JOHNSON: Well, we had been, you know, in the Pilotless Aircraft Research Division—had been doing that all the time in a smaller way. We had ordnance rockets and then we had the test vehicle that went on the front, and they had to be separated after they did their thing. And so, we had had a chance to explore a whole lot of different ideas. Some worked and some didn't work.

There was another thing that we found in the Pilotless Aircraft Research Divisions, that people didn't know a hell of a lot about the aerodynamics of hypersonic flight. But we found out the hard way that things that had funny shapes—asymmetrical shapes—were more prone to having trouble than things that were more or less bodies of revolution. So, we stuck with those bodies of revolution for a long while until the Shuttle came along. If you notice, everything was essentially a body of revolution. And there were a lot of us that were very much worried about the Shuttle, since it was so clearly not a body of revolution.

NEAL: Obviously, we're going to get to the Shuttle—

JOHNSON: Yeah, yeah.

NEAL: —just a little bit later. Right now, let's stay with Mercury for just—

JOHNSON: Okay.

NEAL: —a bit because here you had a spacecraft that finally was conceived and you flew it on a Redstone rocket, suborbital, testing your wings, as it were, even though there were no wings on that spacecraft obviously. Did the spacecraft evolve at all during the Mercury days? Or did it pretty much remain in the same design for all the flights?

JOHNSON: Initially, it changed a little bit. But by the time it got to actually being flown on the Redstone, things had settled down. And there were very few changes of consequence then; that is, you couldn't look at it and see any great difference. There had been problems—there was a series called the Little Joe's and the Big Joe's, and they were boiler—called boilerplate things designed just to test certain performance characteristics. Now those flights, and they were unmanned of course, suborbital, but they revealed a number of surprises. And that was—it was very important because we caught the thing at a stage of design that you could change the—you might say, the production article without a great deal of cost and trouble. And of course, there was no man involved in it either.

NEAL: Can you elaborate that point for us just a bit, what you discovered?

JOHNSON: Yeah. If you can remember the shape of Mercury. It was essentially a cone, except for where the apex of the cone would be it ended up a cylindrical section. If you can remember. The sides sloped up and there was—It was balanced like that because—to house the parachutes, for one thing. There just wasn't enough space in there for them to house the parachutes. We miscalculated the heating effects of doing that.

It turned out that the sloping sides of the Mercury were relatively cool. And—but when that change in direction—suddenly instead of sloping sides, a cylinder—it got very hot there. Much, much hotter than anybody had anticipated. And they had to change the—the skin of the thing. Found out that it was completely inadequate. Now a—Big Joe found that out. I remember that when we got it back, we had burned some holes in the side. Actually burned all the way through! And it had survived, though, but it was obviously—needed to be redesigned. But some flights like that pointed out a number of things. The stability of the system was always in question.

NEAL: You say there was some question about the stability, obviously, was sufficient.

JOHNSON: Yes. Whether this blunt body shape would work. But, do you remember there was a Big Joe flight that it did not separate from the Atlas initially? What happened was that the Atlas continued to thrust when it was—not much, but just enough that when it—Mercury tried to separate, the Atlas kept pushing. And the Mercury spacecraft used up all of its control gases trying to turn itself around, to enter the—to enter the atmosphere in the right direction. But it was still being pushed by this great, monstrous Atlas. And it wasted all of its gas trying to turn the whole system around, and it had ran out of gas; and finally the Atlas gave up and fell off, too.

But now it was—Mercury was heading in the wrong direction to come in with no control system to turn it around. But it was inherently stable in the other direction, and it turned itself around. Now, we were absolutely delighted at that because here was—it…unexpectedly…[exhibited greater one-]point stability than anyone had thought. Now that—you know, that's a very satisfying feeling to know that if you had—if you ran out of all your control gases, the damn thing was going to turn around in the right direction anyway.

NEAL: Wasn't that the real reason for the ballistic reentry itself, and the shape that you came up with?

JOHNSON: Well, it—well, the real shape was to take care of the heating problem. Now, it was theorized that it would be stable in this position also. But there were a lot of people that were—would not have thought you could become 180 deg wrong and then turn yourself around. But it did.

NEAL: Like "I shot an arrow in the air. It came back to Earth, I know not where. But it came back to Earth."

JOHNSON: That's right.

NEAL: That's really the point.

JOHNSON: And they come down point first because you've got feathers on the back.

NEAL: Well, finally with Mercury then you realized you had a machine that could take men into space. There was something else that had to be learned. How would the man react inside the spacecraft? Did you follow those flights?

JOHNSON: Well, of course there was just a small group of us; so everybody paid attention to everything. But that really wasn't my bag. I didn't design life support systems. I wasn't—I was interested in the physiology of the man simply because it was a mechanical system as far as I was concerned and he had to be supported mechanically. And so, I was interested in the body structure and how the couch should be made and that sort of thing. And, of course, the man had to be positioned properly in the spacecraft.

NEAL: If I remember correctly, C. C., as Mercury really began, somewhere shortly inside that envelope the President announced after [Alan B.] Shepard's [Jr.] flight that men were going to go to the Moon.

JOHNSON: Yeah.

NEAL: And I imagine that created a few changes back at Langley, didn't it?

JOHNSON: It sure as hell did. You know, it's one thing to sit around a—the table at noontime and play Pinochle and bullshit. It's another thing for the President of the United States to all of a sudden tell the world what you're bullshitting about! You know, "Now, put your money where your mouth is" is what that would be.

NEAL: How did you accept that challenge?

JOHNSON: I don't know. I—if I knew then what I know now, I'd think I'd have gone to Australia or somewhere and got the hell out of there. But I don't know.

NEAL: But you didn't.

JOHNSON: No.

NEAL: You went ahead.

JOHNSON: I don't know. I think that's a good thing about being young. You're not—nothing frightens you much when you're young. You know, you can lick the world.

NEAL: Anything's possible.

JOHNSON: Yeah.

NEAL: And in this case, it certainly was possible.

JOHNSON: Oh yeah. Yeah.

NEAL: How soon did you begin designing on Gemini, coming out of Mercury?

JOHNSON: I personally didn't have much to do with Gemini. It—Gemini was really an outgrowth of Mercury. I mean, it's an extension of Mercury. McDonnell was already set up, and the people that were working on it. And they had learned a lot of things about spacecraft and Mercury and—the organization that did Mercury was all in place. I really never had much to do with things once they got into the factory. Once a job would, say, be turned over to McDonnell Douglas or whoever—

NEAL: Wasn't the big thing, though, the big difference (from your point of view) the fact that Gemini was designed to dock with other objects in space. And that's where you came aboard and said, "Okay, let me go to work."

JOHNSON: Yeah, except even then, I—I'm surprised now in telling you this, but—I'm surprised that I was not involved, didn't involve myself, in that. I think the reason was that we was—had started Apollo. You see, we were working on Apollo before Alan Shepard took his flight. And so, as far as I was concerned, I was deep into Apollo when Gemini was being developed. Now, as it turned out, I wish I had paid some more attention; because some things happened in Apollo that were led by Gemini. For instance, the docking system had a lot to be desired. And it ended up that Apollo inherited some of the concepts from Gemini, which was not a fundamental—not a very good system. And it was later on corrected in Apollo-Soyuz. But that's another story.

NEAL: Well, we'll get to that—

JOHNSON: Yeah, yeah.

NEAL: —part of the story, too, I hope. Didn't you at one time even consider a paraglider landing system?

JOHNSON: Yes, yes, yes, yes! And it just—there were so many troubles with that thing, just every time one turned around. But I really shouldn't talk about Gemini because I didn't have a, you know—a hell of a lot to do with Gemini.

NEAL: Stay with the chutes.

JOHNSON: Yeah.

NEAL: All right. Well, how did all this preliminary thinking affect the planning for Apollo? Now let's see. I notice here you once said, "In designing Apollo, the engineers and designers would come to what seemed to be a completely rational design, but it would've been achieved in a completely irrational manner."

JOHNSON: Well—.

NEAL: I love that quote. Is that true?

JOHNSON: I—it is true. It's almost like a—what's the old story, if you give enough monkeys enough pianos, and one of them will end up playing *The Blue Danube* or something like that? I don't know what it is. I think it's—I—the first place, for some reason or another we were not antagonists. That's suggested a lot of people that work together are antagonistic, and they are. Somehow or another, there was an exchange of ideas without the feeling that "I have got to win my argument." And that people would listen to what someone else said; and then think about it and say, "Well, maybe that's not a bad idea after all." And I think that had a hell of a lot.

Now that's not really a rational process, I suppose. You know, people would—I'm not doing this very well. If I could do this very well, we would do everything right. You know that statement was—has been made about juries. Oftentimes I've heard lawyers say that, that a bunch of the most ill-informed people that do nothing but argue and fume and fuss and have got different points of view, and they've already made up their minds before they go—somehow, 9 times out of 10, they come up with a reasonable verdict. Twelve people. You say, "Well, how in the hell did they ever do it?" But they seem to do it.

NEAL: Well, in this case you had a big mix them and match them. You had the von Braun team in Marshall [Spaceflight Center, Huntsville, Alabama]—

JOHNSON: Yeah.

NEAL: —you had your team—

JOHNSON: Yeah.

NEAL: —which was here in Houston by that time. No, let's see. We're still back in the Gemini days.

JOHNSON: Yeah.

NEAL: You haven't even come to Houston.

JOHNSON: No. That's right.

NEAL: You were still—where you were during that period? At Langley, or getting ready to move to here?

JOHNSON: Getting ready to move to here. In fact, I—Gemini was really got going after we moved here I think.

NEAL: And Apollo, of course, is—

JOHNSON: Yeah.

NEAL: —is really—the planning phases for Apollo started coming together after the move to Houston. Is that what you're saying?

JOHNSON: Yeah. We had a letter contract with North American before we left Virginia.

NEAL: Why North American instead of Rockwell? I mean, instead of McDonnell Douglas?

JOHNSON: Well, McDonnell Douglas, first place they had Gemini. And Mercury was still going. Like I said, you know, all this happened before Alan Shepard took his first flight.

NEAL: So, a new contractor who's—

JOHNSON: So, a new contractor.

NEAL: —obviously—

JOHNSON: Beside, I remember doing the evaluation of the Apollo proposals all the many companies put in. Alan Shepard was on this team I was chairing. And he wouldn't come to the meetings. And I said, "You know," I said, "come on, Alan." I said, "I know you—I know that you've got the hots for North American, but, you know, let's give this a proper try and score them like everybody else." He says, "It's hopeless. They're going to win anyway." And I said, "Well, we've got to go through the—I don't know that you're right, but in any case nobody asked us to just give an offhand opinion. They want us to evaluate the whole damn thing." Well, anyway, it turns out Alan was right. And later on, I said, "How—why were you so damn sure?" He said, "Well, I reasoned that they were just flying high, wide, and handsome with a—" you know, they'd done some supersonic flights and all. Hypersonic flights with the—what is that?

NEAL: X-15.

JOHNSON: X-15, yeah. And they were on the West Coast. The West Coast needed some money. They were—it was about a disaster area at that time. Convair was folding up and everybody. And he said, "You know, anybody can figure out what's going to happen." He said, "It don'tmake any difference how we score this. It's going to be somebody else." Now I daresay—say in hindsight, that's probably as good a way to decide something as any other way.

NEAL: But as you—

JOHNSON: Anyway, that's how—that's how—apparently that's how the North American got their job.

NEAL: —as you began to look at Apollo, here you were mixing the Centers—

JOHNSON: Yeah.

NEAL: —coming into a whole new arena. For the first time you weren't flying on a missile anymore. You were flying on a rocket designed to fly as a rocket.

JOHNSON: There was—there was a couple of things right up at the very beginning that got that started right. First off, it was agreed that in the hierarchy of the system that the spacecraft was first, the launch vehicle was second, and the launch facility was third. That was going to be the pecking order. Now that was a great thing to decide. Whether it was right or wrong, whether it—it was the right order, the fact that there was an order was a very important thing. The second thing that happened, at least between the spacecraft and the launch vehicle—that is, between Houston and Marshall—was that we agreed one day, right at the very beginning, that the interface between those two systems was going to be as though there was a sheet of ¾-in. plywood across there. And everything on one side was Marshall's, and everything on the other side was the Manned Spacecraft Center. Now obviously you can't completely do that; but there was going to be no integration of these things. The spacecraft was not going to try to run the launch vehicle, and the launch vehicle was not going to put through wires through to try to run the things up front.

Now—and that concept lasted throughout the program; and that was a great thing. People argue that say, "There's a great duplication. Why in the hell should we have two, let's say, inertial measurement units? One of them in the launch vehicle and one in—?" We said, "The reason we have two is so we don't have to have meetings and decide what the one of them is going to look like. It's cheaper. You do yours any goddamn way you please. We'll do ours any goddamn way we please. And don't you second-guess us, and we won't second-guess you." Now, I think that's a great way to do that. I can't think of anything worse than to try to integrate the whole damn thing! It takes 10—in fact, that's what's happened to the Space Station. Not only is it different agencies but different countries have to get together and decide what the hell they're going to do. Don't even speak the same language!

NEAL: A little—

JOHNSON: Like a Tower of Babel.

NEAL: —a little difficult, isn't it?

JOHNSON: Yeah. You can't even—you can't even do this when you—when you're all in the same country. How in the hell are you going to do it?

NEAL: And yet as I remember that era, you had a tremendous spokesman as well as a powerful engineer. His name was von Braun.

JOHNSON: Yeah.

NEAL: Did you work closely with him at all? Or was he on the other side of that big piece of plywood you put up?

JOHNSON: Well, he was on the other side as far as I was concerned. But obviously, we—it—at some level in the NASA hierarchy that piece of plywood didn't exist. But I just meant engineering.

NEAL: The mix was upstairs?

JOHNSON: He was a remarkable man. I didn't know him personally very much, but I had come in contact and seen what he did. If you remember, a lot of people said, "Well, he's just a silver-tongued devil and makes a great spokesman and, you know, he's managed to keep his German accent after he's been here 40 years," and all this kind of thing. But I can remember on one occasion I'd gone to Marshall to discuss something that—we were at loggerheads about something. And we talked and talked and talked. And we argued. And neither one of us wanted to yield a point of—it's almost like we didn't even want to solve the damn problem. I mean, we didn't want to agree. And we got back together after lunch. And all of a sudden von Braun walks in. And he said, "How are you guys doing?" And we had to admit that we were kind of stalled out. And he said, "Well, what's the problem?" And somehow or another we told him the problem. He said, "Well, the solution is simple. Do this and this and this." And we agreed that it was a very reasonable suggestion he made, and so we settled it—he settled the damn thing in about 15 minutes, and we had been spending—we had spent the whole damn morning arguing about it! So—

NEAL: You—

JOHNSON: —so he was not just a figurehead.

NEAL: He was an engineer.

JOHNSON: He was an engineer, and a good one.

NEAL: A very good engineer.

JOHNSON: Yeah.

NEAL: Okay. I think we're running out of—

VOICE OFF CAMERA: Go.

NEAL: Got speed. All right. Now we're going to pick up again. And at this point, we've been talking [about] Dr. von Braun.

JOHNSON: Yes.

NEAL: And you called him "Wernher." We all did. But he was "Dr. von Braun," and he was a militant leader of his people. He was one of the influences at that time over on the propulsion side of the house.

JOHNSON: Yes, yes.

NEAL: Let's talk about some of the people around you, who were building the spacecraft and the roles that they played. Can we do that?

JOHNSON: Sure we can. I'm going to speak of the civil servants, not the contractor people. Because in the first place, although I knew some of them very well, you know, I wouldn't presume to talk about their—how they ran their shop or anything like that. But, I think we were very lucky because at the Langley Research Center, it had operations people, it had aerodynamicists, it had structures people, and, with the advent of the Pilotless Aircraft Research Division, it had gotten some propulsion people. Now as guys started out, they didn't know a hell of a lot about propulsion, but they soon learned by doing it. Of course, you know Max Faget.

NEAL: Max Faget.

JOHNSON: Max Faget. Max and a man named Guy [Joseph G.] Thibodeaux [Jr.], a fellow from Louisiana—let me see how they got to know each other? Oh, they were mustered out together. Thibodaux was in the Corps of Engineers in Burma during the war, and Max was on submarine. And somehow they both got—I think they'd both been to LSU [Louisiana State University], too. LSU. And somehow or another, they both got mustered out at the same time, in the same place, and they decided to seek their fortune with NACA. And they both got hired, and both immediately got sent over to Bob Gilruth's organization that he was just putting together for the Pilotless Aircraft Research Division. Now there were some others, but those two were kind of buddies and stuck together. Thibodaux, for some reason, elected to work the propulsion systems. Well, for one thing, he'd been in the Corps of Engineers and I guess he was good at blowing up things. So he got into rockets. And Max, of course, was a aerodynamicist. So he got involved in aerodynamics.

But here were two guys, typical of those people that came to work then. Eager to make their mark in the world, and just getting out of the service, and one thing and another. And, you know, bright as can be; and that was just typical. There was the Chris [Christopher C.] Kraft that—he was in the operations side of the house. He was then in what we called Flight Research. They were using airplanes to do the research work. And, so these people had—and Jerry [Jerome B.] Hammack was over there. And Chuck [Charles C.] Mathews. And all these people were—had gotten their feet wet doing other things. So, somewhere within Langley itself, it had all the basic elements to do this whole thing.

We had the Wallops Island little launch center. Now I'll grant you, compared to Cape Canaveral at the time it was a rinky-dink place. But nevertheless, it pointed out some of the problems with ships at sea and not hitting them and getting boats out to pick up things and that sort of thing.

NEAL: Bob Gilruth figured largely in all of that—

JOHNSON: Oh, yes, yes.

NEAL: —didn't he?

JOHNSON: But somehow or another, he didn't seek to—didn't seek to stand in front of a lot of people and say a lot. But people listened when he said something. And he waited a while to speak; and then when he said something it was pretty clear that he knew what the hell he was talking about. And what's more, you'd better damn well do what he was talking about!

NEAL: Would you say that essentially he was the boss?

JOHNSON: He was indeed the boss! There was no question about who was the boss. And you can't always say that about some things. But he did not come out and make great speeches and say this. But he—I remember once—this is kind of a personal thing about myself with him. I had grown a beard. Don't ask me why, but I had. It was all the rage at the time. It was a great, bushy thing. And we were in the cafeteria one day, and he said, "Why don't you—why don't you shave off that beard?" (It was clear he didn't like it.) And I said, "Well, I would if I had a good reason to do it." And he said, "I'll give you a good reason. You go home and shave that goddamn thing off!" I went home and shaved it off.

NEAL: Hard to imagine Bob Gilruth—

JOHNSON: I know it. But he—and he didn't say it in a loud voice. He just told me it very quietly. I don't think anybody else even heard what he said. But I heard what he said!

NEAL: Now let's take this beast called Apollo from the ground up. How do you design a spacecraft that's really going to be the center point to fly to the Moon with three people when your total experience up till that time has been along a different line of endeavor? Can you describe the evolution of Apollo?

JOHNSON: Yeah. Well, let's just start with the so-called command module.

NEAL: Yeah.

JOHNSON: That is where—the thing that houses these three guys. It didn't take long for everyone to agree that a crew of three was the proper number. I think because there was always the possibility that one person would be hurt or disabled, and that would leave two people to manage to get home. At one time, it was—it said, "Well, we—that—with three people you can stand three 8-hour watches per day." That was probably the shipboard influence that got into the system.

NEAL: A lot of Navy at that time—

JOHNSON: Yeah.

NEAL: —wasn't there?

JOHNSON: It turned out that operationally that never happened. Everybody slept at the same time, and everybody worked at the same time. That—and—to this day, they do that on the spacecraft. It's not a business of somebody standing watch, you know, and all. Eight bells. It's—you know. But given the three, they had to be configured in some arrangement. There had to be places to sit and places to sleep and places to eat. A toilet facility. A fellow named Will [Willard M.] Taub and I fiddled with that a long time.

And then there was the argument about ground impact and the men sustaining the g-forces. That—the fundamental argument was: "Do you cushion the entire spacecraft," like Mercury was. It had a big bag, if you remember, and you would squash the bag. " [Or] do you individually cushion [each] seat…?" I argued to do each seat; and I remember Charlie [Charles H.] Feltz at Rockwell (North American at the time)—Charlie Feltz and his gang were arguing to spring the whole spacecraft. To drop the heatshield and have a series of dampers to do that.

I remember we argued all day there. And some time during the night, Charlie switched to my side. And so then we ended up springing the seats. My argument was that it was silly to take a 14,000 lb spacecraft and spring that, when all you had to do was individually spring a 180-lb man. Three 180-lb men. Now, it's not quite that simple because it—that caused a hell of a lot of trouble, springing those seats. If you ever looked at that conglomeration of struts in there that take side loads and up and down and back and forth and all that. But then there was the business of getting out of the thing in a hurry in case you had a fire, which it turned out they did have. To locate the entrance and the exit of the thing so that they'd get in. Then there was the business of docking. They had to be arranged in a manner that, after you docked—that there was a passageway. So, putting all those things together that we arrived at the three seats side-by-side like this, and they would fold away. They could be folded away so that they'd have more space.

Now that arrangement misled people later on in the design of living areas in spacecraft. And I'll tell you why: Because the crew was so confined in the command module that there was no need for supports, in a sense, in zero gravity. There was always something your toe was under, or you were always here. You couldn't go anywhere anyway. And the crew began telling people that this business of zero g is of no consequence. "Don't worry about it. We don't need any kind of supports." Because everything was based upon being in a place that you couldn't go anywhere anyway! Now that misled people in Skylab for a while in the design of things in Skylab. But I kind of wandered away from there, configuring the Apollo spacecraft.

NEAL: We'll come back to that a little later, as a matter of fact.

JOHNSON: Yeah.

NEAL: Here you were, still designing the Apollo.

JOHNSON: Yeah. And all this was going on, you see, when we were at Langley and hadn't even come to Houston. I have all the old—you know, many old sketches of these configurations and all.

NEAL: The Space Task Group moved to Houston at the time of the Gemini series beginning.

JOHNSON: Yes.

NEAL: Gemini IV.

JOHNSON: Yeah.

NEAL: That's when you actually made your move—

JOHNSON: Yeah.

NEAL: —so as Gemini was beginning to fly, you were making the move. But you had already designed—

JOHNSON: Yeah.

NEAL: —the next generation of spacecraft, and were building. Was there hardware in the loop at that time?

JOHNSON: Yeah. There was—some things led up that had been learned in Mercury led Apollo astray; that is, the wrong conclusions were drawn from some things. Mercury was a horrible thing to work on, because it had an outer shell and all the equipment was packed inside, and it only had a small hatch to get in there. And so only one man could get in at a time and work on anything. And it was just a mess, you know, to put everything inside. Well, it was put inside because it was going to be in the water; and people reasoned that you should keep the place dry, as though we were going to use it over again. Now if we had had any sense, anybody knows you're not—you're not going to use the damn thing over! That's been in salt water and bumped around. And I don't give a damn how careful you are; you're not going to use it again.

Gemini recognized that problem, and then everything on Gemini was on the outside! They put everything on the outside. Because they—McDonnell had found out how much damn trouble it was to—for technicians to try to climb inside and put everything inside, so they put everything on the outside.

Apollo was kind of caught in the middle. It had not really found out the true story about that. We didn't quite know what the hell to do. But suddenly, the business of the Van Allen Belts and radiation problems came into focus, and of all these dire predictions of—that you're going to get fried alive when—somewhere between here and the Moon. So, all of a sudden, we decided that we'd better arrange the equipment the best way we could to surround the men. The devil with whether it was inside or outside. And then—and also reasoned, "We're never going to use one of these things over again anyway."

And so, then that drove the arrangement of equipment. To offer that as extra shielding, you see, around yourself. Now it turned out that the Van Allen Belt didn't play much of a role one way or the other anyway. But there's oftentimes things influence a design that later on turn out to be for the wrong reason; and there's some times you did something for the wrong reason but it turned out to be the right reason for it. That's what I probably meant by saying there's a very irrational process that you go through. Serendipity, I guess it's called.

NEAL: That's a good word.

JOHNSON: Yeah.

NEAL: Serendipity. Well, finally through this evolutionary process and the people that you've described taking their role in the formation, Apollo began to fly. Once it was flying, did it evolve very much during the missions? Did you make many changes over a period of time?

JOHNSON: That's—that makes me think of something probably more interesting than that about the changes. When a program starts, a dozen people make all of the important decisions. They essentially cast into concrete the fundamentals of the thing. A dozen people. Or five people. And as a program develops, there're more and more and more meetings to decide more and more minor things. And after a while, near the end of the program, there will be 50 people deliberating whether to put a piece of Velcro this big right here or put it over here. And great minutes are written about why they put the Velcro here or there. And three years before that, four people decided whether or not to use a Saturn or to use some other kind of rocket. It just works entirely backwards.

So, there are multitudes of things that go on later in the program, but they get more and more trifling. More and more trifling. And always the weight is a problem. The weight always exceeds what you think it's going to be. Now that's the place where the guys at Marshall saved Apollo's ass, I'm not kidding you. They built some capability into that Saturn that was not—I don't say it was not supposed to be there, but it was not the design objective to do certain things. They put enough in there that—I don't know whether they recognized that we were going to be in over weight, but they put that margin in there. And that saved the day.

NEAL: How much extra weight did you have to pack by the time you finally flew? Was it a big difference?

JOHNSON: You're damn right it was! The Apollo—the parachute system for instance was designed for a certain weight of the command module; the command module exceeded that weight. They had to go back in and redo the parachutes. And this thing snowballed. When you redo the parachutes, the space for the parachute takes more space. Now you don't have the space, so you have to figure out something also. It's just terribly important to recognize what your weight is likely to be.

NEAL: C. C., I'm going to hold here for a moment.

VOICE OFF CAMERA: And rolling.

NEAL: We were talking of the fact that, with the Apollo in the design phases, once you started to fly I had said, "Did the flights then create the occasion for, was there a need, did you change the spacecraft very much in the evolution of flight?"

JOHNSON: Surprisingly little. It—if you consider the fact that we went through a year or so of detailed engineering before we settled the issue of whether there would be Earth orbit rendezvous or lunar orbit rendezvous. Now that's not a trifle. That is a fundamental characteristic of the whole Apollo, is whether or not it would rendezvous a great number of things in Earth orbit and then head for the Moon and land with a big thing and come back; or whether or not you go to the—like a lightweight to the Moon and then separate at the Moon and land, and then rendezvous at the Moon and then come back home. There were fundamentally two schools.

Marshall wanted, I suppose (since they built large launch vehicles)—they wanted to put up a lot of launch vehicles and orbit the Earth with—and then launch a big monster towards the Moon. It was—the issue was kind of debated at Langley (and we were still at Langley then). There was a man at the Langley Research Lab (not part of the spacecraft), but that he had calculated and had presented an argument that this—the most economical way was to rendezvous at the Moon. To land a small craft on the Moon and rendezvous in orbit about the Moon, and then come home. There was no point in putting a big, heavy spacecraft down on the Moon and have to take it all back when all you needed to do was put the men down there in that.

But intuitively, when you think how difficult it is to orbit the Earth. You say, "My God! are we going to try to do this at the Moon?" You know, "We haven't even done this on Earth that many times!" And so, more or less intuitively people would say, "Well, that's the silliest thing I've ever heard." But the more you got thinking about it, and the more this guy talked about it (his name was John [C.] Houbolt, John Houbolt). The first thing you know, it was a very convincing argument when you got right down to it. And we had tried all sorts of ways to land big things on the Moon on paper at that end, and most of them were a bunch of nonsense.

There were some politics in the thing, too. Because for instance, the Lewis [Research] Center [Cleveland, Ohio] built big propulsion systems, and they were going to get the job of having this big lander that was going to land on the Moon. Marshall built the great Saturns, and they wanted to build a whole bunch of Saturns. So, there got to be some politics. For some reason or another, the argument [of] lunar orbit rendezvous prevailed, that argument. I can remember the—I can remember the day the decision was made, but that's another story. But that was a—that was a major change in the program. And how in the devil Apollo managed to change itself at that stage of the game without starting all over, it's a miracle.

For instance, North American kind of fought the whole idea of lunar orbit rendezvous because they knew that there would be another contractor would come along and get this craft that was going to go down to the Moon. They didn't want anybody to have another piece of pie. But even though they didn't want that to happen, they agreed to configure the command module so another craft could have docked at the end of it. Now, there's two groups of people: the politics told them to do one thing. There's probably some engineering heads agreed that, "Well, we'd better hedge our bet, you know, and fix it up." But the upshot of it was that somehow we got by with that whole thing; got our new contractor to build the lunar module. [North American] Rockwell made some few changes to the command module to accept it. We built a different—what was called a SLA [Spacecraft Lunar module Adapter], a great adapter that would house the lunar module. And this was a completely different configuration from what we started. How in the devil we got by with that, I do not know. Now—but we did. And it all worked. It—somewhere in the back of people's minds, they must have something was telling them that this is the way it's going to be, and they were really working towards that end.

NEAL: When did the final design get locked in? Had you moved to Houston by that time?

JOHNSON: Yeah. Charlie [Charles W.] Frick was the Program Manager for the command module. And Charlie knew—he knew that this thing had got to be settled. We could not keep on arguing this and people charging ahead like everything was settled when it wasn't settled. He managed to convene a great meeting at Marshall with Rockwell (I keep saying "Rockwell," it's—

NEAL: North American.

JOHNSON: —North American)—North American and of course von Braun's people and us and people from Lewis and I don't know. That whole 10th floor was just jam packed with people. And everybody got up and gave their little stories and their spiels and saying things that we had all been saying for 2 years. Same goddamn thing. And there was this kind of silence after everybody said anything, you know, what are you going to do? And all of a sudden this guy named John [W.] Paup (P-a-u-p, he spelled his name), he was the Program Manager at North American. He all of a sudden says, "Who's the son of a bitch here that's not for lunar orbit rendezvous?" There's all these people sitting there. Not a soul said a damn word. And John said, "Well, I guess that's what we're going to do!" You know. That was the advent.

NEAL: And that's the way it was.

JOHNSON: That's the way it was.

NEAL: So, you had a design—

JOHNSON: We had a—

NEAL: and things were ready to go. And then as you were finally getting ready to send men up into space, disaster struck.

JOHNSON: Yes, yes. That—

NEAL: The Apollo 1 fire.

JOHNSON: Yeah, yeah.

NEAL: And all of a sudden, the design flaw had been discovered, hadn't it?

JOHNSON: And it was—we made such an obvious mistake that I think that's how it got by. It was a schoolboy mistake. And, you know, a bunch of us were all involved in it. And we all had better sense (I think we had); but there was one little thing that just escaped us, and none of us thought about that: the fact that it was going to be tested on the ground. Now if it had been that would never have happened in space. But we overlooked that when you pressurize that thing with that much oxygen in it at sea level pressure, that's a hell of a lot different than the 5 psi that it would see in space. And it was a bomb ready to go off!

And, you know, people blamed it on North American for, let's say, shoddy wiring or something like that. Well, that may have been—that may have been the trigger; but it was a disaster waiting to happen. And it was—would not be fair to blame that on North American. I think all of us that had a place in the decision to use that system should take the blame. Not any one person, but collectively, we should have known better.

NEAL: That was a valid reason for using that system, wasn't there?

JOHNSON: Yes. It was, but it was not a good enough reason. If we had really thought about the hazardous situation on the ground testing, I know we would have never gone that way.

NEAL: How would you have done it differently?

JOHNSON: We would've made a more complex system and accepted the complications of changing the atmosphere in flight, which we ended up doing. That's what we ended up doing. And the reason—the first place the reason that there was a pure oxygen atmosphere in there was, at that time, we—our pressure garments were not developed as well as they are now. If you had more than about 5 psi (5 pounds of square inch of pressure) in these suits, they became so stiff that the men couldn't do anything, you know. The medical people had said, “Well, we need the 5 pounds of square inch for metabolic reasons.” Now it turned out they didn’t.

People in Denver don’t have that. People in Denver only have 3. And in Mexico City. But anyway, that was, you know—that was a little mistake. We could’ve made a different pressure suit. But anyway, we ended up with the 5 psi of oxygen. What we didn’t think about is that when we’re on Earth in sea level pressure that it would not be 5; it would be 15! And, you know, in principle it’s no different. But in fact, that partial pressure of oxygen is just a bomb. If you filled this room with that and, you know, one spark and the whole room would just poom! We’d be gone. So, it was a terrible mistake. You can’t undo it.

NEAL: You redesigned around it.

JOHNSON: Yes.

NEAL: How did the redesign work? What did it do?

JOHNSON: Well, it changed—it—while on sea level, the thing had an atmosphere more or less like what we breathe here right now. But as it ascended…[it reduced cabin air pressure to stay within 5 psig, and added oxygen as necessary.] More complicated but it works. It works all right. Now it all started because that pressure garment would not hold anymore pressure than this. And so our whole command module was only designed for 5 psi; and later on, when you get to Apollo-Soyuz, that gave us a problem with docking with Soyuz because they were designed for sea level pressure. And so, we had to build that—if you remember that intermediate module in between them? There was an airlock so you could go from one to the other.

NEAL: And I think we're working our way slowly toward that.

JOHNSON: Yeah, yeah.

NEAL: So, let's continue and finish up with—

JOHNSON: Yeah, sure.

NEAL: —Apollo, and then we'll move through Skylab into Apollo-Soyuz. Right now, here we are: the next major thing that came along, other than the fact, the obvious fact, we flew to the Moon. That must have been a tremendous moment for all of you.

JOHNSON: Oh boy.

NEAL: Actually making it.

JOHNSON: It's unbelievable. I—you know, my mother—my mother, she knew I worked on all this. And she said, "You don't really think that happened either?" And I said, "Well, of course." And she said—she said, "I watch television. You know what they do on television. They fake all kind of things." And I said—she said, "Were you there?" "Well, no, mama, I wasn't." "Well, how do you know that you were not fooled along with all the rest of us?" Well, I must admit she had a point. I really wasn't there. And I got fooled about a lot of things, so—anyway I don't think I ever convinced my mother. I think she went to her grave not quite sure.

NEAL: Do you really think that NASA staged the event in the desert?

JOHNSON: NASA doesn't have that much sense to do that. I think ABC or CBS might get away with doing it.

NEAL: I'm glad you didn't say "NBC" in that context.

JOHNSON: Yeah, I was careful not to say it.

NEAL: Thank you kindly, sir. Well, the next big thing then that happened, though outside of the obvious (which was a success), was failure in terms of Apollo 13.

JOHNSON: Yeah, yeah. I can't, you know, speak technically about that much because that cryogenic system, I—,you know, I understand how it works and all that. But I'm not sure of the mechanics.

NEAL: It wasn't your area of expertise.

JOHNSON: No. I don't remember.

NEAL: Well, why don't we then move out and beyond.

JOHNSON: Okay.

NEAL: Because now Apollo has gone to the Moon. It's performed its functions. And the time had come for, not an adaptation but for another spacecraft: a space station to be called Skylab.

JOHNSON: Skylab.

NEAL: Did you work on it?

JOHNSON: Yeah, I sure did.

NEAL: How did—what did you do?

JOHNSON: I was out of a job about that time. Apollo had done its thing. We had not started on the Shuttle. I was running an outfit called the Spacecraft Design Division at Johnson Space Center. We were dealing with the advanced design of space stations and that sort of thing. But I was out of a job in the sense of, you know, a pressing particular project to work on.

There was a—there was a person there that was called the Principle Investigator for Habitability and Crew Quarters for Skylab. Now that program was really run out of Marshall. And, other than the crew being here and some operational aspects, it was a Marshall program. But JSC was cognizant of this, of what they called a "principle investigator," which was more or less a research type of activity that had to size up the crew quarters and how habitability provisions went on. The guy that was doing that became ill and had to resign that position. I think I had been fussing to somebody over the lunch table about some of the things I had noticed on it, and so one day Gilruth said—he didn't use the word "smart ass," but, you know, he said, "All right," you know, "smart ass, you're now the principle investigator. You fix the thing."

Well, I was really delighted because I'd seen some things I didn't like on it. The people at Marshall were so—they had so many problems with the structure and what you might call "hard systems" that they didn't really want to—nobody wanted to mess with the crew quarters and how people lived and what they eat and how they dress. I didn't know a damn thing about it, but I figured I could learn. And so, I set about trying to organize this and do more than just report on how it went. I decided that the best thing to do was to redesign it so that it would work, so that when I reported it I could report something that would work and not something that didn't work. Because I knew damn good and well what we had wouldn't work.

And so, we waded on. I divided up habitability into some elements like architecture and mobility and restraint and the environment and the clothing and the food and the waste management and tackled each one of them, as opposed to just arm waving and saying, "I don't—" You know, I didn't give a shit about the color of the walls or that kind of thing. And I was worried about the lighting and places to sleep and what the garments—the garments for instance.

There were going to be three crews of three men. That's nine people. None of them the same size. You didn't even know who they were going to be beforehand. But this—but the Skylab had to be stocked with clothing for people that you don't even know who they're going to be. Well, all of the crew says, "Well, you know, we'll carry our own flight garments." And I said, "I can't think of anything worse than a flight garment. When you don't know what size anybody's going to be and you've got something between the shoulders and the crotch that is not long enough for you, you're going to be in deep trouble through the whole mission. Beside, the temperature's going to vary. Either you've got the jump suit on or you don't have it on. You don't—you can't take off your shirt without taking off the whole thing." I said, "If you wear just like everybody now wears shirts and pants and underclothes and undershirts, that's what we ought to put on there." Well, finally everybody agreed that that was the sensible thing to do. There was no use in inventing new clothing just to go there.

Now, I remember one of the guys said—we had this pretty blue—I think it was pretty blue clothing made, you know. And we put white stripes down there so that when you take photographs, you could—you could tell the position of people so that, you know, you could study how they react and check it. Well, that's when the crew rebelled. You know, they said, "You won't let us wear our damn jump suits, but," they said, "we'll be goddamned if we're going to wear these little legs with white stripes down their side." So, there was a little bit of compromise there.

But—and the food. The food on Apollo and everything had been in plastic bags, you know, and that kind of things. And you'd mix it up and squash it all around and squirt it in your mouth. Well, that's all right. That's better than not eating. But if you're going to be someplace 3 months, you really should have something that's more like, you know, you're accustomed to eating.

And so we reasoned that we should, first place—we should have a place where everybody was meant to eat in. And you sit around the table. And you talk like you—you know, you don't perch on the side. You see the people in Shuttle, how they do? Somebody's sitting over here and somebody's hanging up here, and, you know, that's no damn way to eat for 3 months! And so we built a little table, had a little table fixed, and then we made a—we designed a tray and put all the foods in cans, and the trays were electrically heated and with timers, and so you could put all the stuff in there in the morning before you went to work, and when you come in at lunch it's all heated up for you.

We got some utensils from Oneida. Stainless steel. That was magnetic, so that you put magnets in this little table top, and when you put your fork down it just stays there. I've got a set of that home now that I use. Things like that. We argued that if you put a little bit of gravy on a plate, you can take a plate here on Earth and turn it up about like this and nothing will fall off. It just don't go floating away in zero gravity. I said, "Eat with a knife and fork and cut your goddamn meat and all." And it did. It worked fine. Everything worked fine. But I notice Shuttle goes right back to the goddamn old bags in space stuff and the like.

NEAL: Now you're talking the difference between a spacecraft and a space station.

JOHNSON: Right.

NEAL: But that's what you were doing; you were designing and working a space station.

JOHNSON: We tackled everything that way. You know, we said, "Why change it from Earth unless you have to do it?" The cabinets and all. People went around inventing new latches on cabinet doors. Ace Hardware has worked on cabinet latches for a zillion years. They know all about it. Some of the engineers designed special ones that will break the first damn time anybody uses them! You know, some of the NASA guys.

NEAL: So, what did you do? Go to the hardware store?

JOHNSON: Yeah.

NEAL: Literally?

JOHNSON: Yeah.

NEAL: Can you tell us a little about that?

JOHNSON: Well, it's just like buying the silverware, the flatware they ate with. Went to Oneida. In fact Oneida gave it, they were so—they were so pleased to have their stuff on there, they gave it away. But that's the way that we tackled that whole business on there. Now some of the things, it was too late to change.

NASA had—do you remember George [E.] Mueller was the head of Manned Spaceflight? He knew of a man named Raymond [F.] Loewy, a very, very famous French-born industrial designer. And he had talked somebody into hiring Raymond as a consultant out of Marshall. Marshall didn't want to have anything to do with him. In the first place, he was a Frenchman (I gather). But—so, he came around here one day and I was delighted—you know, I thought, "Man, what a guy to have on your side! This—this famous Raymond Loewy." And he was appalled by the way the Skylab looked inside, with all the harsh metal and everything. And he advised some things to do.

And one thing he said was, he said, "I think it's marvelous that you've arranged this little" what we called the "wardroom," where they could eat around this little table. He said, "But it needs a window." And he said, "You know, that's the most relaxing thing in the world." I went to Marshall and I said, "We need a window." The poor guys were behind schedule, over budget. Cutting a window in the side of that thing in a pressure vessel and putting a big, thick piece of glass that wouldn't come out of there, they couldn't think of anything worse. And I knew that problem. Hell, I'm enough of a structures guy to know that what a pain in the ass that is. Thermally, every way in the world! But I said, "We've got to have a window."

Well, it ended up in this great meeting in Washington, again, to decide whether or not to put the window in. And poor Leland [F.] Belew, who was the Program Manager, he told how terrible it was to have to do this; and I told how, you know, with—I went through the story of the two eyes, the most wonderful instruments in the world, and to deny them being able to look out and see things is crazy. And George Mueller listened to this and he listened, and he knew the problem. And he turned to Raymond Loewy and he said, "What do you think about this, Mr. Loewy?" And Loewy said, "I can't imagine not having a window." And Mueller turned to poor Leland Belew and he said, "Put the window in." And it turned out that that window was the means of—a lot of things were observed. Just casually. People would be sitting there just looking out the window and say, "What the hell is that?" You know, you'd see a—something on the surface of the Earth that nobody had ever noticed before because not many people get up there and look down at the Earth, you know.

NEAL: It's one thing that every astronaut that's flown—We're out of tape again.

JOHNSON: Yeah.

VOICE OFF CAMERA: Speed.

NEAL: Skylab must've been fascinating, putting all these design features together.

JOHNSON: Yeah.

NEAL: And then when you had the chance to see them work, when you saw Pete [Charles C.] Conrad [Jr.] running the Skylab 500 up there and Joe [Joseph P.] Kerwin exercising—

JOHNSON: Yeah, that's right.

NEAL: —in space.

JOHNSON: That's right.

NEAL: There you saw the reality of your dream, didn't you?

JOHNSON: Yeah.

NEAL: But before that could happen, you had to fix that machine. Because when it first went up there, it didn't quite take the right position.

JOHNSON: Yeah, right.

NEAL: Can you describe that for us? And how the fix was made?

JOHNSON: Of course, everyone was—everyone was shocked when—after the launch, we found out that one of the—one array was gone and the other one didn't deploy and—

NEAL: These are solar arrays, you're talking about?

JOHNSON: —yeah, the solar arrays. And that some of the thermal protection had torn off. And it was—I suppose most of us just gave it up and said, "Well, that's the way things go." But as people started looking at it, it, you know, wasn't clearly a lost cause. For instance, we had Apollo sitting there to be launched, and it could go up. The craft was in orbit; it was in pretty good shape. It was getting hotter by the minute because there was no sunshade then in any way; their thermal protection had gone. It wasn't making any power, but it had batteries and it was still alive.

You know, once the shock got off—wore off, people said, "Well, you know, let's fix it." And, it was a madhouse around here! It was a madhouse! Almost immediately, I think, Jack [A.] Kinzler—I think he was running the machine shops, Technical Services. And I think they had been doing some work that had to do with things inside of Skylab of—and he knew that there were—there were ports on the side, airlock type of ports that you could put things out through there. I don't know what his whole thought process was, but he thought about an umbrella. Raising an umbrella.

Some other people had had kind of guessed at the problem with the solar arrays, what was—why one of them was stuck. And they theorized that, "Well, it could be cut loose." And once you cut a few things, it would hope—spring itself open probably. I got to thinking about the problem, too. And we decided, "Well, we'd better have some sort of backup. That Kinzler's idea sounded like a good one, and the most practical one to do." I suggested that we do an EVA [extravehicular activity]—what was called a standup EVA. You open the hatch on the command module, Conrad stands up in the hatch with a boat hook type of thing, we have an awning already stowed away with guide ropes on it. We had found places on Skylab that he could take this hook and hook these things and then literally pull this awning up over the top of the thing.

It would've been very effective, but it was risky, certainly riskier than what Jack had proposed. Because it meant bringing the Apollo right up close to it, and in the meantime they would also try to cut the—you know, cut the solar array away. But we decided to do them both; in case one of them didn't work, we'd have the other one now. So, there were kind of two groups of people working like mad.

Anything anybody wanted, you got that worked towards that. I remember one night, we suddenly realized that we needed a certain paint—a thermal type of paint—to put on this awning that we were making. The only place you could find some, I think, was Durham, North Carolina. We got an astronaut in a T-38 and within a half hour, he was on his way to

North Carolina. The man had the paint ready when he landed. He paid the man whatever it was ($10 a gallon), got back in that $3 million—$30 million airplane, and flew back—flew back here. And we painted the thing the next morning. But that was the way things worked. And, whatever needed to be done got done. And by God, they fixed the damn thing! You know, I think that was a—that was a real coup, to salvage that thing. And it went on for three missions.

NEAL: As someone in the design phase of all this, it must've done your heart good to see that something like that could happen.

JOHNSON: Yeah. And you know, it could still happen. It's not like that's the only time it's going to happen. No reason why it can't happen again with things.

NEAL: It's kind of the history of the space program, isn't it?

JOHNSON: Yeah.

NEAL: Use your ingenuity to make up—

JOHNSON: Yeah.

NEAL: —for what you don't know.

JOHNSON: It would've been so easy to have given up. You know, that first 24 hours after it, it would've been so easy for everybody to say, "Gee, that's tough." But somewhere along the line, somebody said, you know, "Goddamn it, we're going to fix it!"

NEAL: Do you—would you like to have seen the Skylab stay up there? Or were you one of the group that said, "Let's bring it back. It's time has been served."

JOHNSON: No. I'm embarrassed every time I think about it. We had a crackerjack space station there; and we—you know, if you look at our history in the spaceflight business, we never plan for anything to last long. Every program was dead end. I don't even think we wanted anything to last. It was too much fun building new things. We had that marvelous Saturn V. The greatest machine that was ever built! And the only one left is sitting over here in the visitors' place, and here and now, nowhere else. That great machine. Mercury, you know, abandoned it. Abandoned Gemini. And abandoned Apollo. Left Skylab, you know, just—"Yeah, what the hell, we'll build a new one." It's that kind of attitude. It's almost—it's almost like the Agency doesn't want anything to last!

NEAL: Isn't that the American way—

JOHNSON: Yeah.

NEAL: —with automobiles—

JOHNSON: Yes.

NEAL: —the same way?

JOHNSON: Yeah, I guess—I guess that's what it is.

NEAL: Well, of course, one thing that was done next after Skylab, there was something called Apollo-Soyuz [Test Project].

JOHNSON: Yeah. Yeah.

NEAL: As a matter of fact, there was a split in the road right there; and you worked on Apollo-Soyuz as well.

JOHNSON: Yeah.

NEAL: Can you tell us about that?

JOHNSON: Out of a clear blue sky, there came some message from Headquarters—.

NEAL: We're about to catch that big time alarm. Do you want to—

NEAL: Say when. We were just about to start talking another project on which you worked: Apollo-Soyuz. ASTP. What do you remember? How did that begin to go together? It was kind of a divergent program, moving away from things.

JOHNSON: Part of the—part of the activities in the Spacecraft Design Division had to deal with that—with joining two spacecraft. Now, Apollo had done it and Gemini had done it. But it was an ad hoc arrangement in both of them. It—as we thought about it, we said that, "Sooner or later, spacecraft that wish to join in space, we—you cannot afford that they have already been tested somewhere else and not—they have been made matched pairs so that they are fit. It's got to be some—it's got to be like a railroad car, that any railroad car in this country, either end can attach itself to either end of any other railroad, whether they've ever seen it or not, they all work. We need something like that." That the Gemini docking arrangement and the Apollo one were just the opposite.

It was what was called a male-female situation. One side is male and one side is female. If two males get together or two females get together, then this system won't work. They also blocked the very passageway that you would like to affect. Almost always if you put the two things together, that's a convenient place to pass through. But these things were such that they occupied this space! So, you had to disassemble them after you docked before they would fit. So, as we were thinking about it, we decided that the system should be essentially two circles (like this). And then we got thinking more about it, and we said, "Well, how can they be universal and all lined up?" And so then we said, "They should do this. Not like this, but like this." Now you're all lined up, and you can still have the hole through the center. We were working on that.

Just about that time, Dr. Gilruth called [Glynn S.] Lunney and me and a guy from Marshall named George [B.] Hardy and he said, "We have been told to meet with the Russians and talk about advanced systems." And he said, "I picked you two guys. I picked Lunney because he knows about the operations involved, orbital mechanics, and communication. And," he said, "I picked you because you deal with the hardware systems and mechanical systems of spacecraft." He said, "I have no idea what these guys want to talk about. What are we going to talk about if we get there?" And Lunney says, "Well, I can tell them of our experiences at the Moon and the guidance systems and our communications things." And I said, "We've been working on a docking thing that, sooner or later, we must get around to talking about docking." And Gilruth said, "Great." He said, "Let's get our act together; and we'll cross our fingers and hope that we are guessing what they want to talk about." And we hit the nail right on the head! When we got there, they had some presentations in a very general kind of way. Nobody mentioned Apollo-Soyuz. It was just hypothetical activities in the future. And Lunney told them—gave them his story and I gave mine.

And we signed a memorandum of understanding, it was called, that we would keep in communication and discuss ideas, and that 6 months from then they would come to Houston and we would have—talk again. When they arrived in Houston that following summer (we went there in October of 1970)—incidentally, that was not a good year in Russia and the United States relationship. We were in war in Vietnam. There were great billboards, all in Russian, showing Uncle Sam with blood running out of his mouth and little babies, tearing them apart and stomping on them, you know. I thought, "Oh Jesus." You know, "Here we are, right in the middle of it." Well, anyway, it was nothing. We were treated fine. They arrived in Houston the following summer, and we were flabbergasted. They said, "Why don't we have a joint mission?" No more talking about the hypothetical future. They said, "Let's—next year, let's dock."

NEAL: The Russians instigated—

JOHNSON: Yes!

NEAL: —the action?

JOHNSON: And I almost dropped my teeth, you know. And we had to think on our feet pretty damn fast right then. And of course, the telephones got as busy as hell between here and Washington. But first off we said, "We cannot get ready in a year. We need more than a year." And they couldn't have gotten ready either, but I think they just wanted to act big time, you know, and say, "Let's do it in a year." But they said—and we said, "We'll do it." Now we've got to get down to cases and really start talking.

Well, that led to a series of meetings; and then we went back to Russia. And lo and behold! The next meeting that we had in Russia, they said, "We have an idea for a docking system." And they showed us a picture, and it was exactly the damn thing that I had showed them when we went over there the time before. And they said, "We have a great idea. We want to do the thing this way." And we were all being very diplomatic, and nobody said—everybody agreed. When we got down to really the nitty-gritty (it's one thing to just say this, but obviously we've got to agree, for instance), and on Lunney's side of it they had to agree to a zillion things about communications and all the tool systems and launch and all this kind of thing. But I just dealt with the mechanical things.

On—probably on a trip later than that, they had designed their docking system—essentially it had three fingers. Like this. We had designed ours with four. Now obviously, it can't be three on one side and four on the other. We were going to have to agree on that. Their system was—was mechanically driven; that is, with a bunch of little rods and gear teeth and things that form little motors; ours was hydraulic. And whether we used three or four didn't make any difference to us. But they would've been dead in the water if they tried to mechanize theirs with four. It was enough trouble with three of them, but to have another whole set.

I said, "Okay, we'll do it your way. We'll go with three." My counterpart, a guy named Vladimir [Sergeyevich] Syromyatnikov, a brilliant young guy, he didn't know what to do about this. I had agreed to do it their way. And he was prepared for a great, long, bloody argument, you know, and all this. And I just said, "Okay, we'll do it your way." And he called for a recess. And he went to tell his boss that, you know—that we were not going to fight. We were going to agree. And he—they—I think they thought there was a trick. There's got to be a trick here somewhere! And it wasn't any trick! I knew it didn't make any difference to us, and I knew it would not work for them. And it was silly to hold it just as a matter of principle, just because we gave into them. But anyway, apparently they finally ended up going to Gilruth and asking him, "Was it all right if I made that decision?" And Gilruth said, "Yeah. Whatever he said, that's what the hell we're going to do." And so they went with it.

When I got back here, the news, of course, proceeded me back here. And all my colleagues said, "You son of a bitch!" You know, "You gave away. What did you give in to them bastards for?" And I said, "Well, we want to get on with the program; and we don't give a damn which way it is. We can make it—we can make it work either way." And they said, "Yeah, but, goddamn it, you give in to those son of a bitches." And I said, "Now, wait a minute." I said, "We've taught them more bad things, and we're going to break those guys." I said, "We've taught them about preliminary design reviews, critical design reviews, delta design reviews, coordination meetings, paper this thick for everything they do." I said, "They're going to go broke trying to do it that way!" And sure enough, they did. They went—they went broke.

NEAL: You think the downfall of the Russian economy was all because of Apollo-Soyuz?

JOHNSON: No. But we taught them—we taught them how to spend money that they didn't have.

NEAL: They're still doing it, aren't they?

JOHNSON: Yeah.

NEAL: Well—

JOHNSON: But anyway, it was—they were great people to work with. The technical people. They put their first team there. They didn't have a lot of bench strength. But they had a crackerjack first team. And everyone was cooperative. We didn't talk politics. We didn't have anything—you know, nothing like that went on.

NEAL: For the first time, you were able to see Russian engineering.

JOHNSON: Yeah.

NEAL: What you saw. Did it surprise you?

JOHNSON: Well, I wasn't surprised because they had been doing some great things. But I really didn't expect to personally run into so many guys that were really crackerjack.

NEAL: Did you learn anything from them?

JOHNSON: Yes. You know, a lot of things that they—and—now one thing they did have a problem with: They didn't trust one another as much as they trusted us. Now this sounds surprising. I mean, in little things. A fellow asked me, he said, "Will you give me a certain—some information I need?" And I said, "I don't have it with me, but I will—I'll send it to you when I get back." Later on I saw him, and he said, "You never sent me what you told me you would." And I said, "Yeah, I gave it to Ivan" or somebody else, you know, "to give to you when you got back." And he said, "Don't ever do that! He's not going to give it to me. He's going to keep it for himself." Now, we would never think about doing a thing like that. But I guess they were not quite as sure of themselves, and were kind of protecting each—protecting themselves.

NEAL: As you look at what you learned of the Russian space program, had theirs followed a similar track to yours?

JOHNSON: No. They just flat didn't have the money. They—everywhere you went, you could see that they made do with things that we wouldn't make do with. Their labs had wooden oil floors. The plaster was cracked on the walls. There were light bulbs hanging down on a cord that you reached up and turned the switch. You know, all their equipment was kind of crummy, crummy stuff. Now they made up for it with industry. They worked hard and very conscientious people.

NEAL: Did it lead you to wonder how, with that background, they were able to fly the complex machines necessary to go in space?

JOHNSON: Yeah, but they did it because they just worked hard. The guys working on it just plain worked hard. They didn't spare themselves, you know. They were really dedicated.

NEAL: And did they learn from you?

JOHNSON: Well, I think they kind of marveled at all the things we've got. I remember, we took a couple of IBM typewriters over with us because we—you know, we needed some—something there. And those poor girls there in the offices, they looked at those IBM electrics and they had these old mechanical clunkers and all, you know. Clunk, clunk. Making 12 carbons. And make a mistake, and they have to erase all 12 carbons. And there we had that goddamn Selectric, you know, and you know. And they just—they just marveled at it.

The Xerox machines. When they first saw a Xerox machine, they said, you know, "Anybody just walks up and makes a copy." They said, "Why don't you make money?" And I said, "Well, that's not considered cricket." They couldn't understand why everybody didn't just go up and make all the dollar bills. They were a great bunch, though. I still see Syromyatnikov occasionally. He comes here when the Shuttle and *Mir* were docking. You see, he was a docking guy. And he would be in Mission Control here doing those operations.

NEAL: Did you think at the time of ASTP—did you think at the time that we would wind up literally with the International Space Station at some point in the future?

JOHNSON: Why sure, I knew it was going—you know, that's what we were really working towards. There wasn't much point in doing Apollo-Soyuz if it didn't kind of demonstrate that it's reasonable to do these things.

NEAL: This was in the thinking then—

JOHNSON: Yes.

NEAL: —of ASTP—

JOHNSON: Yes.

NEAL: —even then.

JOHNSON: Yes.

NEAL: Interesting point.

JOHNSON: Yes. And of course, if you're going to assemble things in orbit, you're—as far as I was concerned, you had to have a docking system. And from Lunney's standpoint, there has to be a communication system and an agreement on operational protocols to do this. And so, this was all paving the way. And I'm sure the Russians must've had that in mind.

NEAL: You were laying the groundwork for the future.

JOHNSON: Yeah. Yeah.

NEAL: Well, something else that happened just about that same time. It was the advent of something called Space Shuttle.

JOHNSON: Yeah.

NEAL: You and Faget got deeply involved with that, didn't you?

JOHNSON: Yeah.

NEAL: Can you tell us a little about that?

JOHNSON: Yeah, we—I think what really happened—now this is a terrible thing to say, but I think we got bored. You know, Apollo was flying great; and Skylab was hanging around and all this kind of thing. And, you know, why—let's have a—let's have a Space Shuttle. Everybody wanted to have, you know, something really challenging to do. And he and I got thinking about it, and we had a configuration that he and I decided to build a model of it. I was going to build the booster part, and he was going to build the manned spacecraft. And it was—it was a horrible thing. It didn't perform at all well, you know; and we talked to Mr. Gilruth and he said, "You guys ought to know better. That thing you've got, any fool knows that that is—"

He explained some of the aerodynamics of the thing, and Max and I really were embarrassed because we should've known better. Here we're supposed to be a hotshot spacecraft design, but we made a bunch of schoolboy mistakes on the thing. Gilruth took one look at it and showed us what was wrong with it. It didn't end up being anything like that. But—fortunately—but we went through—we must've gone through 3 or 4 dozen configurations of the Shuttle. Of different concepts and things in—in the course of finally arriving at what it turned out to be, you know.

NEAL: What were the specifications against which you were trying to design? What were you really trying to build?

JOHNSON: Well, there was a conflict with the Air Force. The Air Force had something in mind that didn't—was not the same as what NASA's objective would be. But I presume in the politics of the thing, there had to be some sort of meeting of the mind because, without the Air Force support, we would've never got the Shuttle. So, for instance, the cross-range capability during entry. The military was interesting in a great cross range so they could land where they wanted to in one orbit, at any given time could get back.

Now that is—is not—not necessary at all for this Shuttle's missions these days, these so-called scientific missions. That's not necessary at all; but you can understand in the military it might've been very important to—to get back on a moment's notice. And things like that. Its lift weight and the size of the payload bay was [*sic*] really much—it's—it's more space there than the—than the thing can lift. That is generally speaking if you filled up the cargo bay in Shuttle, it generally would end up too heavy. But it got off. It got worked out. And it turned out the Air Force never really used it.

NEAL: Oh, they used it a couple of times.

JOHNSON: Well, I mean it was never used for what it was—I don't know exactly what it was intended for. But it was never used to that capacity, to my knowledge.

NEAL: I guess that brings us around to your look, based on your knowledge of the past—your look at the future as to whether this country's space program is moving in a good direction, in a different direction, and do you see a future in space? Do you see people in the future doing—

JOHNSON: Oh yes, sure.

NEAL: —what you did in the past?

JOHNSON: Sure, sure, sure. I can't believe people will be content to stay on Earth. I just can't believe it. Any more than they were content to stay in Europe or to stay in Asia. You know, another continent beckoned and there's another mountain to climb just for the hell of climbing it, you know. Beside we—we're apparently overpopulating ourselves. So, sooner or later we'll have to do something.

NEAL: Looking back on it—

JOHNSON: Yeah.

NEAL: —C. C., I think you found yourself in the right place at the right time didn't you?

JOHNSON: You'd better believe it. It's—I just happened to catch one of those waves, baby, and we rode them—rode it right to shore.

NEAL: And you know we've been talking for quite a while now. I want to give you the opportunity to make up for my shortcomings. If there's something that I should have asked and didn't, or if there's something that you're just dying to tell us, this is that time.

JOHNSON: No. No, I—

NEAL: The microphone and the camera's all yours.

JOHNSON: I don't know. I—on—after this interview, of course, I'll think of 20 things. But right at the moment, I can't think of anything. I feel a little bit sorry for the guys coming along now. Because the first place—not that everything's been done by any means. But we kind of licked the icing off the top of the cake and, you know, they've got to eat the cake with no icing left on it anymore now. And of course anything they do, somebody will say, "Oh what the hell! We did that in 1965" or something like that.

NEAL: You don't think a colony on the Moon or a trip to Mars might be a little different?

JOHNSON: Yeah, yeah. Yeah.

NEAL: Particularly if those journeys embodied new technology? Something different?

JOHNSON: Yeah. It's kind of tough to—not to be able to play in the game anymore. You know, I know Max feels that way because he said so. That you don't like the idea that somebody else is going to do all these things, and you don't have a chance to participate in them. But, you know, you've really got to thank your lucky stars that you got to do what you did.

NEAL: Was there any single thing in your entire career that stands out in your memory as, this was really the turning point or a highlight of all the things that I did?

JOHNSON: No. When the things happen, they just seem like that that's, you know—that's as usual. And it's only after it's all over with that you say, "Well, that's really not all that usual and that it doesn't happen very often." But each day is just a day working. It's a day working.

NEAL: You took it a step at a time.

JOHNSON: Yeah, yeah. I sound like a basketball coach now. One game at a time.

NEAL: Very good. C. C., thank you.

JOHNSON: Okay. Well, it's been my pleasure.

NEAL: It's been a grand interview. And we've, of course, been talking with Caldwell (call him "Cadwell")—

JOHNSON: Yeah.

NEAL: —or C. C—

JOHNSON: Yeah.

NEAL: —and we've been talking about the history of the space program here at the [Johnson] Space Center.

JOHNSON: Yeah.

NEAL: It's a good place to talk.

JOHNSON: Yeah.

NEAL: Okay, fellows.

[End of Interview]