# NASA HEADQUARTERS NACA ORAL HISTORY PROJECT
# ORAL HISTORY TRANSCRIPT

RICHARD E. KUHN
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is May 2, 2008. This oral history is being conducted with Richard Kuhn as part of the NACA [National Advisory Committee for Aeronautics] Oral History Project sponsored by the NASA Headquarters History Office. The interview is being held in Hampton, Virginia, during the NACA Reunion Number 12. Interviewer is Rebecca Wright, assisted by Sandra Johnson. Thanks so much for taking your time away from the reunion events to sit down and visit with us today. I know that you were a part of NACA for 15 years. Tell us how your time with them began. How did you first become [an employee]?

KUHN: When I was in school, I used some NACA reports for various things. I really had no idea of NACA before I went off to school. I was raised in southern Illinois in a farming community. My dad was a carpenter, and I would work for him in the summertime or on one of my uncle's farms with my grandfather. I was born just before [Charles A.] Lindbergh flew the ocean, and so obviously I wanted to be a pilot. Well, the next thing I knew, I had to wear glasses, so I couldn't be a pilot, so I was going to be a mechanic so I could be around airplanes.

When I started looking for where to go after high school, while I was in high school, when I was thinking ahead, I found this place that offered a degree in aeronautical engineering as well as a mechanic's license, as well as 20 hours of flying time. So I talked my dad into letting me go to Parks Air College [now Parks College of Engineering, Aviation and Technology].

Now it's part of St. Louis University [St. Louis, Missouri], but while I was there, it wasn't a fully credited four-year school.

When I got into aircraft design class, I found out there were these NACA reports that had things about the characteristics of air foils, and as the flow went over it at a certain angle of attack, you got so much lift coefficient, CL, so much drag, so much pitching momentum. So you [work with] these, and you figure out what your airplane size is, [etc]. Anyway, I was using some of these NACA reports which got me kind of interested. Where is NACA, what is NACA? I found out there was [an NACA laboratory at] a place called Langley Field, Virginia, and so when I was nearing graduation, I sent them an application for employment.

By this time, the war [World War II] had started in Europe, and the Japanese had bombed us in Hawaii. So I was going to school on the deferment, but NACA wrote back and said they would hire me, so I came out to NACA and started in the equipment design group. But I, pretty soon (it was a matter of a few months) was tired of that. That wasn't what I wanted. I wanted to get into the wind tunnels and the aerodynamics, and so I asked for a transfer and lo and behold, I got one.

I got a call one day from a guy by the name of Aubrey Harris. I went over to his office and interviewed with him, and I guess he liked what I said. Anyway, I was transferred over there and started working on the low speed air characteristics of airplanes. The lateral directional problems, swept wings was the problem at the time. This was before there were any swept wing airplanes flying, but if you sweep a wing, the characteristics when you yaw it—if you're flying forward and you point the nose off to one side, that's called yawing—all of a sudden when you do that, the aerodynamic coefficients change, so you've got to calculate and figure out what does that do, how much rolling movement do you get, and what does it take in a rudder angle to do that, and all these kind of things. The whole swept wing thing was new, and so I was put to work on trying to help sort out some of those things.

I don't know how long it was, but somewhere along the line, I guess I got a reputation for having ingenuity. The Assistant Division Chief, Charles [H.] Zimmerman came down to see me and said that they were thinking of some VTOL [vertical take off and landing] airplanes. This is going to be a propeller-driven airplane where the whole wing would tilt to the vertical so that the flow from the propeller wasn't impacting on the wing, so it could go rise straight up. They'd use the controls on the wing to yaw the airplane and use differential blade angles on the propellers for roll.

But they wanted to do some wind tunnel tests with this. I was in what's called the west area of Langley, and there were some guys over in the east area, which was the Air Force part of the base. The early facilities were built in the Air Force part, and then after they got going the NACA had bought property on the west side of Langley and established a facility over there. I wish you had been with us this afternoon, today on the trip, because that's where we just went, and you could have seen my wind tunnels.

WRIGHT: That would have been nice.

KUHN: So we got into the 7x10 tunnels which were being built. I helped with some of the design work on some of the equipment that was going to be used. I started thinking about how to do some of this testing, so we could set up a model so we that we could test, tilt the wing, and measure the forces on it under various heights from the ground, and roll, and yaw angles, and various things. So that's how I got into this whole thing was with doing that kind of work.

WRIGHT: There were, of course, wind tunnels at Langley when you arrived. What type of changes did you start to develop that changed what was here? Like you mentioned, they had different requirements.

KUHN: The early work here was just in the facilities that we had, but one of the first things—let me throw another thought in here—in addition to tilting the wing, the Assistant Division Chief Charlie Zimmerman [asked], "Why can't we put flaps on the wing, bigger flaps than we normally have, so that we can deflect the slip stream instead of having to tilt the whole wing?" But this was going to be in hover, so we don't need the wind tunnel. So I just designed a little platform to do that on and to mount the model on a—do you know what a strain gauge is?—a strain gauge balance system, so that we could test the model at various heights and various attitudes and measure what the characteristics were and see how things would work.

Then we wanted to [test] at forward speeds, and unfortunately, when you turn the slip stream that far, [and] you put that in a normal wind tunnel, you're going to change the flow around the model quite a bit. A normal size model in a normal size wind tunnel, isn’t going to work at those conditions. So I figured out that we could go up into the upstream part of the wind tunnel. The wind tunnel, it's got a big end, and this one we were using was 30 x 33 feet. That was brought down to a 7 x 10 foot test section, and there was enough length up there that I could put a liner in, and we put what we called the 17-foot test section upstream of the 7 x 10 test section. We did some model work of the tunnel first and then built it, and so we started testing models in that facility. Well, actually we did tilt wing and deflected slip stream on different models.

WRIGHT: You mentioned about the war was underway when you joined. How did the need to develop aircraft, or the requirements for aircraft, directly affect what you were doing?

KUHN: Well, not really very much at the time. NACA was looking ahead, and as I say, Charlie Zimmerman had gone to industry [before the war] and worked on a two-propeller plane. The wing looked like a big, huge pancake or discus, and there were toward the side two shafts going forward [to] two propellers, counter-rotating. This was going to operate at extremely high angles of attack and so forth. That's what got him interested in this and how he get started, and then he came up to me when he began to realize that turbine engines were going to get the engine weight down low enough that maybe VTOL would make some sense.

Now, none of this was directly war-related. This was looking ahead at what things were expected to develop into. So we still had deferment, but we weren't working for any particular part of services. I don't recall the sequence of developments. There was a part of the military called DARPA, Defense Advanced Research Projects Agency. They were interested in some of these kind of things, and somewhere along the line, we got talking to each other. I don't know whether they called us or we called them. The idea at this point was to build propeller-driven airplanes that could take off and land vertically.

The helicopters were of course in use, and these people could see the advantage of being able to land vertically in a small place, not having to have runways wherever you land. So this was to try to get something that would have a higher speed and longer range than a helicopter. A helicopter at high speed is limited by the forward going blades going supersonic. Sometimes you hear a helicopter coming over and you hear a flap, flap, flap, flap, flap. Well, that's the forward [going] blades going supersonic, and you're hearing the shock waves coming off of those supersonic blades. So the idea was to try to develop some kind of an aircraft that didn't get limited in speed and range like the helicopter was. The first ideas were—and [these were] Charlie Zimmerman’s at the time—propeller-driven, tilt wing [and] deflected slip stream [concepts].

At the time, at Langley, there were—in our division—a free flight tunnel and the full-scale 30 x 60 foot tunnel. The free flight tunnel, well, that was an interesting facility. The tunnel was just an entrance, a test section, a short diffuser, and a propeller at the end [of the diffuser], all as one unit. That was mounted inside an octagonal building, on bearings, so that the whole tunnel could change its angle of attack. They would build a model of an airplane—there were some peculiar ideas that came up at various times—so they could build a model of it and attempt to fly it in that facility as a free flying model. So the first thing here on the VTOL business was, well, let's build one and put it in there and try to fly it.

Mac [Marion O.] McKinney [Jr.] was asked to build a model of a tilt-wing airplane and try to fly it, but they don't get any force data on that, so that's what Charlie Zimmerman came over and—it didn't have to be in a wind tunnel, it was just in a room. Multiply the dimensions of this hotel room by two, that's about as big as the facility was. This was a model that had propellers about, what were they, nine inches in diameter, four of them across the span. So the whole model's about this big in that big of a room. So the recirculation was not that big a problem. So that's how we started with the VTOL.

Because most of my career was related to jets rather than propellers. We built the model and did the testing, and they did the flying work, and we found it could be done. In fact, the Air Force paid for a research airplane, manpowered, of a tilt wing. It just had two propellers, but they could tilt the wing. They built it and flew it, and we had it here at Langley. So it was all checked out, but it just never went anywhere. But somewhere along in here, and I don't remember the exact dates and so forth, but I got interested in jet VTOL.

If you look at my list of reports, there'll be a lot of reports on stability and control and stuff that I did before we got into this. You can get the dates from some of those reports, they'll be some things said about tilt wing or—let's see, what have we've got here? [Refers to reports] Well, this is some of the stability work. I should have looked at this earlier. Oh, here's one in '59. So it's somewhere by the middle of the '50s, we were dreaming about VTOL, and we, the country, had developed turbine-driven engines.

They were much lighter than the old reciprocating engines like the automobiles—well, not the automobiles because they're water-cooled, we had air-cooled engines. But still, they were a lot heavier, and when you start getting into jet engines, and you put another turbine behind a jet engine to drive the shaft to turn a propeller, you've got a much lighter piece of equipment than you have with an old, reciprocating engine type. That's why this whole VTOL thing started getting interesting. So those of us in the research [end of] things were thinking, well, what could be done? That's how we got started.

WRIGHT: Was your work, and your goals, impacted by the fact that NACA transitioned into NASA in 1958?

KUHN: We had started this before NASA, before any of the space stuff came along. We were already thinking in terms of these lighter engines and the possibility of taking off and landing them vertically. NASA did not have any big affect on what I'm talking about here. This was all aimed at flying in the atmosphere and around the world—I don't mean nonstop around the world. Some place in the world, not around the world.

WRIGHT: Well, that's good. The transition didn't affect what you were doing? You were just able to keep on doing your work?

KUHN: That's right, that's right. I hardly noticed that it was different. Well, I really didn't notice that things were that much different until I got further up in the organization and eventually became the Branch Head and then Division Chief, and realized the politics was a lot different. But that's way ahead of us.

WRIGHT: Well then, tell us the next big project. You said you were starting to get more interested in jets.

KUHN: So then the next thing was thinking about jet VTOL, and there you have the problem of the jet impacting on the ground. If it impacts on ground, you take a conventional jet and just point it at the ground, there's going to be dirt flying everywhere, so you have to have some kind of a prepared surface. I did some work on just exactly that problem: taking a jet out and measuring the impact pressures and the flow going out, and understanding the flow field around and how thick it was.

Then, if you have a conventional airplane—let me borrow this book a moment because it's all in here—but if you had a conventional airplane with a jet coming out of it to support it [at altitude], well, that's all right. But now you bring that over the ground, that jet impinges on the ground and flows out in all directions, that jet on the ground flowing out is pulling air into it. So all of a sudden, the airplane wants to sink, you have to add more power, more thrust, when you're hovering close to the ground.

In fact, that's what this book is all about. *The Aerodynamics of Jet and Fan-Powered VTOL Aircraft in Hover and Transition* [by Richard E. Kuhn, Richard J. Margason, and Peter Curtis]. That became the area of my career from that point on, basically. I was trying to figure out how much extra thrust do you have to build into the airplane, depending on whether you are horizontal attitude or vertical attitude, and what you can do about these [problems]. We again, in that same big room, [tested various] configurations.

For various sized plates and various jet arrangements, if you've just got one jet, you'll get a suck down. But if you get two jets impinging, the flow on the ground comes together and projects up and you get a lift out of it. So if you put these things together right, you can cancel out most of that suck down. So that took quite a bit of playing around with different sizes and jet arrangements.

WRIGHT: Can you share with us the processes or how did you develop—learning one thing and then having another one effect that?

KUHN: We were always thinking about, "Okay, how would we build an airplane like this?" Then we'd set it up and make some measurements like I'm talking about, and so you'd move the jets in various positions. And we're not doing this with an airplane configuration, this is just maybe a couple jets or three jets in various positions. Measuring the flow out and measuring the suck down on various sized plates. This was developing a systematic database, and we'd go through a series of sizes related to each other so you can plot things up against the size of the plate or the height, or various conditions like that.

Trying to get a database that's got enough breadth to it so you can develop methods to predict. If you draw up an airplane like this, [we] can go through and figure out how much thrust you're going to [need], or how much control, or is it something impossible? So to develop a database so you can go into a book like this and find the—well, here is the suck down, right here [referring to book]. This is the lift loss, as a function of height over the [jet diameter, here's the effect of] the ratio of the jet diameter to the plate diameter and the height, and this is where we were just looking at the edges of the plate, what the effects would be. But here we're losing 8 percent of the lift. This was a particular Lockheed configuration that they were playing with. And yeah, and we were talking with the industry.

WRIGHT: That was going to be my next question. What propelled you to move one way or another? Was it the industry or the manufacturers asking you for things, or were you giving them information?

KUHN: It works both ways, in general. Most of this work, and Mac McKinney and a couple others, were doing it on our own. I mean, we were looking at what was going on and going through these configuration bases to develop a database that could be used for estimating these things. But at the same time we were doing that the Air Force gave a contract to Bell Aircraft to build [the] little X-14. It had two jet engines and louvers to deflect the flow down. It was a straight wing, looked a little bit like a low-wing light plane. A cockpit for one person, a straight wing of aspect ratio like you see flying all the time, with a conventional body and tails. With the louvers to turn the flow down, and then to deflect it aft so it can fly off. They found, when they started to fly it, that yeah, it would suck down. They were not surprised by it, but they didn't know what the magnitude was going to be. That one came real early in the whole thing, before we got very [far] into this kind of work. They came down short of what we had gotten, and it checked out against what they were doing pretty well.

WRIGHT: Well, as you were doing all of these areas of research, you were also getting more responsibilities. It wasn't too long before you became a supervisor and started directing a research team.

KUHN: Yes. Well, it was, I'd have to look at my—

WRIGHT: I think somewhere here, the one you had sent last time was somewhere around in '62. Is that about right?

KUHN: Yes. Here's some of the other things that were going on at the same time. Jet flap concepts, ground effect machines. So yes, by that point, I had, as it says here, ten professionals. So they were—well, I guess by that time we had a lot of people working on it. Ten professionals. I’m trying to remember.

WRIGHT: You mentioned the Air Force, but you also had mentioned that you worked as a consultant for some work that you were doing for NATO [North Atlantic Treaty Organization]. I found that was interesting, especially during that time period, the early 60s.

KUHN: Yes, in fact I got over to Paris [France] a number of times, I don't think it mentions that there. But yeah, those NATO exercises, well, the British had built the—are you familiar with the Harrier airplane that the Marines fly? The British developed that for their military services. The Navy, I think it was the Navy. But they had developed that and flown it, and we'd built—I wasn't involved, but this other branch had built a model of it and flown it, but that was before the '62 date you're talking about. They had done that early.

The NATO exercises were exercises looking at advanced aircraft. If you've got enough power, enough thrust, to lift you vertical, you should have enough thrust to go supersonic, and the Harrier was far from a supersonic airplane if you remember. I had to go to France. The British, the French, the U.S., Swedes, Norsemen, Italians. A lot of the Europeans, obviously except for the Germans at the time—well, no, I guess by the time we were doing this, the war as over before I ever got over to Europe. Later on, we did get the Germans in as well.

But the idea was anybody that was thinking about any of these advanced airplane concepts that would do something, there was some work going on, and we tried to get intercommunication so we knew what others were doing. We were quite close to the British. They had done the suck down that I was just starting to talk about early on. We went on into other, lateral directional characteristics, and the noise; acoustic environment. If you put it that close to the ground, you get acoustic waves reflected from the ground, so all of these things have to interact with each other.

So I guess I was back and forth to Paris a half a dozen or more times when we would get together to talk about these problems, share experiences. I'm not sure what came out of it as far as, you know, there was no big breakthrough that said, "Look, there's an airplane." But we got to know the French and the British.

WRIGHT: An exchange of ideas.

KUHN: It's an exchange of ideas, exactly right. Yes.

WRIGHT: Well, it's still in the mid 60s, you conceived and justified and guided the development of that 14 x 22 foot wind tunnel.

KUHN: Well, that was the next thing. I mentioned the 17-foot test section, that's the first thing we were using. But it pretty soon became clear that we needed something better than that. By that time, we'd learned enough about the sizes and so forth. Did you see the 14 x 22 when you were out there?

WRIGHT: Yes, we did.

KUHN: They're doing something to it right now, they've got the whole big front end encased in canvas of some sort. I don't know what's going on. Maybe they're just painting it. They wouldn't have to put canvas over it to paint it. Anyway, that's all beside the point. But, we decided we needed a bigger tunnel, and so we developed a 14 x 22 V/STOL [vertical short take off and landing] tunnel. In fact, somebody today on the trip called it the V/STOL tunnel. Just as we drove by it, he said there's the V/STOL tunnel.

WRIGHT: That's quite an undertaking, from the very beginning to the actual development. How long did that take?

KUHN: To build that tunnel? I'd just say it took several years. I don't know, I can't give you a number right now, I'd have to go back.

WRIGHT: But that was your project?

KUHN: Yes, well I came up with it and decided we ought to have it, went down to the Division Chief, and he agreed immediately. We made a presentation to the Director, and he saw what we had, and he had a sketch of where we would build it. He said, "Yes, you need that tunnel. But I don't want to see it where it is. I want to see a drawing showing interference between one of the tunnels you've got and this new one." He didn't want to get stuck with still another wind tunnel, which was perfectly sensible. So I went home that night thinking, "Did I win or did I lose?"

But I came up with the idea that we could put it on the other side of where I'd sketched it, and build it [beside] the low speed 7 x 10. We had a building which was T-shaped, the offices across the front and shops down between on the leg of the T, wind tunnels on each side. The low speed 7 x 10and the high speed 7 x 10, which was the one I cut my eye teeth on calibrating and everything. Put it on the low speed side, and we found there was enough room there that we could build it before we tore down the low speed 7 x 10. Then I drew a model preparation building between the new tunnel and the shop that we had, so that that would show the interference between the old tunnel and the new, but we could keep using the old tunnel until we got the new one built and ready to operate.

WRIGHT: That came in handy, didn't it?

KUHN: So that worked out. So then we built the model preparation building across, in between, after we tore down the old, low speed 7 x 10, and long after we got the new V/STOL tunnel in operation. I thought that was clever.

WRIGHT: It sounds like someone looking at the whole picture.

KUHN: So we got that going that way, and most of the rest of my career, or most of my work was then related to the jet and fan powered aircraft rather than building the propeller [driven type]. That was pretty well over with. We got the propeller-driven type to the shape where somebody could come up with a drawing of a propeller-driven V/STOL airplane, and we could go through and calculate what it would do. So there wasn't anything more for us at Langley to do, we don't go into the details beyond that, but we could see exactly how it could be done. But most of the effort from then on was on jet and fan-powered VTOL aircraft that would have the speed and range, fighter capabilities if you needed it, that kind of thing.

WRIGHT: Tell us how that impacted your job. You did more research and projects to our studies to follow up on those requirements?

KUHN: Now we're well into NASA, but we always operated pretty much in the old NACA mode. We would see a need, a problem, see the desirability of something but here's a problem in getting there, and then we would go to work on that. We were always talking with DARPA, with the Defense Advanced Research Projects Agency, and organizations like that related to the military—not always talking to them, but they'd come by and we'd get together with them occasionally at meetings.

WRIGHT: One of the things you mentioned to us was this QUESTOL [Quiet, Experimental, Short Take off and Landing] project for the Source Evaluation Board, and even though the program was abandoned, that work led to the Air Force connecting some new airplanes.

KUHN: Oh, yes, the YC-14 and 15, those were jet flap airplanes, which is another way of getting low speed flight. You don't get the VTOL. Do you know what a jet flap is? Are you familiar with that?

WRIGHT: Vaguely.

KUHN: You've got a wing, you put a flap on it. Normally, there's a little gap between the leading edge of the flap and the wing surface, so the flow comes over, comes through it. The other option is to just have a hinge there with a blowing slot that you take compressor bleed air off of the engine and blow out of that slot. Well, first of all, if you only deflect the flap 10, 15 degrees, it usually can work pretty good. You don't have to do much. But if you want to get more lift out of the flap, you have to keep the flow [over] the flap from separating. So if you put a slot there, you get the natural blowing. Or you build in a slot, and blow high pressure air from the engine [over the flap], you can go at a much higher lift. And that's what these YC-14s and 15s, were variations on those kind of things. I got a Special Achievement Award for this work. Well, unfortunately, that's where it ended again. I mean, most of what I've done didn't go anywhere. There were bits and pieces of it that have shown up, like blowing flap and that sort of thing.

WRIGHT: But I guess that's part of the research work that you did, it's proving that some things don't work, right?

KUHN: I think what the Air Force decided was that it took too much out of the airplane to do that for the short take off and landing you got, or for the VTOL. So they didn't go ahead with developing the [blown flap] airplanes. So that's the tradeoff. You’re looking to try to get better performance in take off and landing or something, but if it costs too much in another area, [it’s usually dropped. If it’s developed, it’s usually done by the military] or whoever's going to buy the airplane, or the airlines—except we're not dealing with airlines in this category. These would all have to be military before they would go to the airlines. But if the military developed any of these airplanes, then the technology could be built into commercial airplanes if they had a need for it.

WRIGHT: What's the most significant change in technology that impacted you along the way? Or maybe you could just share some of the different types of technology that impacted your work?

KUHN: Well, the development of the jet engine was what started this whole thing rolling. And being able to bleed air off of the engine for flow control and so forth. That says, well now, there's possibilities of doing things that we weren't doing before. Like the old DC-3. You know what the DC-3 is? I'm getting old enough I find I got to ask people if they know what a DC-3 is.

WRIGHT: That's okay, we understand that.

KUHN: But the whole idea is to try to figure out how you can build airplanes that will do something better than what we're now doing. Advance the thing.

WRIGHT: Did you find new technology along the way that helped you do your job better? Anything in particular?

KUHN: Help me do my job better?

WRIGHT: For instance, the introduction of computers and being able to keep different types of databases.

KUHN: Well, that I never really got into that. Now, the coauthor of that book here, Richard Margason, showed up—I forget what school he came out of. I guess he was here on one of our exchanges. Students sometimes get in on an exchange. Anyway, I met him, and he was the computer guy. But I never touched a computer until I got out of Langley. Now, where we were getting all of these data—did I show you this? I showed you the picture of these, I think.

WRIGHT: Yes.

KUHN: Picture of these guys. They're getting their data, they're writing it down on these pads. We would have these data sheets that they'd get taking data off, and we'd take them into the computer room, which was filled with eight or ten young ladies, most of them were math majors. They sat there with Friden calculators. And they'd turn the crank or punch the buttons. In the early days, they turned the crank to go through and reduce the data, multiply this column by that column, and add that and this and that sort of thing. (Refer to photos 1 and 2)

When we built the V/STOL tunnel, the 14 x 22, we put computers in there to take the data, print it, and so forth. There was a division that handled the calculation, that did the computing, except from these girls. We were getting big, mainframe computers at Langley, so when we went to build the V/STOL tunnel, I went over to the guy that ran that shop and said, "We're going to want to get this into the computer age, put computers in here, and what should we do?" Anyway, they took care of that part of the thing. That's as far as I had to go on that.

WRIGHT: That was good.

KUHN: I literally didn't touch the keyboard of a computer until I retired. Then I eventually bought a—both of my sons, had gotten into that stuff before I did—I got a PC computer. It's got something wrong on it right now. When I get home, I have to go to work on it.

I didn't interact with computers myself. But I did get Margason and of course the girls in the computer office, and the big computer division, that all worked together. When we built the

V/STOL tunnel, all that data could be taken over on the tape to the computer division. I don't remember where we got to the point where everything was done in house, even. But I think that was about the time I left. I didn't, myself personally, work with it much.

WRIGHT: Definitely a difference, wasn't it?

KUHN: Oh man, yes!

WRIGHT: I guess data, sometimes, was quicker? Was it quicker before or after the electronic computers, compared to the Friden computers?

KUHN: Well, compared to taking it to the girls to do it, it was much quicker. Once they got the thing integrated, you could come out with the data plotted. I don't know how they're doing all this now. I can visualize, and I'm talking about years ago, that you could plot—well, you could plot the data, but you wouldn't necessarily have the plots you would want to put into a report. You'd have to wait until you got through the mishmash of what you'd understood to do that.

But then again, you could go and say, "Here, I want this plotted this way," and get it off the computer. But that was much later. Most of these later things were still in the mode of we're doing experimental work and we're not setting it up. To what extent the data was plotted on the computer, and to what—a lot of times I would want to plot it by hand. I learned more plotting data than I did any other way. You see how it goes, and that's where you can learn a lot.

WRIGHT: You were so instrumental in the V/STOL tunnel, and then you were moving up more changing from Assistant Chief to Chief to these divisions. Did more tunnels come up in operations while you were in charge of those divisions?

KUHN: No. There was not much in the way of new tunnels. We were using the facilities that we had.

WRIGHT: But there were just so many of them. There were quite a few out there.

KUHN: I wasn't in charge of all of them. We had the V/STOL tunnel and the 7 x 10s, and I've forgotten what we did have. We had the full scale tunnel and the spin tunnel.

WRIGHT: One of the things that you did put that I found was somewhat interesting was that so much of the work had been done with airplanes, but at some point, you started working in support of air cushion vehicles and high speed trains. Can you talk a little bit about that? That had to be a little different from what you were doing on the norm.

KUHN: Oh yes. The air cushion vehicle, first of all, it was the air cushion. Just take a disk and put a slot all the way around the edge, and blow air straight down. That'll put pressure under the disk and lift it up. You [blow air downward] around the edge, the air flows outwards. Well, it wants to flow inward but it can't go anywhere, and it builds up the pressure under there and so you can get an air cushion landing gear, or vehicle. But there were ideas—you could put several of those together in a train. Or you can build a track just for that purpose, and I don't know that anybody's ever done that, but that was some of what we were doing, what we were thinking about. But the idea was to use those to replace wheels. You get zero friction.

WRIGHT: Well, before you left NASA Langley, you were over the subsonic and transonic aerodynamics division, and then became Special Assistant to the Director.

KUHN: I'll come back to the Special Assistant to the Director. The subsonic, that was pulling together some of the facilities. The spin tunnels that were in the east area. There were a lot of facilities that I didn't have any direct use or involvement in during my career, like the spin tunnel and the full scale tunnel. The free flight tunnel, I mentioned that a while ago, where the whole tunnel could be tilted. What else did we have? I'm trying to remember, the V/STOL tunnel, the 7 x 10s.

WRIGHT: Let me offer that, because you wrote all those down for me earlier.

KUHN: Oh, I've got them here, have I?

WRIGHT: Yes.

KUHN: Oh, sure, the eight-foot transonic tunnel, high speed 7 x 10, pressure tunnel. [The one-thirtieth (1/30)]-meter, a cryogenic tunnel which was the tunnel prior to the big cryo tunnel that's out there on the transonic. At this point, I'm much more NASA oriented than NACA oriented. I'm not involved with the details. Now that's my simple way of looking at the difference between the two. There was still somebody that got to worry about details in the case of NASA, and somebody else has got to worry about the overall in the case of NACA. But that's the way I think about the two. In other words, that was just amalgamation. Somebody decided that we had to have somebody to take those over, and I was the guy that got tapped.

Then, as Special Assistant to the Director for Aeronautics, that was one year up at David Taylor Model Basin [West Bethesda, Maryland], and I knew Harvey Chaplin up there, I'd communicated with him, and they were doing some V/STOL related work. I decided I wanted to get out of the NASA work. I did consulting afterwards. Harvey Chaplin and the guys at David Taylor were doing some V/STOL work, and I wanted to go up there. You know, I can't remember what tipped what on that. In the books, they asked for me. I was about ready to leave and they asked for me, so I spent a year up there.

WRIGHT: That's good timing.

KUHN: I just spent a year up there with them on what they were trying to do, helping them as much as I could.

WRIGHT: Why did you decide it was about time for you to leave?

KUHN: I was getting into too much red tape type of stuff. Too much administrative. I just wanted to get into the details. I wanted to plot data. You don't plot data as a Division Chief. Things weren't going to go anymore in the direction than what we had done, and they were going to die off. It's just the way it is, if industry doesn't pick up on things—you don't keep working on it just because you want to. That's what it amounted to. So most of the stuff I had gotten interested in had pretty well been done or was in good hands, and so I decided to quit.

WRIGHT: More things to go do.

KUHN: Yes.

WRIGHT: I want to ask you about your consulting work, but before we do that, give us your thoughts about what you feel the greatest contribution, or what you worked on that brought you the greatest satisfaction when you working for NACA and for NASA?

KUHN: I guess this really sums it right there. I put it in the book.

WRIGHT: The jet-induced effects.

KUHN: I enjoyed putting that book together and getting the help from those other guys. Peter Curtis is an Englishman, and Rich Margason had been working with us at Langley, and I started this, got a hold of Rich, and we had a lot of fun putting it together. We got into the hot gas ingestion part of things, which I haven't even talked about. We did some hot gas ingestion work at Langley, but I got Peter Curtis involved to help flesh out that area.

WRIGHT: Sounds pretty comprehensive. Tell us about consulting. How did you enjoy the transition to your own boss?

KUHN: Well, I enjoyed talking with people and a number of those reports toward the later thing were reports that I wrote in what I call consulting here.

WRIGHT: You had quite a diverse group of folks. From everywhere from DoD [Department of Defense] and Naval to, I noticed, the Chrysler Corporation.

KUHN: Yes. I noticed that one the other day reviewing all this stuff, and I can't remember how that came about. Oh, I know what it was. I had done the V/STOL tunnel, and somebody—whether Chrysler went to somebody at [NASA] Headquarters [Washington, D.C.] or at Langley for some help, I guess it was something like that, and whoever they got a hold of recognized the V/STOL tunnel I'd built was the same size, and sent them over to me. It's just that simple.

WRIGHT: Just that simple.

KUHN: That kind of thing.

WRIGHT: Was it different consulting with the military than it was working with corporations?

KUHN: I don't think there was that much difference. It was a question of, this is our idea and what problem are we going to run into and how do we do it. It's the kind of thing I was dealing with, there wasn't that much difference. There was a difference for proprietary and classification, of course. Those kind of differences, you have to be careful of.

WRIGHT: You did consulting work for about 20 years. Are you still doing it now?

KUHN: Now, I've been out of it for quite a few years. There's just not that much going on, and they've got their own people. I'm happy. I'm quite happy.

WRIGHT: I guess when you get on airplanes, you must look at them a little differently than the rest of us.

KUHN: Well, I check to see if the flaps are down on both sides—no! (laughter)

WRIGHT: Maybe you can draw us a picture before we leave so we know how to check it out.

KUHN: I know what's going on out there. It's well done, so no problems. It doesn't bother me.

WRIGHT: Do you see a lot of changes in aircraft coming in the next years, based on what you know?

KUHN: Well, it's really a question whether—not in my lifetime. I'm already 84, so I'm not going to be around that much longer.

WRIGHT: It'll take a while to develop?

KUHN: The military has the XF-35, which by the way, one version of that is going to be a VTOL.

WRIGHT: You'll see your work.

KUHN: We were out just now at Langley Air Force Base, looking at the F-22 and the F-15s sitting there, and the F-35 is being built for the Air Force and the Navy, the Royal Air Force, for a number of military services. And the VTOL version is to serve the Army needs. So that'll be the next one.

WRIGHT: I find it interesting, work that you've been doing all these years is still being used to day in developing.

KUHN: Yes. Well, it's taken a long time for a lot of this stuff I've been working on to get anywhere. It'd really be interesting to see how the F-35 does. But the British want, definitely want it.

WRIGHT: We're getting close to an hour, and I promised you before we started that we'd stop and kind of regroup and see what else you'd like to talk about. Is there anything else that you'd like to talk about?

KUHN: I guess we pretty well covered it.

WRIGHT: Let's just stop for a second, and I'll let you take a look at your papers that you brought.

[Pause]

KUHN: This second to last one here is something I was asked to do for a conference in England. Just a, "Where are we? Where are we going?" But there's not much being done anymore in these areas.

WRIGHT: So did the Royal Aeronautical Society in London contact you about doing the paper?

KUHN: Well, not the Society directly.

WRIGHT: But you presented it to that conference?

KUHN: Yes, I went over there to present it. But we've been through this stuff. That's where things stand, and now the people that operate these machines have got to be deciding what they want. If you want a jet-driven VTOL airplane, they can be built. Lockheed, you just go in and knock on Lockheed's door.

WRIGHT: They can do it?

KUHN: Well, in fact, they're building one. The F-35. (laughter)

WRIGHT: What was the most challenging aspect during all this development that you encountered?

KUHN: I guess I don't think about the challenging aspect. I think about the interesting things to work on.

WRIGHT: That kept you going, didn't it?

KUHN: Yes.

WRIGHT: Did you ever run across a time where someone told you that they may not want you to continue doing your research on this area?

KUHN: No. The supervisors that I had were all in favor of it. NASA and NACA was a highly technically-oriented organization. What are the problems and how do we attack them was the thing. NASA has got a lot broader base and broader area, and they don't, they don't have to get into that a lot with their stuff.

WRIGHT: Well, we certainly appreciate you sharing the details with us today.

KUHN: I hope I've covered what you need.

WRIGHT: I think you did. So thank you.

[End of interview]

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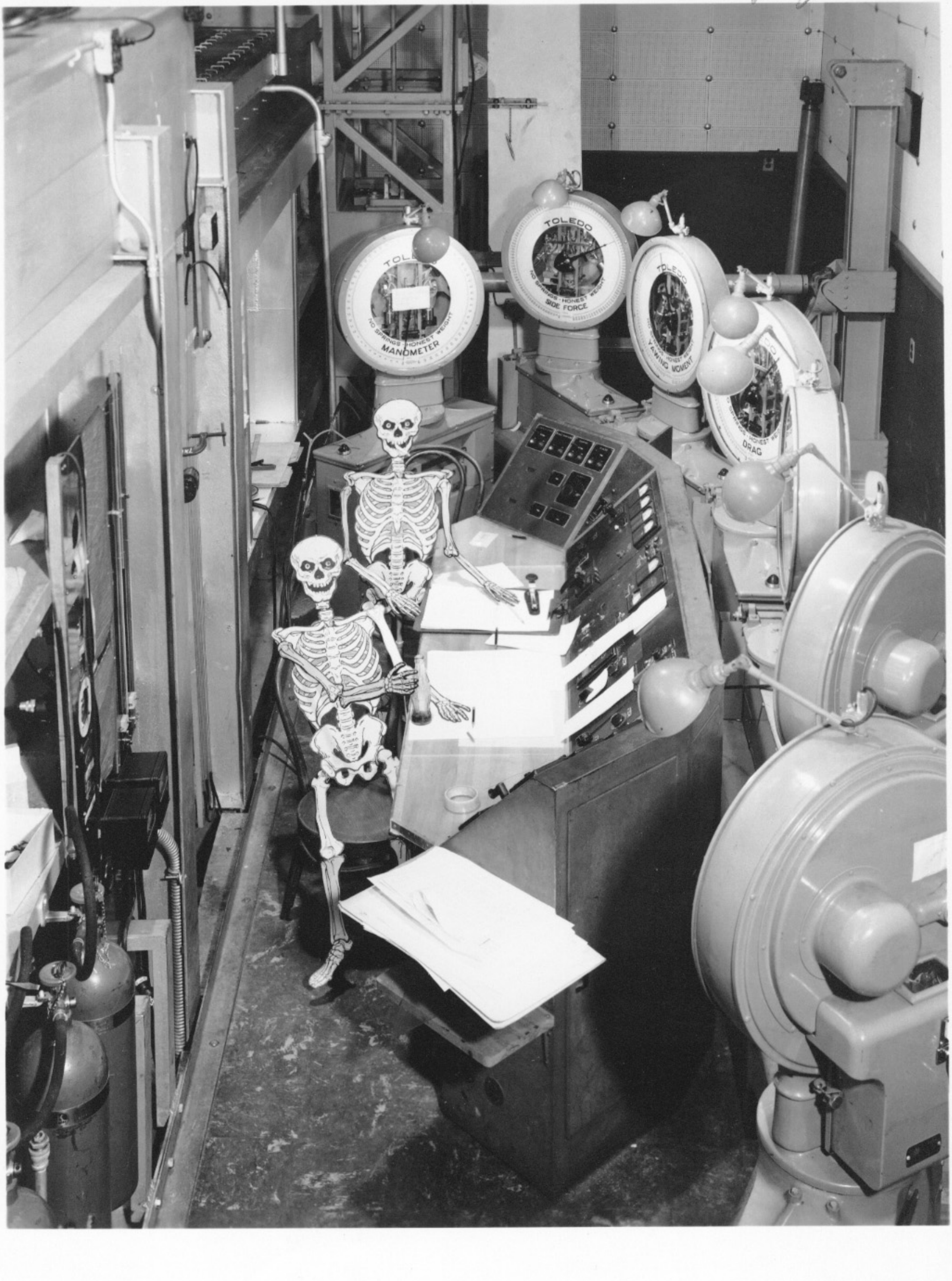


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