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ORAL HISTORY TRANSCRIPT

CHARLES D. WALKER
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is April 14th, 2005. This oral history with Charlie Walker is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. The interviewer is Sandra Johnson, assisted by Rebecca Wright.

I want to thank you for joining us again today.

WALKER: Well, again, I want to thank you for the opportunity again, so it's a pleasure, thanks.

JOHNSON: We ended up the last session talking about your first flight, [STS] 41-D, and I'd like to begin today by asking you a couple more questions about that flight, the first one being during that mission the icicle formed on the water dump nozzles, and I would like you to share any memories you have of that situation and how the crew overcame that.

WALKER: Well, let's see. 41-D was the maiden flight of *Discovery*. There were some relatively small design changes in the Orbiter vehicle since the previous model came off the line, and so one of the things that came to light later, one of the things that was changed was the design of the wastewater dump nozzle. Apparently thought was given that the nozzle should be redesigned to change the rate at which and the pressure at which wastewater could be dumped effectively overboard, and maybe even change the spray pattern so it didn't spray the wings and potentially

ice up or hit the wings. Anyway, so the nozzle had been changed, but of course, it had never been tested in vacuum, at least for any long periods of time, before.

Well, it came to the crew's attention, and the ground by telemetry, that after a couple of days that there was some increased pressure in the water dump line, and that indicated an obstruction at the exit, at the nozzle, the nozzle being on the surface of the Orbiter on the port side. So [we] took the opportunity—Hank [Henry W. Hartsfield, Jr.] had the remote manipulator system on board, of course, and the ground asked that we take a look back, so to speak, take the camera, around the shoulder from the cargo bay, and look at the nozzle. And, lo and behold, the camera images showed an oddly shaped icicle of up to a couple of feet in length, extending outward from the nozzle.

So the later determination was that, well, the design of the nozzle was not such that it forced the water away or moisture away before it could freeze, and that it had started to freeze and that over the hours of dumping since the first water dump that more and more ice slowly accumulated and extended outward as a big 'cicle.

We at first took note of this with amusement, but then the ground told us that, "Well, we really can't enlarge that 'cicle, that icicle, because if it breaks off during reentry, it will follow a streamline back." The water nozzles are at about the same elevation, if you will, on the side of the Orbiter as the wing, and nobody wanted it to come off and hit the wing during reentry, and they didn't want to hit the tail or anything. So, gosh, a two-foot icicle, that's going to weigh several pounds, and it's going to be—so, not knowing what to do with it, the first thought was—well, obviously, the first thing we need to do is not grow it anymore, which means, oh, we don't dump any water.

Oh. Which means—well, see water comes on board from basically two sources, the fuel cells combining hydrogen and oxygen to create electricity, and oh, by the way, water as a by-product. The crew would use water, but then—well, actually, I said two sources; it's really one source, the fuel cells. The crew just processed the water. But that was another, so to speak, secondary source, because the crew's wastewater from the waste collection system is stored on board for a period of time and then literally dumped overboard, sprayed into space overboard through the same wastewater dump nozzle.

So after a little bit of cogitation and with the ground's message that, well, we needed to conserve water; all the tanks would be stored full; and oh, by the way, we needed to minimize the use of the waste collection system, because water went into that, the tank, and helped fill the tank up there, too. Well, of course, the response to ground was, "Well, where are we going to put this water and the wastewater until we figure out how to fix that 'cicle outside?"

So, the bottom line being that the crew was forced to minimize the use of the WCS [waste collection system]. Interesting that we found a way to store water to prevent the growth of what we at that point euphemistically on board began to call the icicle; we nicknamed it the "pee-cicle." But we had to deal with the onboard water situation, wastewater.

As it turns out, NASA, wanting to try to prepare for all possible options, there was stored on board, we came to find out—we didn't all know about it before flight—but with this situation, the ground radioed up and said, "Well, we find out that we have stashed on board for you some old Apollo Program waste collection bags." Now, we won't go into detail here how they did it on Apollo, but it was kind of like camping. But there were bags on board that we literally could urinate in that were left over from the Apollo Program. I don't know, I'm kind of an amateur

historian, so I felt a little bad at peeing in these historic bags, but we had to do what we had to do.

So here we had these bags, and so instead of using the waste collection system, starting on day three, probably—I'm guessing now—we started using these bags. Now, in zero-G, everything's weightless, so when you use the bag, it doesn't stay at the bottom of the bag. So my thought was, this is bad; looks bad, and it's hard to seal up to keep everything inside. So I said, "Look," I said. I think I told Hank or Mike [Michael L.] Coats. I said, "Here's an idea. We change our underclothes like every day, including our socks. So they're just stashed in a bag, and they come home, and they're washed when we get back to the ground. But why don't we put something absorbent in those bags, like our old socks?"

So that's what we did. So we were using these bags with absorbent socks in them to keep the slosh down, so to speak, and we did this for a couple of days while the ground was trying to figure out what the heck to do with the pee-cicle outside. Well, the procedure, as it turned out—oh, and one of the thoughts was, well, somebody should go outside, maybe and—in fact, I know it was onboard volunteered. Steve [Steven A.] Hawley and Mike [Richard M.] Mullane, if an EVA [Extravehicular Activity] had been required, were the trained and scheduled Mission Specialists to suit up and go out, and they were all for the idea of going outside and knocking the pee-cicle off the side of the Orbiter.

As it turned out, the ground kind of nixed that, because, number one, the pee-cicle was like off the port side just off the nose of the Orbiter, and there are no handholds or any other way to get there, so it would have been something that had never been tried in the program before, and nobody wanted to try it the first time in this kind of situation. But the other alternative was literally to use the Canadian Arm to bend back around—and I'm with my arm here showing

how—from the shoulder on the sill of the Orbiter, bend it back around literally almost to the limits of its motion until it could come around and bump up against the icicle. And that's exactly what the ground decided we should do.

Hank, being the commander and having been trained on the RMS [Remote Manipulator System], but not the prime RMS operator, Hank insisted on taking control of this, because if anybody dinged up this new, brand-new Orbiter for the first time, that it needed to be the commander. He would take responsibility, in any case. So Hank very judiciously and expertly dinged the icicle.

Of course, with the camera on board on the arm and at the wrist joint of the arm, the camera could look at the icicle until it got within, oh, say a foot of the icicle. Then it couldn't see it anymore, because the camera was looking this way; the icicle was now so close that it was out of view of the camera. So the last few inches of motion was in the blind, and that was what was really the risky part, if the arm should jiggle or jostle one way or the other. But chances are, if you were that close, the few inches of motion, you were going to know where it was going to go, and you were okay. And as it turned out, that's exactly right.

So it was dinged; it was bumped enough to break it off. Didn't take much force to break the icicle off. I think there's one or two photographs in the photo library that Mullane took out the rear window or the overheads as the 'cicle was seen to go floating off into its own orbit.

Then from that point on, then, we watched the buildup outside. We adjusted the flow rates and dump times to dump the by then very full water storage tanks, and prevented growth of a 'cicle from then [onward]. When the mission was returned, the Orbiter was—its next modification—was modified with heaters, and I think all the Orbiters got heaters added to that area of the nozzle to prevent ice from forming in the future. So as far as I know, nobody has

ever had an icicle, by any name, form on the outside of the Orbiter since. So that's the story of the icicle.

JOHNSON: We hear that there was a logo patch with "Icebusters"?

WALKER: Yes. Yes, I remember that there was a "Icebusters" logo patch about that time, noting that the *icebuster* term was drawn from the then—within a year or two, I guess about a year of the flight, *Ghostbusters* [movie, 1984] had hit the big screen. So, yes.

JOHNSON: At the end of that flight, the landing, since this was the first time that you landed, and I was wondering if you could give us a description of that feeling and what that was like for you, the reentry and the landing.

WALKER: Yes. Let's see. I'm thinking; I'm not remembering exactly this reentry and landing. I think we reentered and landed in the day—I know we landed in daylight. I think the entire reentry, or most of it, anyway, was in daylight. That wouldn't have been the case, though; we landed in the morning, and this was the first landing of *Discovery*, and the landing was at Edwards Air Force Base [Edwards, California]. So part of the reentry had to have been on the night side.

Yes, and it's occurring to me now in recollection that I do remember having seen the reentry plasma outside the window for the first time on that first flight; noting again that I was seated in the middle of the middeck. The view outside, the only view I had was through the entry hatch, the portal in the entry hatch, but even then, just that small view, it was very

impressive to see the plasma. The plasma's not so bright that it's visible in sunlight, so it's really only seen from on board and inside when the reentry trajectory is on the night side of the Earth. And, in this case, yes, I think at the start of our reentry, anyway, that it was.

The colors, it was amazing to watch the colors go from a black through the darkest of reds into red and then orange, yellow; you go through the spectrum, ending with deep blue and violet and then back to black again. They're pastel shades of those colors, and so it looks—your mind can take it in as just so soothing, that palette of colors, if you will. But intellectually, you know that it's 3,000 degrees out there just a fraction of an inch beyond the outside of the window.

You also see fluctuations in the density of the color. In other words, the hues kind of change darker blue, if that's the color of the plasma at the moment, the temperature and the color of the plasma. So it's kind of like rippling patterns, and the ripples change fairly slowly. And again, you see this change in the density, even though you intellectually, again, know that you're going, jeez, 18,000 miles an hour. And yet the change, as that plasma is surrounding you as you proceed through the atmosphere at that velocity, the changes are so subtle and slow. So it's an intellectual experience to view that and to then know and cogitate on what's behind it and what's going on out there as you're seeing this visual sight.

The reentry, we'd spent six days in weightlessness, so everybody was well adapted to weightlessness and could move around extremely easily without gravity, so now it was an exercise, a mental exercise as well as a physiological one, to readapt to the onset of gravity. The reentry, the deceleration got no greater than, oh, about 2.8 Gs [gravity] or so, maybe 2.5, 2.8 Gs.

But the buildup after retrofire—and the retrorocket fire was interesting, because then is your first—in almost a week's time, it's your first experience with significant acceleration or

gravity again, and for several tens of seconds while the retro engines—or the engines are firing, the orbital maneuvering system's engines are firing in a retro mode, the deceleration. Everybody is seated, but we have our water containers with us in our hands, because we're rehydrating, taking salt tablets to retain the water; rehydrating, getting the fluid back that the body will need to adjust volume the blood vessels and vascular system up with when you're back in 1-G.

So we started doing that, water containers in hand, and the retro rockets fire, and everything starts moving in this direction, back towards you, and you feel the acceleration. It feels really odd at this point. You're just not used to acceleration now, consciously. Once the retro rockets have fired, everybody's still in their seats, and you just remain in your seats, knowing that you're forty-five minutes away from landing.

But the sense is still that you're in orbit, and you are still in an orbit; it just so happens that the velocity that you've taken out of the spacecraft has changed the orbit now to where it intersects the surface of the Earth half a world away. So while you're still in orbit, pretty soon that orbit's going to intersect the atmosphere, and weightlessness will be gone as you start decelerating in the atmosphere.

Well, many—ten, twelve minutes later, as we first encounter the resistance of the atmosphere, it's a very slow—it's hard to sense when you start feeling that deceleration, the decelerating forces on you. But again, what I found useful was the water container, because you could hold it out in front of you, of course, and let go of it, and when you're still in the low-gravity orbital path, orbital flight, it'll just sit there weightless.

So you hold it out in front of you, and you start sensing gravity, and you let go of it, and you see it starts drifting visibly down toward the floor of the Orbiter. And pick it up, put it back up in the air again higher, and let go of it, and it drops a little faster. And so you play this little—

I played this little game over the next five minutes or so as the deceleration started as we really entered the atmosphere I'd put the container up in the air, let it go—it would drop a little faster. I'd catch it before it hit the ground and put it back up in the air, and it seems like after about three or four minutes of that, it was dropping so fast, I couldn't catch it before it hit the floor and went skittering away somewhere.

The deceleration forces are down through you, forcing you into your seat. You get to the point where they feel unusual. Again, you're not used to feeling gravity. But they're not painful by any way or means. They're just a tug on you. But now that you've left the freedom of weightlessness behind, this constraining tug, it was a little disconcerting to me. I didn't like it. I didn't like the constraining nature of acceleration of gravity on me. It didn't feel right. And, of course, from that point on, it was going to have returned, and it returned with a peak of, again, about two, two and a half Gs, maybe, during reentry.

At the same time, the vehicle, as we came out of the Earth's shadow and after the plasma had disappeared behind us and we were slowing down, the Shuttle's going through S-turns to dissipate energy along its flight path, and these S-turns would—again, I'm looking out my port window, and I could see when we turn, bank to the left, looking down at the surface of the Earth, and it starts zipping by. It looks to be zipping by even faster than it was as we were in orbital flight; we're just closer. Turn the other way, and I'd see the blackness of space once again.

Now the deceleration forces are such that you can really sense this change in motion, so we feel like we're flying again. We've been flying all along, but now the sensation of flight really returns as the G-forces vary from left to right, up and down, a little bit. Landing, Hank and Coats did an extraordinary job, an expert job of bringing the Orbiter into Edwards. The landing was uneventful in that regard.

I just remember looking out the window, again, my little nine-inch porthole over here, and seeing Southern California get closer and closer. First the coast of California, then inland, the desert, the mountains, and that was actually my first trip to Edwards Air Force Base. Quite frankly, I think it was probably the—I don't know, one of the firsts nobody ever needs to record—but probably the first person to ever have [made their first visit to] Edwards [by] flying [in] at Mach 25 from somewhere else.

So the landing—for me, it was an emotional experience at having now arrived at the end of my space flight. Still at that point I didn't know I was going to have any further flights. I thought that was probably it, and it was such an extraordinary experience, and now it was, for sure, over with. I came to sense a real defining moment, a physically and emotionally defining moment, when [it came to me that] this experience, this great thing called space flight, is based on, among—well, really, probably above everything else, it's based upon velocity.

It's putting people and machinery at high speed at the right velocity, the right altitude, the right speed, around the Earth till you keep going, and you're working in this high-velocity environment that we call orbital flight. When you want to come home, you just take out some of that velocity with some rocket energy again, and use the Earth's atmosphere to slow you down the rest of the way until you come gliding in and lose the last part of the velocity by applying brakes on the runway until you come to a stop.

So I noted in my own mind two definitive points here that really, without debate, start and end this great experience. One is the high-energy event that we call launch, straight up when the rockets start; to the landing and wheels stop on the runway horizontal, and the brakes have taken hold, and the energy is gone, and the spaceship literally rolls to a stop.

I can remember in my—strapped into the seat, now feeling like—the term that I think everybody must use is "feeling like a ton of bricks," and literally, it does feel that way. It's like every part of you now has weight, and you feel every part of you have weight. Your head is very heavy, and you're wearing this ten-pound helmet, anyway, or [two]-pound helmet, but now it feels like tens of pounds, and it's pulling your head down. Every muscle is straining, almost consciously feeling a strain, at trying to keep balance, to move this or that appendage or the entire body against gravity. You just sense gravity all throughout your body, and, again, it's such a remarkable and different experience than what you've just had for the previous six days in which you didn't feel any weight at all, and were quite liberated from it.

So now it was a matter of that last lurch up against the straps, sitting in the seat as the Shuttle comes to a stop. And there was a moment in which I both felt overjoyed to be home and have successfully accomplished the mission, at the same time that I felt sad, quite sad, at having left behind the freedom of weightlessness and the great views from the vantage point of space.

The vehicle was safe. The guys on the flight deck were going through the closeout procedures. Ground crews were closing in. Of course, we sat unstrapped, but we would sit in our seats for another, oh, ten, fifteen minutes as the ramp was brought up, the sniffers checked for ammonia leaks and/or hypergolic propellant leaks, found none, and put the stairway [up to the hatch], and opened the hatch.

All that time, all of us are beginning to get our land legs back, unbuckle, start to try to stand up. [I said to myself,] "Ah, this doesn't [feel good yet.] Wait a little bit longer." So you kind of move around, move your arms first, your feet first, your legs first, then stand up, make sure you've got your balance back. The balance is the one thing that you just don't have. Again, the brain hasn't been utilizing the inner ear or senses of where the pressure is on the bottom of

feet, for instance, to use as cues to balance itself against gravity. It hasn't done that for a week. So you've got to carefully start through all that and consciously think about balance and consciously think about standing up, and we very consciously do that, because the last thing you want to do, in front of hundreds of millions of people watching on television, is to fall down the ramp leaving the Orbiter.

So very consciously thinking about standing up, and I felt a little lightheaded. The weightlessness thing again. The body adapts by, among other things, letting go of a lot of fluid, about a liter of liquid, which makes you clinically dehydrated while you're in space, except the whole condition of the body is different up there, so you're really not dehydrated in that environment. But if you come back without replacing that liter of fluid, then you are dehydrated. You try to stand up with not so much fluid to go to the head, and so you literally could pass out. Nobody did that, but I know I had sensations of lightheadedness for the first few minutes until I just literally worked at getting my balance back and focusing attention, and the body was adapting all that time, too.

But leaving the spacecraft, everybody [was]—I know I was—holding onto the handrail as I went down the stairway. Got to the bottom of the stairs, and I was walking like a duck, because I was trying to keep my balance, for certain. Then after that, get in the van, go back to be taken to the medical quarters, where we did some postflight medical exams. It felt good to take a shower after six days.

Every sensation for the next many hours, normal sensations of water running over you in a shower, strange. Because again, here this water's hitting you, and it's running down, and hours later, I found that I still could at any moment just think about the sensations in my body, and it was odd to feel this pull down toward the surface of the Earth, to be stuck to the surface of the

Earth. Twenty years ago, it was still fairly new to hear comics or some wag note that the this or that "sucks." Well, come back and the astronauts were saying, "Well, the Earth really does suck." So it keeps me drawn right down to the surface. Gravity is really real, and it stands out in your mind to, again, the freedom of weightlessness when you've had that opportunity. And that was just very much on my mind.

I remember even a day, two days later, probably like a day later at a meal, I was sitting down, and I could not easily figure out whether I should sit back against the back of the seat or learn forward, because my head was telling me I was leaning forward at an angle, and, in fact, I was sitting almost straight up and down. So the inner ear is still adapting to its own senses and the body's cues to orient itself and still doesn't have itself figured out completely yet.

I also remember waking up the next morning back here in Houston, waking up and going into the bathroom and wanting to brush my teeth, and I did that, and I remember letting go of the toothbrush, and it fell to the sink top, and I probably laughed. Then I pick up the cup of water to rinse my mouth out, and then proceed to let that cup go again. It's like, again, you're still thinking weightlessness, and you're really used to that.

Finding the situation where gravity is ever present is just such an interesting experience, because now, again, you've had that contrast of a different place where that wasn't part of the environment and you note when you get back how remarkable and how constraining [gravity] is. So, I've said enough about that, probably.

JOHNSON: Was it amazing to you how quickly your body adapted to weightlessness the first time, as compared to coming back, or was it about the same amount of time readapting?

WALKER: My experience is that different systems of the body adapt at different rates, and so like it took my inner ear and my brain three days, as I think I've noted before, to really get used to moving around and orienting myself and feeling comfortable with the orientations, that I knew where I was and how I could get [comfortably] from this orientation to another orientation. It took about three days for my head and brain to figure that out. I think it took my body, my stomach, some of the internal processes, digestion and the like, less than a day to get right side—to do whatever they needed to do. I didn't feel any symptoms after a day or two days in that regard.

The balance thing, right away, within hours in space, within an hour, really, you figure out what you need to do to, say, push off from a wall where you are against one wall, and even move ten feet across the cabin to another place, and to get from that place where you are to one that you want to get to. To reliably know, and it's a matter of dynamics, it goes through the brain that you've got to calculate, "Do I push?"—and here I'm showing with my hand—"Do I push off on this wall next to my head, or do I push against the wall some down here near my midriff?"

Well, yes, you push near your midriff, because that's where the center of gravity, or the center of mass, in that case, is. So basic physics, a force vector through the center of mass will give you a linear projection of the object. But if you push off of the center of gravity or center of mass, you're going to get not just a linear motion, but you're going to get a rotary motion as well. So you try that once or twice, and you're like, "Uh-oh, that didn't work as well as I wanted. That didn't get me where I wanted to go or how I wanted to get there." So very quickly your brain figures out how to begin to move the body around in weightlessness, so that adaptation happens pretty quickly.

On the ground coming back, again, it's not entirely the reverse of that, because here we've all grown up for some decades before we go fly in space in gravity, and it's just natural. Except it is programmed in, and that programming is submerged with new habits that you gained to work in weightlessness, and you have to pull that programming back, or the brain does, and it does so at different rates, I think.

So balance, some aspects of balance—you can walk. Within tens of minutes, you can walk comfortably. You may look a little odd, because you're not walking as expertly as you had done for twenty, thirty, forty years before. It takes a few more hours, maybe a couple hours to do that. But you can walk, so balance comes back pretty darn quickly.

But it's probably where the nonautomatic stuff, like I've remarked about just automatically leaving a glass hanging in the air, thinking it's going to stay there. You just get into habits there that are semiconscious, and it takes a little while for, I think, the body and the brain to let go of that and to relearn that, no, I'm stuck here again to the surface of the Earth. I've got to put the glass right up here on the table directly. So different rates of adaptation, I think.

JOHNSON: You mentioned in the last interview that the CFES [Continuous Flow Electrophoresis System], some of the experiments were contaminated. At what point did you learn that that was contaminated?

WALKER: I learned that days after returning. After I got off the vehicle, the vehicle was then, of course, towed to the mate/de-mate facility out at Edwards, and my project's ground support folks got access to it within, oh, I think eight hours after we landed. So they pulled samples out of the

apparatus then, and within hours those samples were back at our labs in St. Louis [Missouri] and going into testing, among other things, testing for bacterial contamination. And it took maybe twelve hours further before those tests had evolved to the point where the lab technicians could see that there were contaminated samples.

So it took a day or so for us to find out. I got the word via a telephone call that, "Well, we got sample back, but it looks like it was contaminated by our processes somewhere along the way." That is, exposed to nonsterile conditions somewhere along the way during the processing. Because in flight, the entire system was self-contained, and I didn't get into it and open up any of the sterile system, so it was contamination that we knew had probably happened accidentally during servicing of either the apparatus in Florida before flight or the samples, which were put into the apparatus at that time before flight. So it was a day or so that I learned that we had [bacterial contamination]. That just meant that the samples could not be used for animal testing.

Now, remembering again that we were refining, purifying pharmaceutical-grade materials for pharmaceutical research, and that our partner in the research in the commercial—soon we hoped it would be a commercial project—was Johnson & Johnson [Corporation], Ortho Pharmaceutical [Division], and they intended to use some of these samples for first-level animal testing toward the eventual—it would have been many tens of months later that they first could have gotten [United States] Food and Drug Administration approval, after much more testing, to use this materials for a pharmaceutical product.

But all of that would have had to start with animal testing, but you don't inject animals for pharmaceutical testing with bacterial contaminants, because that undoes all of the benefits of the test or the reasons for the test, and the bacteria would cause side effects, maybe even death of the animal. So, anyway, the contamination was just not good for that kind of testing.

But we could do all of the chemical and physical testing of the samples, except for the animal testing, that would tell us what we had there in terms of its chemical nature. We went ahead and did all that, and that proved that we, in fact, had done the right things. The process was doing what it needed to. It was purifying better than had been ever purified on the ground material. It just had been side-contaminated with the bacteria.

JOHNSON: You mentioned a couple of times last time and then this time again that you thought that your first flight, that was going to be it, and, of course, you were the payload specialist for that, because you had the most experience with the apparatus. At what point did you learn, or maybe it was known all along, that the CFES was going to fly again?

WALKER: We had negotiated—I think I mentioned in a previous interview that my program management had negotiated at NASA Headquarters [Washington, D.C.] this joint endeavor agreement to enable us to fly the research, the development research and development apparatus, and that it was for up to seven flights. Before my flight, we had flown four times, so my flight was the fifth time in a sequence of up to seven.

With my flight, we thought we would probably go to—at first thought was, well, we'll send along one of our own researchers to maximize the information return on how the equipment operates, to be able to conduct some—in the Shuttle Program, they're called developmental test objectives, DTOs; I'll use that, apply that term to our little project, in which we could test some changes, adjust some parameters in the controlling computer or in the physical setup of the apparatus while it's in operation in orbit, just so we can test the envelope, as we would say in the

aviation business. Just test the variability of the device and how it would accommodate this or that changing or fluctuating condition. So I did all that.

A thought was that I might only have to do that once, or somebody might only have to do that once, and then we'd know enough about the apparatus and the quality of product that it could return, in terms of purified research materials, such that we could then go back to a semiautomated apparatus that a NASA mission specialist could turn on, turn off, and we could conduct the last one or two research and development flights in our program that way. We wouldn't need a payload specialist again.

Well, what we discerned with this flight was, well, number one, [the previous sample] was contaminated, so we really need to do it again, even though the contamination was not part of the onboard process. We also discerned that it did take more in the way of attention, that our particular design of this apparatus took more personal attention, direct attention, to keep it under control, so to speak, and within the intended conditions for the production of pure pharmaceutical product. It took more physical—it took more temporal attention, personal attention, more time in operating it than we thought would have to be the case.

So the request went in to—and I guess our management had also decided, even just prior to my flight, that we wanted to modify the equipment again. In other words, another major change in its design, upgrade, if you will. For the next level of research and development production of pharmaceutical material in flight, we wanted to change the design. So it wouldn't be the same design we'd be flying the next time. It would be different. That, together with the just-learned lesson that, gosh, the apparatus generally takes more attention to keep it under control than what we'd anticipated.

So all of that came together in my management's mind as, "Well, we really ought to have our R&D [Research and Development] engineer along with it to devote as much time to it again as it will need." Again, given the understanding with NASA that the mission specialists that would be assigned to operate the device couldn't spend but maybe 10 percent of their time in flight operating it, we just deemed that to be inadequate for our needs.

We expressed that to NASA management, and the management apparently said, "Well, if we do that, we'll train another one of your engineers, go through that process. Or, Walker seems to have made it back okay, and none of the crew really got ticked off at him on this flight, so maybe he can fly again, if you want to do that."

So we said yes, and I said yes. But that came about within a week or two, probably no more than a month after 41-D had landed, that decision, the request of NASA and NASA's agreement that, "Yes, we will fly a payload specialist another time, at least, and we'll fly Walker if that's what the company wants to see done." So that was basically how that came about.

JOHNSON: At what point did you learn that you'd be flying on [STS] 51-D? And I know there was a combination with that flight.

WALKER: Yes, there were some things. Well, the basic question that I would hear you ask and want to answer is how soon after 41-D was I aware that I'd be flying again, and I sit here unsure as to exactly what I think. Remember that we landed in early September of [19]'84. I think it was probably within a month's time after that, within thirty days, within probably the month of September that we—the McDonnell Douglas Astronautics Company, our project, the electrophoresis operations in space project, and myself—got word from NASA that we not only

were going to be flying—NASA would fly the electrophoresis equipment again—but that I as payload specialist would accompany it. So probably within that thirty days.

So the question, what flight would I be on, was really not what flight would I be on; what flight could accommodate the electrophoresis equipment, first and foremost. It was a physical installation in the middeck, and so, of course, it had to be mapped into and taken into account with the other payloads that were on the future manifests, the near-future manifests, for the program.

As I remember it, the way that went was that I was first—I and the electrophoresis device—was first manifest on 51-A, which was scheduled for like November of '84. So here it was like the end of September or thereabouts that we find out that we're going to, yes, be flown again, but, oh, by the way, it's going to be in two more months' time. And yes, Walker can go with it again, but now he's got to integrate with that crew and get his procedures worked out with those crew procedures and crew activity planning.

So I remember that once word did come to us, that it was a pretty fast march to get ready. So I got to know—I'm sure I'd already met the crew of 51-A at that point, which was Rick [Frederick H.] Hauck and Dave [David M.] Walker and Anna [L.] Fisher, Dale [A.] Gardner, I think, and Joe [Joseph P.] Allen [IV]. So there were discussions, and I was in meetings with them in which we were literally planning my participation with the crew on that flight.

Then something—I probably knew at the time, [that something was probably the EOS (Electrophoresis Operations in Space) project management's decision—at McDonnell Douglas Corporation—that we could not correct the cause of the previous contamination problem and meet the STS Program's integration timeline for STS 51-A], but I don't remember now—something changed, and within probably a week or two weeks of those kinds of discussions, I

was moved off of the crew in the manifest for future flights, and they went on their way to and did, of course, execute their flight, and I was reassigned to [STS] 51-G, which was in early [19]'85. I guess that was Dan [Daniel C.] Brandenstein and J. O. [John O.] Creighton, Shannon [W.] Lucid, John [M.] Fabian, and some others.

So I was bumped from one crew to another, and started planning and did start some training with—did do a little bit of training with—that crew. Mostly it was at the early—here we were months before that flight, so the training was just I would follow them, maybe sit behind [Brandenstein] and Creighton in a fixed-base or motion-base simulator, just to get the feel of the way they were going to be piloting [flying] the mission; starting to sit in planning meetings with the crew to start planning out the procedures.

Now, right about that same time, as a little footnote, I'll note that the 51-A crew, of course, proceeded toward their flight. I remember when they went to the Cape [Canaveral, Florida] I actually sent a telegram down to the crew quarters. Now, remember, this is the mid-1980s; no e-mail. Sent a telegram to the crew quarters that arrived the day before their launch that sent my regrets that I wasn't on board with them on this flight, but I had something else important to do. And I got word from Joe Allen afterwards that they got a big kick out of that.

But I make that comment, noting that these were extremely interesting times, because here I was, the itinerant, and there weren't that many. There were just, at that point in time, other payload specialists coming into training. I remember in late '84 and into '85, the international payload specialists just started entering the picture, the first international PSs, the first non-Spacelab payload specialists. So here I was kind of the old hand of the outsiders who were working with the Astronaut Office, and I was bumping from crew to crew, it seemed like.

That may sound a little odd, but in the big picture, I think as anybody can see looking back at the big picture history of the time, the manifests were very dynamic. Shuttle flights, there were a lot. We were doing four, maybe four Shuttle flights a year in the '84, '85 time frame. Manifests would change. One payload would go from—because it wasn't ready for launch at that point in time, it would suddenly be adjusted to either further downstream, or maybe even come forward if a cargo bay slot opened up in a manifest on an earlier flight. So it was interesting to watch the payloads adjust around, and I was a payload. I was going along as a payload with this electrophoresis device, so I was being bumped from flight to flight.

But in getting ready for, then, 51-D, at this point I hadn't arrived on the 51-D manifest yet. I was on 51-G, and as I said, we were doing some planning meetings, and then it was decided that, no, my payload could fly earlier in the middeck of 51-D. But 51-D, and I can't remember the crew, because the [STS] 51-E crew became the 51-D crew when their Orbiter was dinged at the Cape by a processing accident.

Some composite material on one of the cargo bay doors, I think, was bent by a work stand hitting it, and that set back that flight on their vehicle, so they were moved forward, because they were essentially ready to fly, and they bumped the 51-D crew that went on downstream. And their mission landed in the—landed, so to speak—their mission was moved to *Discovery*, where the electrophoresis apparatus was already installed.

So I kind of came along. I was a payload that was already on board, and that crew joined me. So Bo [Karol J. Bobko]—I always told Bo and Don [Donald E.] Williams and the crew I kind of welcomed them on board. They didn't think that was too much fun, I don't think, at the time, me welcoming them on board the mission. So I ended up on their mission because they got

moved in there [when] their previous vehicle had gotten dinged in a processing accident, and me and my hardware was already on board the craft that they were handed.

So [I] began working, again, replanning now the mission with them, integrating my mission procedures in with them. That crew was, still is, I think, one of the best experiences that I had the whole time. Bo Bobko made for a really good family relationship, so to speak, among the crew members. He made everybody feel like that they had a place in a team; that they all were a team; that everybody contributed, and, oh, by the way, everybody should have fun, too.

Not demeaning any other crew that I flew with or anybody else that I worked with, but it's a matter of interpersonal dynamics, any situation where two or more people work together ends up being, to a great extent, a function of just the interpersonal dynamics. It was just a lot of fun, this group working together, spending time together.

So the planning and preparation for that flight went, I think, very smoothly. I was going to be operating some relatively new equipment, a change to our electrophoresis apparatus in terms of some of the electromechanical subsystems within it and some of the processes. We had changed a number of processes just to improve the sterility, the biological sterility of it, to avoid the problem we had and some other anticipated possible problems that we had discerned over the previous few months of experience and work with it on the ground.

So we got ready for the scheduled flight in April of 1985. Interesting to note that here we sit today on the fourteenth of April, and what twenty years [earlier] would be flight date two.

JOHNSON: That's true. I hadn't thought about that.

WALKER: In fact, let me make a footnote here that two nights ago now, the twelfth of April, 2005, I was sitting at home, in fact, reviewing a tape I had made from NASA Television on my home television of the confirmation hearing of now, as of last night, NASA's eleventh Administrator, Dr. Mike [Michael D.] Griffin. I was watching the hearing, the confirmation hearing, and the phone rang. My wife Susan picked up the telephone, and she let out this mild squeal, "Oh, Jake, good to hear from you. Yeah, he's sitting right here. Let me get him." So she hands the phone to me, and it's Jake [Edwin Jacob] Garn. Jake is calling to wish me happy anniversary.

JOHNSON: How nice. [Laughs]

WALKER: So I make that note in fond consideration of that, just that kind of attitude. In fact, I ran into Bo Bobko a month ago, and Bo very much wanted to have the entire crew together. Of course, unfortunately, Dave [Stanley David] Griggs is not with us anymore, having died in an aircraft accident, what, fifteen or more years ago now.

But to have the remainder of the crew all together at Bo's house down here in Houston, but some business situations prevented him from scheduling anything this week to do that. He did have us all together, and we all did get together ten years ago on the tenth anniversary and spent a very fun evening recollecting goings-on in and around the flight. I note that, just a reflection here ongoing into the future of the closeness of the crew, and it was just a great experience.

JOHNSON: You mentioned Jake Garn. At what point was he added to the crew, and how did that affect the training?

WALKER: First of all, you'll have to ask Jake to hear it firsthand, but as I remember hearing it, Jake had been lobbying some time with the NASA Administrator to get a chance to make a Space Shuttle flight in his responsibility as Chairman of a NASA oversight body within the United States Congress [the Appropriations Committee of the U.S. Senate]. Just part of his job; he needed to do it. Of course, you look at Senator Garn's history, and at that point he had some 10,000 hours logged in I don't know how many different kinds of aircraft, having learned to fly as a naval aviator, and had gone to the Air Force when the Navy tried to take his ticket away from him and wouldn't let him fly again. So he went over to the Air Force Reserve, I think.

So anyway, Jake was very aviation oriented and certainly enamored with the agency's activities and just wanted to take the opportunity if one could be found. So his lobbying paid off, and he got the chance to fly. He was still in the Senate and would take the opportunity on weekends to come train down here; would take congressional recesses, and instead of going back to his home state, to Utah, he'd come down here to JSC [Johnson Space Center]. So he worked his training in and around Senate schedules. That started, I remember, around January of '85.

I think Jake was named, was identified as a space flight participant in January of '85. So literally two and a half months before flight, Senator Garn was identified as a crew member. I do remember that there was at least hall talk around the Astronaut Office of, "Oh, my gosh, now what's happening here to us. What have we got to put up with now?"

But Jake, from my experience, and here is an outsider talking about another outsider, but I think Jake accommodated himself extraordinarily well in the circumstances. Now, while he

was a United States Senator and a politician in his current life, he had been a military officer; was an aviator and a pilot. He knew the world in which he was getting. He knew it from an operational standpoint and an attitudinal standpoint.

What I saw was a Jake Garn that literally opened himself up to, "Hey, I know my place. I'm just a participant. Just tell me what to do, and I'll be there when I need to be there, and I'll do what I'll [need to] do, and I'll shut up when I need to shut up." And he did, so I think he worked out extraordinarily well, and quite frankly, I think the U.S. space program, NASA, has benefited a lot from both his experience and his firsthand relation of NASA and the program back on Capitol Hill. As a firsthand participant in the program, he brought tremendous credibility back to Capitol Hill, and that's helped a lot. He's always been a friend of the agency and its programs. To this day, he continues to be.

JOHNSON: Did that bring more attention from the press before that flight, or do you have any memories of that?

WALKER: I recall that it did bring certainly more attention. Here was the first politician to fly to space, and by its nature, yes, that brought attention to the flight. I can't say that much in the way stands out there. Quite frankly, I think I was a little gratified that any attention that might have come to me was now deflected to the U.S. Senator here. I don't recall anybody taking exception at the increased attention to the flight. I think we all went about our duties and answered the questions that needed to be answered.

I feel, in reflection, that probably NASA Public Affairs was, to some significant degree, insulating us. I know that should have been, and I'm sure they felt like it was their job to do that,

in a fashion. They undoubtedly felt like they were on a razor blade; on the one side there was the pull by the media to know as much and get as much insight into the crew and the Senator's participation with them and all of his thoughts, etc., during that time frame, at the same time that the NASA family and Public Affairs needed to insulate the crew, who was trying to concentrate on getting ready to fly to space, to let them do their job and get trained and not think about that. So, interesting circumstance.

JOHNSON: Maybe you can walk us through some of the similarities or some of the differences between your first flight and this flight, as far as the experience of going to the Cape and getting ready for the flight and launch.

WALKER: Well, let's see. First and throughout, it was more comfortable. I had a more comfortable feeling about it all. This was the second time, and I kind of knew what to expect. In fact, I've got to think hard about how many rookies there were on that flight. I was no longer a rookie. Jake Garn was. I think Dave Griggs; I think it was Griggs' first flight. I think it was Rhea's [Margaret Rhea Seddon] first flight. [It was Jeff (Jeffrey A.) Hoffman's rookie flight.] And, yes, I think it was Don Williams' first flight. So I guess Bo and I were the only flown on board.

So it was more comfortable for me, not to say that I felt blasé or ho-hum about it, by no means. You just can't go out and sit on a rocket and go into space and feel ho-hum about it, even after umpteen flights. It just isn't going to happen. But a person can feel more comfortable. Some of the sharp edges, to put that term on it, of the unknown, of the tension, is just not there. I guess maybe a better way to put it, I would suggest, is now you really know

when to be scared, and after, of course, the 41-D experience on the launch pad, yes, I was a little scared when we got out there on the launch pad on the twelfth.

So I remember flying down. This was a time when payload specialists didn't get much [Northrop] T-38 [Talon - astronaut training aircraft] time. We didn't get backseat—we weren't trained backseat T-38 flyers, not to the extent that [a few in] the Astronaut Office wanted, anyway, nor the front office, I guess, down here at JSC. So I didn't go down with the crew. I didn't go down with the 41-D crew in the T-38s, down to the launch site for launch. I didn't fly down in the 38s with the 51-D crew. In both cases, I went down on the NASA Gulfstream, along with George [W. S.] Abbey and Jay [F.] Honeycutt and Captain [John W.] Young and maybe one or two others, and arrived probably just a little bit before, as I remember, just a little bit before the flight crew did.

So we would arrive in the NASA Gulfstream at the Shuttle Landing Facility an hour or so maybe ahead of the 38s, and then the crew would arrive, and I'd go out and meet them at the 38s, and then we'd talk to the press on the ramp, like it's still done today. I remember getting questions about, "What's it like for your second flight?" I don't remember what I said, but I think I remember that, yes, Jake Garn got most of the questions, and Jake, being the consummate and well-practiced politician, did very well in answering those questions.

At the crew quarters, I remember just a lot of good times and a lot of humor, good times in terms of humor. I don't remember being remarked upon or leaned upon as one of the old hands on board. I think everybody—I mean, having flown once already. I didn't remember anyone emphasizing that to me, which was fine with me; I didn't want the added pressure of having to be a mentor to the professionals here. These guys had gone through years of training

just to do this. I'd been doing it for a few months or something like that, so I was passenger on an earlier flight. So that was all fine with me.

Everybody did extraordinarily well in preparing for the flight. Of course, Rhea was—Rhea Seddon, as a physician, one of the experiments on board was the first flight of a U.S. echocardiograph device, and Rhea was going to do echocardiography of the hearts of I think at least three of the crew members, and, of course, I as payload specialist, Jake and I were the obvious subjects. We really didn't have much of a choice in whether we were going to be subjects or not. "You're a payload specialist; you're going to be a subject." So, we were practicing having our hearts scanned and looked at and imaged in training on the ground, and baselined down there at the Cape.

The training exercises: I remember going out once with the crew; I did go out with Bo and Don in the Shuttle Training Aircraft, the STA, down at the Cape as they went out to do approach and landings, and I flew along with them as just an observer and sitting in the third seat. [I] Got quite a kick out of that, going through the STA exercises with them several times down there. Just nothing else really stands out as remarkable during that time frame, getting ready for flight.

JOHNSON: How about the launch itself?

WALKER: Again, unremarkable, which is kind of an almost remarkable thing to say about a Shuttle launch, but having gone through one, the next one, this one—I think we got to—I remember a delay. We sat on the pad for several minutes—[a "hold" late in the countdown].

Again, for 41-D there was delay for, I think, was it an aircraft out in the SRB [solid rocket booster] drop zone.

This time we were delayed for fifteen, twenty minutes or something because of a freighter, as recollection—it turns out that we were told that I think I remember hearing over the air to ground, "Well, we're going to hold at T minus twenty because the Coast Guard has discerned that there's a freighter going through the SRB drop zone out there." I can remember commentary once we found out the freighter's name was the *Ocean Mama*, and the commentary about the parentage of the captain or the crew. But they moved out of the drop zone and so after a short delay of several tens of minutes, we were back into the count.

Liftoff, let's see; I was in the middeck with Rhea, I think, with Rhea Seddon. Ascent was, again, as exciting an adventure as it was the first time. I think I spent more time this time looking out the window than I did the—again the window; I was in the middle, nearly in the middle of the middeck and spent a lot of time with my head vectored over to the left and looking out the porthole. But it was different this time, in that Senator Garn was on the middeck with me. On 41-D it was only myself and Judy [Judith A. Resnik] on the middeck, and Judy was near the access hatch.

This time there were two seats in the middle of the middeck, and it was myself on the port center side, the left center side of the middeck, and Jake Garn was over to my right. Jake has publicly said lots of times afterwards, he said, "Well," he said, "that was certainly the right place for me." Now, remembering Jake Garn was a conservative Republican Senator, Jake would say, "That was certainly the best place for me." He says, "I'm on everybody's right, and it was appropriate for me to be on Charlie's right."

I'll go back just a second to say that, in recollection, while we were in crew quarters, that from the career astronauts—I didn't get questions from the rookies like, "Well, what's it going to be like? Tell me what to expect," yadda, yadda, yadda. I didn't get those kind of questions from them. I did get those kind of questions from Jake. He says, "You've done this before. Tell me. Give me the real inside scoop. What's this going to feel like? What's it going to be like?"

"It's going to be great, Jake. It's just going to be great. Just stay calm and enjoy it."

So, going uphill was the big ride. As I remember it, nothing really untoward happened going up. We got into orbit, and I can remember there was the usual over-the-intercom exuberant pronouncements, "Yee-ha, we're in space," yadda, yadda, yadda. Jake and I were—I can remember shaking hands, my right hand probably with Jake's left, gloves on, and "We're here," and then Jake and I both kind of look at each other, and we're both beginning to feel weightlessness. [Laughs]

I could tell that Jake's feeling it about as rough as I am, and, of course, here again this is my second experience, and I had anticipated that, yes, I'll probably have the same kind of symptoms, and that was the case. Jake didn't know what to expect, and I shouldn't go into much—you'll have to ask Jake. But it's on the public record, so Jake has talked about how he felt during the first two or three days of flight. But Jake felt it, and it became clear very quickly that he did, and I'm sure that I showed that I did.

So Jake and I were not very conversant and we weren't moving very much in the first few minutes or more after we got on orbit. We just didn't want to, as we say, "zing the gyros" by moving our heads around very much and disturbing ourselves. So for me that was the interesting experience of going uphill now with a bigger crew, seven people now in this crew versus the six of the first flight.

JOHNSON: What about the CFES? How did it respond and work during this flight, and did you get some of the results you were looking for?

WALKER: With regard to that apparatus, there was one circumstance, and I guess this will serve to, in fact, correct a little bit of what I just implied in that the preparation for flight was unremarkable. Well, there was a circumstance in which, as we were at the Cape within the three days before flight, I was finishing up looking through the procedures, going over procedures with the crew, just refreshing ourselves with what we were going to do. While we were doing that, my team—of course, as part of the bigger NASA [industry] team—were preparing the Orbiter *Discovery* for flight out on the pad. My project folks were out there filling it full of fluid, sterilizing it with a liquid sterilant, and then loading on board the sample material and then the several tens of liters of carrier fluid.

That electrophoresis device started leaking. Inside the Orbiter, on the launch pad, it started leaking. Drip, drip, drip. Well, of course, that didn't go over very well with anybody, and our folks diligently worked to resolve that. Right down to like twenty-four hours before flight or so, that thing was leaking out on the pad. Bobko and, of course, with the Shuttle program management, were in active discussion as to whether the leak could be overcome such that the device could be loaded up with liquid for operation in space, or not.

If it had not been charged with liquid, I wouldn't have had anything to operate with. It wouldn't have been operable in space. The question became, "Well, maybe we don't even fly Walker, if he doesn't have a reason to fly." So there was active discussion until about a day before flight as to—this is all happening within about a twenty-four-hour period up till T minus

twenty-four or thereabouts—as to whether I would fly or not, because maybe my device wasn't going to be operational in flight and so I had nothing to do, so to speak.

But it was resolved. There was talk in which—Rhea Seddon was my backup. I had trained her as the backup operator on the device, and so she was a little anxious, too. Or actually, I think she was probably a little more happy, because that would have given her more free time in flight if she didn't have to watch over my shoulder and maybe, if I for some reason couldn't conduct certain procedures, she would have had to. She would have had more free time.

But it turns out they fixed the leak on the pad and loaded it up and it flew to space, and I checked it up there and did find that the leak wasn't occurring, either during launch with all the acceleration on the fluid. So we were good to go once we got into space. But, yes, there was that little bit of tension with regard to the electrophoresis device.

In flight, it worked well. Again, I was doing a lot of testing of some design changes in the apparatus and in the software that controlled it, as well as conducting the pro forma separation and purification of some biological materials over several tens of hours, almost a hundred hours of operation in flight, taking samples for both my testing, because I could do some bacterial testing in flight to see if there was contamination taking place, and storing samples, small samples for the ground to later test as well.

I was also doing some periodic insertion of some NASA samples, because, again, part of the joint endeavor agreement between our company and NASA was that NASA would have the use of the device in flight for maybe up to a third of its operating time for NASA's own research that the researchers, as it turns out, out of the materials lab at [NASA] Marshall Space Flight

Center [Huntsville, Alabama], would want to do on this type of apparatus. So I was conducting those experiments for NASA.

I also—this was the first flight in which what would later become a long-running biotechnology R&D project on board Shuttle flights, the protein crystal growth work. This was the first flight of the U.S. protein crystal growth apparatus.

Actually, it was a small prototype that Dr. Charlie [Charles E.] Bugg from the University of Alabama, Birmingham, and his then associate, Larry [Lawrence J.] DeLucas, had designed and had come to NASA saying, "We've got this great idea for the rational design of proteins, but we need to crystallize these and bring the crystals back from space. We think they'll crystallize much better in space, and we can do things up there we can't do on Earth, etc., etc., but we need to fly it on board a Space Shuttle flight to see if it will work."

NASA was like, "Well, I don't know if we've got room on a flight just yet; maybe a year from now or something."

But the NASA payloads management just approached us with the concept, exposed to us the concept that they had been brought by DeLucas and by Charlie Bugg, and literally asked if we were interested in helping out. Maybe we had an allocation of so much mass and volume for our equipment and support materials in flight, locker space. Would we have any extra locker space? The protein crystal growth apparatus for that first flight opportunity was maybe only a foot and a half long by half an inch thick by nine or ten inches wide, so it was like a small square tray, a rectangular tray, thin tray. And yes, we found space that we could wedge it in and get it into foam packing.

So NASA accepted the opportunity that we could stow it in our manifest volume and mass. The University of Alabama folks and Marshall Space Flight Center's liked that

opportunity, so we planned with them the procedures. I was trained on how to turn it on and turn it off and to do what little bit needed to be done to it. So the first flight opportunity for the first flight of the U.S. protein crystallography work that then went on for, gosh, some thirty missions or more, I guess, was on 51-D, and I conducted that.

So a lot of side research; the planned work for the electrophoresis protein purification activity. It went pretty well. There was the usual little snags here and there, of some software that had a glitch and I had to reprogram the controlling software; the adjustment of temperature or flow rate and electrical power settings, as I was monitoring the progress of the device. Just kind of manually, semi-manually flying it, so to speak, through its processes, adjusting it, fine-tuning its processes.

I remember that at the time—again, in the mid-eighties—even at that point I think there was still just one TDRS, Tracking and Data Relay System Satellite, in orbit, and so there wasn't ninety-minute communications every orbit with the ground. We still had—we'd call them now, I guess, zones of exclusion; at the time, they were loss-of-signal portions of each orbit. So there was more to talk about than what there was time and opportunity on each orbit to talk to the ground about. Of course, I was just a lowly commercial payload, and so I didn't get priority to talk to the ground. In fact, I wasn't allowed the opportunity to even grab the microphone very often to talk to the ground.

So what we had worked out between 41-D and 51-D, worked out for the 51-D flight, was the use of the data recorder. The Orbiters have data recorders that are used, for the most part, almost entirely and exclusively just the storage of electronic data from the general-purpose computers or maybe some payloads stored on the recorder that would then be dumped to the ground, transmitted to the ground once an orbit or so. The procedure that we had in mind and

put into operation on 51-D was that I would send a lot of my information to the ground on that data recorder using a voice channel on the recorder.

So we programmed in each day, once each day, usually near the end of the crew day, when I would take a couple or three minutes on the voice recorder, or on the data recorder, the voice channel of the data recorder, literally to read in a prepared summary of my progress during the day, problems I might have had during the day, and requests for feed-up from the ground of procedures or suggestions from my support team in the back room to help me with any issues I might have.

So that worked very well. We down-loaded it to the ground at the end of each crew day. We'd sleep through the night on orbit. I'd wake up the next morning, and there would be a message that would have come up in response to my recorded summary and request for help that my folks and the Mission Control Center had worked overnight. So that was an operation procedure that was different on this [flight—different] than before.

This flight also had some—there were some interesting things going on. [STS] 51-D was the first flight for NASA Education of the toys in space [filmed activities]. I still to this day feel a little chagrined that I wasn't offered a toy or the opportunity. Everybody else had a toy, but not me.

JOHNSON: Did Senator Garn, also? [Laughs]

WALKER: Yes, even Jake Garn had paper airplanes; but I don't know. We also did some videotaped—I take that back. At that time there was no videotape. We were doing sixteen-millimeter film, on board, of all of this. So there was filming going on of the toys that each crew

member had to show off. Nobody played with toys in space, never. We just showed them off, demonstrated them for classrooms everywhere.

We did some extracurricular stuff in that regard, like Jeff Hoffman and I spent one hour preparing, at one point later in the mission, some drinking containers, one with strawberry drink and one with lemonade. Jeff, I think, had the strawberry and I had the lemonade, and we would each squeeze out a sphere maybe about as big as a golf ball of liquid, floating in the cabin, and we actually played a little game in which we would put the spheres of liquid in free floating, oh, about a foot apart from each other, and Jeff and I would get on either side, and somebody would say, "Go."

We'd start blowing at the spheres with our breath, just blowing on them, and we'd try to get them together and get them to merge, because it was really cool when they merged. One big sphere suddenly appears that's half red and half green, and then the internal fluid forces would start to mix them, and it's really interesting to watch.

Well, we found it to be a real interesting problem, because as we're blowing, our bodies are moving around, and we start moving in weightlessness, and the balls of liquid start going in different directions. You've got to be quick, and usually there's got to be somebody with a towel standing by, because either a wall or a floor or a person is going to end up probably getting some juice all over them. But that happens on every flight; I'm sure that kind of thing happens on every flight. But we had great fun doing that.

JOHNSON: I think we need to stop and change the tape just for a second.

WALKER: Okay.

[tape change]

JOHNSON: Well, you were talking about some of the experiments and the toys in space. There was also another incident on this flight that required the creative use of the RMS again. Can you share your memories about the flyswatter?

WALKER: Let's see. I think we launched—it was the LEASAT [Leased Satellite, also known as Syncom IV-3] that did not activate when the crew released it on, if I remember, on flight date two. So the problem was pretty obvious from within minutes after the satellite was released, the fact that there was a problem. But it took a day or so to apparently, I think, to diagnose by telemetry to the ground what kind of the problem might be. But still there was not a lot of telemetry, apparently, and so it was not absolutely clear exactly what the problem was. It's just that some electronic—the timer to actuate antennas on board the satellite and to start its reboost process, light the onboard engine, etc., to get it to higher orbit, did not happen.

So what the crew was immediately—once it became clear that there was a problem, we got a little depressed. The crew just got—you train for these things to happen. You know they're really important. Here's hundreds of millions of dollars' worth of satellite out there. Your flight's not that inexpensive, of course, to send people into space. So a lot of effort has gone into getting this thing up there and to launching it and to turning it on and having it operate, in this case, for the United States Navy. And here it didn't happen, so you're like, "Oh, my gosh."

But immediately, with the ground, we wanted to hear what they saw as the problem and how we might fix it. Within seconds; I can remember the crew thinking and saying out loud, "Here we are; there it is." It was there. It was still floating, like a hundred and fifty feet away from us and moving away slowly. "But here we are. We're right here with it. We can fly up next to it. So we just need to know what to do to it. We can fix it. We can bring it back home, maybe, if we need to. Just, ground, tell us what we need to do."

Well, nothing; no answers came to those questions for a day or so, but when the ground, again, had determined that they thought they had a general idea what might be the case, that it might literally be that the switch—there was a finger-shaped switch, a little mechanical switch literally shaped like a finger, about the size of a finger, on the side of the satellite that's supposed to have engaged a stop, if you will, as it exited the Shuttle cargo bay, rotated out, and was supposed to have literally switched the timer on. Maybe that switch didn't get initiated. Maybe it just didn't flick the switch.

So that was the first thing that the ground could think of that we really need to do to see what happens, and maybe that's all it's going to take. Well, how do we do that? Well, the thought coming up was—of course, there was no EVA planned on this flight. There were suits on board, as there always are, EMUs [Extravehicular Mobility Units], and a couple of the guys are trained, of course, to use those. In this case, it was Dave Griggs and Jeff Hoffman. But no plan for an EVA; no planned EVAs on this flight.

But immediately upon some cogitation about there being a problem and what might be done to fix it, of course, Hoffman and Griggs were like all, "Okay, just send us out, coach. We're ready to go." They were all excited about the possibility of maybe getting to go out.

Well, it was a day again before the ground even came to suggest that there might be something that would involve an EVA.

But that's what happened, and the ground came back with the thought that, "Well, you've got a remote manipulator system. You can rendezvous again with the satellite. But all we need to think of now is some way to flick the switch on the side of the satellite." Here's a fifteen-thousand-pound satellite that's twelve feet in diameter. It's rotating. This is a big thing, and you just don't want to get too close to it out in the vacuum of space, when maybe a person shouldn't be doing that. Maybe we can do it with the RMS, but how?

I don't remember clearly whether it was—I remember there was discussion on board. I tend to want to think that we actually suggested putting together some snares and suggested it to the ground. Maybe I'm not remembering it that clearly. Maybe there was, in fact, just conversation back and forth between us and the ground that came up with that, or the ground came up with it.

But anyway, it was a final decision that, yes, we put together some snares, and we started calling them everything from rackets to snares, whatever, names for these things that could be built up and attached to the remote manipulator system, and then to be put very carefully into contact with the switch on the side of the satellite. And we did, and with the ground, there was designs that were conjured up over a couple or three days' time, and by flight day five or six—and we did get our flight extended by one day to do this, so everybody was happy in that regard; they got one more day in flight to try to fix this problem.

We had heard from the ground. I think the ground had faxed up to us some sketchy designs for these tools, and I think there were two tools that were made up. I can remember cutting up some plastic covers of some procedures books. We went around the cabin, all trying

to find the piece parts, and the ground was helping us. The in-flight maintenance folks on the ground were, of course, very aware of what tools were on board, and they looked down the long list of everything that was manifest and tried to come up with a scheme of what pieces could be taken from here, there, and anywhere else on board, put together, and to make up these tools for swatting the satellite.

So we fabricated—I can remember Rhea Seddon, Rhea being the surgeon on board; she was very good with the bone saw. Probably the first time, and let's hope the only time, in space that the bone saw has ever been utilized, and it was used to cut up an aluminum pole. I want to say pole; it was actually an aluminum extension tool the crew on the flight deck have a switch-throwing tool. It's actually an aluminum tube with a hook on the end that, during ascent or reentry when under acceleration, they can reach some overhead switch panels if they need to with this, if they can't reach it with their hand. But part of that aluminum pole was going to make up a good part of one of the rackets.

So I can remember helping Rhea. Rhea cut it in half with the bone saw, and I held the onboard Shuttle vacuum cleaner to pick up the aluminum chippings that came off the sawed piece. Anyway, so we worked at that, putting together the pieces, for the better part of a day, it seems like. Everything from gray tape—thank goodness for duct tape, once again—to pieces of, like I said, plastic covers off procedures panels or procedure booklets, various other knickknacks around the cabin, to come up with—what did we call them?

We had the flyswatter and the—let me see, referring to—was it the—lacrosse stick, that's what it was. The flyswatter and the lacrosse stick, and they were different designs, because we weren't sure and the ground wasn't sure that we were going to get to exactly the right angle of orientation of the end of the remote manipulator system with the switch, and what was going to

catch the switch, whether it be a wire or it would have to catch on something sturdier than that, and maybe it would take more than just the tensile strength of a little plastic wire to pull the switch before the plastic would break.

So, all of those questions. We created two tools in order to try to answer all of the situations that might develop, and then I—again, on maybe it was flight day six, that Jeff Hoffman and Dave Griggs suited up.

Now, here was a change in the plans with regard to my work. My electrophoresis device is designed to operate in the fourteen-point-seven-PSI [pounds per square inch] cabin pressure, of course, stable cabin pressure, since the liquid in my device is referenced to the surrounding atmospheric pressure, and it's sensitive to that. Well, the procedure for EVA is that you depress the cabin, depressurize the cabin, to like ten-point-two pounds per square inch; increase the partial [oxygen, O_2] pressure for the crew members who are going to go EVA; get it much closer, the pressure just much closer to the pressure that they're going to have inside their suits.

Well, that was really going to play hob with my electrophoresis process, so I had to shut down my process and cease from it and kind of secure the device before cabin depressurization, and then on the other side when we boosted the pressure up again after the EVA was done, to again reconfigure my device and turn it back on. So I had some extra procedures and work to do while I was helping them get ready for their EVA. And they were really excited about it, really excited about it. To me, it was a great experience to be there at the first unplanned Shuttle Program [EVA], one of the first unplanned EVAs in the U.S. space program.

But they went outside. Bo and Don rendezvoused with the satellite very expertly. It was an awesome sight to be on the flight deck, looking out over the cargo bay of the Shuttle, moving up on this satellite, and here's this rotating fourteen-thousand-pound satellite just ten feet above

the cargo bay of the Shuttle and maybe twenty feet away from your eyeball looking out the windows at it.

Then these guys [Jeff and Dave] go outside, and they're oohing and aahing about the whole experience and doing great. They go outside, and Rhea commands the remote manipulator system over to the side of the cargo bay. They strap on, literally, with more duct tape and some cinching straps, they strap those, the flyswatter and the lacrosse stick on the end of the remote manipulator arm. Then they come back inside, and we make sure they're okay, and they secure the suits. Bo and Don finish rendezvousing with the satellite, and Rhea very carefully moves the two tools on the end of the RMS right up against the edge of the satellite.

Again, remembering that none of this had been practiced on the ground, that this was all done just with the skills that the crew had been trained with generically, the generic operation of the remote manipulator system, the generic EVA skills, and the generic piloting skills to rendezvous with another spacecraft. And yet we pulled it off; we—they, the crew pulled it off expertly; did everything, including throwing the switch, and the ground saw the telemetry indicating that still nothing was happening, even though we knew, and we had close-up pictures, both sixteen-millimeter and still pictures, showed that the switch on the side of the satellite was thrown more than once by contacting with the tools.

So through that activity, we took away one of the possibilities that the ground had for the failure. They knew it wasn't just the throw of the switch, that apparently either the switch or electronics inside had failed, just failed, period. So there was nothing else that we could obviously do then on that flight, but that information allowed the ground to then say, "Well, since it's not that, then what it's going to take is a change of electronics, for sure."

So it enabled them to plan on a future flight, and in fact, two flights later the crew went up and did, in fact, change out the electronics on it and put the satellite back into operation. So two Shuttle flights; unfortunately, the failure of the satellite to activate the first time, but two Shuttle flights—well, really one additional Shuttle flight—to repair it, and saved a multimillion-dollar satellite and capability for the U.S. Navy through the interaction of Shuttle crews and astronauts with the spacecraft to fix the failure.

So we felt a little dismayed that the satellite failed on our watch and that we weren't able to fix it on the same flight, but we felt gratified that we took one big step to finding out what the problem was, that eventually did lead to its successful deployment. But the guys just had a tremendous personal experience, and, of course, I believe that that experience led Jeff Hoffman to expand his opportunities to contribute to the program because he had that EVA experience. He performed very well at it and became very knowledgeable at EVA activities, and, of course, he went on to a couple more EVAs later on in the program that really benefited the program tremendously.

JOHNSON: And duct tape works in the vacuum of space as well as it does here?

WALKER: Oh, yes. Yes, it does. It sticks. I don't know what it looked like when they brought it back. In other words, of course, the arm came back, the tools came back, in the cargo bay of the Shuttle. In fact, I think Rhea has got a piece of the lacrosse stick at home. Lucky lady. But I don't know what the duct tape looked like. I would guess that out there in the 250-degree sunlight in the vacuum of space that—you know what tape is like on the ground here when you have taped up something, and you let it sit for a long period of time, and you try to take the tape

off later. The fabric may come off, but a lot of the goo stays on whatever it is. I imagine the arm was probably a little gooey at the end of that.

JOHNSON: You mentioned the last time, you described your space flight as magical. Was it the same experience for you this time, and did you get to do any of the photography or have any experience with that on this flight?

WALKER: It was just as magical. In fact, I would have to say that it was different, again, in that since I had experienced it before through another previous flight, that this time I was aware of different things. Again, any of us that have kind of intense experiences more than once and with time in between, I think would agree that the second time around you're not focusing on the same things. You're now maybe a little less anticipatory of everything. You know some things are—how they're going to be, so you can kind of sift those and put those aside in your mind and pay attention to other aspects. There were other things that I paid attention to, like I maybe was more observant of the Earth when I had a chance to look out the windows, more sensitive to the view.

Another part of it, which is different on every flight, has to be different on every flight, is just the interactive human experience of space flight, merely because no single—there's only been once when the same crew has flown twice, and that was what, one of the Spacelab missions back in early nineties. Was it [STS] 87 and [STS] 94? They experienced a fuel cell failure on orbit; had to come back home after three days, so they didn't get to complete their mission, and they reflew the mission like six or eight months later as a separate mission number. So that was the same crew that flew together twice. That's a unique experience.

But every other space flight has been a different set of people in the space flight environment together, and you just interact with different folks in different ways, different team mentality and set of working relationships. So that human part of every flight has to be a little different, and this crew was certainly different from the Zoo Crew on 41-D.

Talk about nicknames, of course, this crew got the SWAT Team nickname. I still have a ball cap at home, "Bo's SWAT Team."

So the interpersonal—Jeff Hoffman brought along with him—and I didn't know it was going to happen; I don't know if anybody else knew that he had it with him, But he brought along in one of his pockets a poem written by his brother. I cannot remember the title of it, and I don't know if he's published it. But one day late in the flight, I think it was the evening before we came home, he had it on the flight deck.

Bo called us all together, and after the meal that night, we kind of just sat with the Earth orbiting or moving by below us, and Jeff read the poem, which was of the nature of reminiscing on really the tendency of people to have lofty thoughts and to think about the greater good, and in this case, to think about those thoughts at a height at which very few people have ever had a chance to look back on the creation that we all know and have grown up in and among, and to consider the possibilities of love and life and freedom. So it was a really nice moment to there be above it all, so to speak, and to hear some good, personal poetry, original poetry, on thinking about those greater things in life.

I also will remark that Jeff Hoffman, being an astronomer, took along with him and got approval to do in flight some astronomical observing. One of those was, if we'll remember back to the spring of 1985, Halley's Comet was approaching the Earth at that time. There was the opportunity to try to spot Halley's Comet as it might be first visible in the sky. So Jeff and I and

the rest of us—I remember I was very interested in doing the same thing—there was one or more nights, again at the end of the day, the crew day, and on the night side of the orbit, in which we turned off all the lights in the cabin and night-adapted our eyes. Everything was dark.

Jeff even had tried to extend that to—he had brought on board a photographer's black bag, like the photographers used to use to change film in. He secured that, again, with duct tape, around one of the overhead windows on the flight deck. He'd get up inside that bag, and it was like, okay, no cabin lights, no instrument lights, totally dark now, let my eyes get night-adapted. And he would use that situation to give himself the best personal visual environment in which to be most sensitive to the stars out the window, and he would try to do some observing and some photography.

I can remember us trying to find the Halley's Comet and never feeling like we succeeded at doing that. But, it was still so far away and so dim that it really probably wasn't possible. But just looking at the sky along with an astronomer there was a great and tremendously interesting experience.

JOHNSON: Because of the weather, you had a delay in landing. How did you spend that extra time?

WALKER: There was time to look out the window, do some more of these observations of the Earth. I remember that we did spend some time—we actually, also because of that, didn't sleep maybe as much on that extra night as we were scheduled to, so the orbital phasing was such that during the crew's daytime, the part of the Earth that was illuminated during those sixteen hours or so, sixteen, eighteen hours, was mostly the Pacific Ocean, the Western Hemisphere, and the

Atlantic [Ocean] and some of Africa and Europe, although we were in a fairly low-inclination orbit, so we would just see the Mediterranean [Sea] and Africa. But my point being that none of India or Southeast Asia or China was really visible to us [in daylight] during much of our waking day.

But if we woke up in the middle of our night, the crew's night, and we were over that part of the world, we'd be orbiting over that part of the world then illuminated by daylight that we didn't get to see during our normal day. So some of us would get up, quietly float out of our sleeping bags and go to the windows and spend a good hour or two, parts of a couple of orbits, looking at part of the world that we didn't get to see by daylight during the planned days, the light side of our mission.

I just never got bored at looking at the ever-changing world below you; ever changing. You're traveling over it at five miles per second, so you're always seeing a new or different part of the world, and even days go by, and you orbit over the same part of the world, the weather would be different, the lighting angles would be different over that part of the world. Just watching the stars come up and set at the edge of the Earth through the atmosphere; watching thunderstorms.

Looking for—I remember with Jeff Hoffman, Jeff and I were—and it may have been at that extra day that Jeff and I happened to be looking out the overhead windows together, just with our fingertips just holding us to the windows and just floating above the windows, looking down at the Earth, and on the night side, and I think that the Moon was half full, maybe, so there was a fair amount of Moon illumination—moonlight—of the dark side, the night side of the Earth.

So we were watching that, just that panorama, in awe, when a streak of light went by over the surface of the Earth beneath us. It was a meteor burning up in the atmosphere. So here's a—quote, unquote—a "shooting star," a meteorite that's burning up in the atmosphere, but it's not like here on Earth where you look up, and you see the meteors, the streaking through the air above you with stars on the other side of the streak. Now you're looking down, and here's the streak between you and the Earth. So it was a remarkable thing to see, and we both made mental note of that and remarked on it, and it obviously still stands out in my mind to this day.

Watching thunderstorms. Again, just the panorama of things is fascinating. Jeff even observed and called to our attention at one point some bioluminescence in the Pacific Ocean, where some algae had been excited by currents, temperature changes, or something, and was literally illuminating. Very low light levels, but it was over hundreds of miles, to the point where you could see it from 150 miles up in space as this dim glow in the Pacific Ocean waters. I can't remember; it was off of Malaysia or Australia where it was happening.

So [we] just spent time looking at remarkable things. I think we probably pulled out the toys again and had some more fun [with toys] in space. I think I even spent a little extra time [working] that day—I kept the electrophoresis machine on and did some more tests and evaluations with those things that we wanted to do to test its capabilities further, so I got a little more time to do that. I think I also remember that maybe the protein crystal growth, we got an extra day, before I [photographed the crystals and] turned that apparatus off, to grow these protein crystals in space.

So an opportunity to do more research, an opportunity to look at the Earth, and just a little more easier-going time without as much in the way of planned activity as was the case

during the plan of the mission, of course. More time to get the feel of the place and to really experience it.

JOHNSON: The reentry and landing, did it compare with your first one, or were there any incidents that you can remember?

WALKER: Well, this time was—this was like only the second landing, I think, at the Cape, *Discovery*'s first landing at the Cape. I can remember that I saw more in the way of daylight out the windows; that daylight illuminated Earth out the window during reentry. I think on this flight, most of the reentry was on the day side, and so I don't think we saw—I don't remember that we on this flight saw the plasma surrounding us, which, to me it was interesting to now compare—to at that time compare a daylight reentry with the nighttime reentry.

Before, on the previous flight, as I remarked, I could see the plasma out the window. I was sitting in the same place, so I had the same view out the same window, of course. But this time, the same point in the reentry, doing Mach 20, Mach 18, it ought to be glowing outside. Well, it was sunlight, and the plasma just is—again, the stripping of the electrons due to the high temperature of the reentry, the light that's created from that is just so dim that in bright daylight, you don't see it. So it was amazing for my mind to compare and contrast. Man, I know that it's fiery outside, so to speak, but can't see it.

I think it was on this flight, too, that I remember the air noise that I didn't notice or didn't remember from the first flight. From 50,000 feet or thereabouts down to landing—actually, 50,000 feet to down about a little less than Mach 1, you can hear the air rushing by the outside of the Shuttle. Of course, it's rubbing against the outside at high speed, the outside of the Shuttle.

That creates mechanical resistance and just vibration and noise, the sound amplified and reflected within the structure of the Shuttle.

So now I noticed the whistling of the wind, so to speak, by, and then I could look out the window and see Florida streaking up, the Florida coast, West Coast, and then the state of Florida below as we do a final bank and turn coming to the Cape and hear the wind noise outside, and I really felt like we were flying. It really felt like flying again and being tugged down into the seat by the deceleration and the force of gravity.

But besides that view, things were again just as they'd been before and as was planned and programmed, so no big surprises until that final, those final few seconds when you expect to be thrown up against your straps by the end of the braking on the runway and the stop. Well, in our case, we're rolling along about ready to stop, and then there's a BANG, and I can remember Rhea looking at me, and Jake saying, "What's that?" Probably somebody else up on the flight deck, "What was that?"

A comment comes from the CapCom [capsule communicator] that they got a report from the landing crew on the runway that it looked like a tire had blown out, and that's exactly what had happened. What we felt on board was, we heard this bang, and, again, it was the structure of the Shuttle, of the landing gear and the Shuttle, carrying the impact of the tire exploding up through the structure and into the spacecraft. But we were probably rolling no more than maybe two, three miles an hour. We were virtually stopped.

But what had happened was one of the tires had locked up on, I think it was, the starboard side, main wing gear, landing gear, had locked up. The tire had skidded, had scuffed off a dozen layers of rubber and insulation and fiber until the tire pressure—and of course the tires were up to several hundred degrees in temperature, taking the resistance of the rolling stop, and that

temperature had increased the pressure inside the tire. Without the tire treads on one side, it blew; it burst.

Thank goodness, Bo had kept it—it ended up just a little bit off the center line of the runway because of that, but we were going very slow, so there was no risk of running off the runway at that speed because of the tire blew. But certainly we heard it on board, and there was a thump, thump, thump, and we stop. [Laughter] We were going like, "Well, what was that?" I don't know; in my own mind, I was thinking, "Did we run over an alligator? What happened here?"

But then it's like get ready to get out, and we heard nothing else about it, so we didn't think anything more about it, probably, until—at least, I didn't—until we got off the vehicle, and one of the ground support crew that came on board to finish prepping us to get off and to bring off the early bags of film and stuff, said, "Well, yeah, you blew a tire. Pieces of fabric all over the runway out there, and oh, by the way, you're not going to get to walk around the ship. They won't let you do that. They're afraid another tire's going to blow."

So, whereas after 41-D, we got to walk around, as just about every crew gets to do if they want to, walk around the Orbiter and take a look at it as it has just brought you back to the good old U.S. of A. We didn't get a chance to do that around *Discovery* then. They were afraid another tire was going to pop. So we got off the bird and into the crew van and back to crew quarters in pretty quick time.

JOHNSON: Well, it's about three-fifteen, so you want to go ahead and stop for today?

WALKER: Yes, it is. I'm afraid I'm going to have to.

JOHNSON: Okay.

[End of interview]