NASA GLENN HISTORY OFFICE
ORAL HISTORY TRANSCRIPT

GEORGE REPAS
Interview by Virginia Dawson
January 23, 2003

GR: George Repas
GD: Ginnie Dawson

My name is George Repas. I [first came to Lewis Laboratory] in May of 1963. I was hired to be an operations engineer at RETF, but it turned out they needed people to build hardware more than operations. So I basically became a hardware designer and builder.

I started working at NASA Lewis Research Center in May of 1963. I was hired to work at the South 40 as an operations engineer because that had been my background, but they needed people to do hardware design and fabrication. So, I sort of got into that. I did some operations work, but the majority of my work was designing and building hardware.

I probably was ten years old when I knew I wanted to get involved in rockets, and I built rockets when I was in high school, and I launched them. I've got the scars, when the propellant blew up one time. The mad rocket kid. And, then, of course, I went on to college and got my college degree. And then, of course, I wanted to get in rockets into the worst way, and I went directly to the New Mexico White Sands Missile Range, where they let me fire a whole bunch of rockets. And then they had a big rocket called the Pershing. And it was too big to fire out there, so then I moved to Florida, and I worked there and launched the Pershing rocket out over the Atlantic. At that particular time, the program ended, and so I was essentially out of a job, and it seemed like a convenient time to come back to Ohio, where my wife's family was and our family was starting up. I got a job here, and I was happy to have a job at the Lewis Center.

The person that was running the South 40 from the time that it was built until when I came on board, there was about a five year period there. The facility had been built, and they fired some kerosene and liquid oxygen engines to check out the facility. And then they immediately installed the liquid hydrogen tank and were spending a lot of time firing rockets to determine the efficiency, what's the best way to build it, how can it stay together, the reliability. We were learning about liquid hydrogen rockets, and that, of course, was a thing that the Lewis Research Center was famous for, was that we pioneered the use of liquid hydrogen rockets. So there was a five year period in there where they were doing this testing. And then I showed up, and I said, I'm ready to push the button and be a rocket guy, but they had too many operations engineers. And they were short of people building hardware for them, so they asked me to kind of go into that area. And hey, I was happy to do that.

When I first came on board, there was a research person named Tom Godwin, and he was looking more at I think efficiency and a few other things. That program was followed up by what was called the Screech program, which was the combustion instability. And that was a very important program because most of the rockets that they were in the process of designing for the Apollo program had combustion instability problems. And so we began building all kinds of different liquid hydrogen, or hydrogen operated injectors. Some of them with this velocity ratio and some with that. And this one with a baffle and that one with a liner. And it was a very extensive program, a very intense program. We often worked very late hours. An eight hour day was not normal. And we found the answers to a lot of questions. There was one report from a person named Pete Wanhainen, and I believe Al Pavli was a second officer, I'm not sure. But in that particular report, we disclosed some very, very important parameters that you must use if you're going to build a liquid hydrogen engine. It was involved with velocity ratio, temperature of the hydrogen, and all that. That report, I don't think there is a rocket company in the world that doesn't have a copy of that report somewhere. That was the kind of work that we did in those days.

We made our contribution to the Apollo program, and all of a sudden that was terminating, and we started looked at research for the shuttle. Because now we were talking about a reusable rocket engine. Prior to this time, every rocket, you fired it, it went up, and it landed in the ocean or something. And when you have a reusable rocket engine, it fires, and it moves, and it fires, and it moves. And it's sort of if you take a paper clip and start doing that, pretty soon it breaks. So we had to be very careful about how many times can you fire it before it's going to blow up. So that's called low cycle fatigue. And we began to attack that problem in about three different ways. First was this plug engine which is behind me, which was a very simple way of putting a lot of different materials, building them into these little spool pieces, and then firing the engine and shutting it off, and firing it and shutting it off, and giving it a sort of a heat cycle. It was actually pretty simplistic. You just stand there and listen. And after 70 cycles it would start wheezing, and ah, okay, it's got a hole in it, and so you shut it down.

We also built some larger engines, I think kind of like that copper thing there, where we put limited number of cycles, perhaps like 26 or 30 or 40 cycles and then it would get a leak. And then we also worked with materials to try to find out what materials were good. And then we also looked at the cooling passage. Should it be a square package, or high aspect ratio, or whatever. So we did a lot of work which was directly applicable to expendable engines like you would find on the space shuttle. So basically in that particular timeframe, the late 60s, early 70s, that was the kind of work we were into.

I think we also did some work on multi-layer insulation which is what you put on tanks to keep the liquid from boiling off. And there were some other programs going on. And it seemed to me like you always had a lot of things going. The Director of the Center, Bruce Lundin, at the time there had been a reduction in force, a number of people were reduced, and we were looking for work, so we did work for the

Department of Energy, which was a new.... I wound up working on the Chrysler turbine car, which is a little strange from being in rockets, but you do what you got to do.

GD: So you left the South 40 at that time?

GR: I worked at the South 40, but I built hardware for PSL one and two, and the Rocket Lab and other places.

I was like a designer, I would design the part, I would have the drafting people make drawings of it. In those days, we had a very large shop. And a lot of times, you would just go to the shop and give them the prints, and they would build it. Sometimes they would go out with it, but most of the time the parts were built in-house, and I would take them over to whatever facility I was supporting. In the case of the Chrysler turbine car, it was Building 15 or something behind the Fab Shop there. And we put the hardware together, and then the research engineer would test it, and get his data and whatever. So even though I was essentially assigned to the South 40, it was not unusual for me to design and build hardware for other facilities. And, in some cases, other NASA facilities.

Test stand B was an altitude facility that we had been given permission to build. The basic idea of test stand B was to test high area ratio nozzles. When you get into outer space, as the vacuum goes down, if you can expand a little bit more, you can pick up a little extra thrust and therefore a little more efficiency, but then if the nozzle becomes too big, it almost becomes too heavy, so the little extra that you pick up, is it worth it? So we wanted to know, where's the best place to be? Should we be at 60 to 1 ratio or 1,000 to 1 ratio? So the facility was built to handle 1,000 area ratio rocket nozzles, and the low thrust was around 1,000 pounds of thrust. I later on modified some injectors and put in some new systems that ran around 4,000 pounds of thrust. But it was a rather unique facility. I think even today it's rather unique in that you are able to fire a rocket engine at sea level, and it is operating like it's in outer space. And we're able to do it because we had picked up some very large gaseous nitrogen bottles, pressurized bottles. We found them on the surplus list, and managed to scrounge them and repair them. And since we had such great nitrogen capacity, we were able to sell this facility to Washington because we had the nitrogen for the ejectors that were needed to suck (?) down this facility as you fired the rocket. That was an interesting program.

The other thing I did there was, they were quite anxious to know thrust very accurately, and I was involved in the design, or at least the procurement and final installation of the thrust end.

In test stand B, we started off with some heat sink hardware which we found out wasn't quite going to make it. It didn't run long enough. So I went ahead

SECOND TAPE:

Test stand B was designed to test high area ratio nozzles. There was a low thrust kind of an engine of only 1,000 pounds thrust, but we were able to run anywhere from like 60 to 1,000 area ratio nozzles. The whole idea was to try to find out where was the tradeoff between efficiency and carrying the extra weight, and getting the extra efficiency by having a higher area ratio nozzle. We started off running the program and we had a little bit of a problem that some of the hardware didn't hold up well because it took a while for the ejectors to kind of stabilize, so I built some water cooled nozzles and then we started putting those on the stand. And then we came up with some pretty nifty ways of measuring the pressures in the nozzles, and then we started running the tests. And it was rather efficient testing because of the Altitude Stand B went through a whole series of tests and got a whole ton of data and there was a whole bunch of reports written, and basically we kind of shut it down. I mean at least it was down when I finally left here.

When we were trying to build higher pressure kerosene-type, you call it RP (rocket propellant), LOX-RP engines, when we were trying to build the higher pressure ones which meant a lot more thrust, we ran into a problem with the cooling. On the Saturn 5, which was on the Apollo program, the kerosene went through the cooling passages and then into the injector and into the chamber. When you start going with real high pressures, the kerosene or the RP tends to start breaking down and coking up, and the cooling passage could wind up getting clogged which is usually not good for a rocket engine, which means it blows up or something. And so someone came up with the idea, well why don't we cool the cooling passages with liquid oxygen, and nobody had ever done that before, and so we started to build injectors and build liquid oxygen cooled rocket engines, and I think you've got one back here. And I guess starting from about 1979 and on and off all the way up to almost 1988 or 1989, we studied LOX (liquid oxygen) cooling. And we built engines and we ran them, and then of course there was this terrible fear that if you ever got a crack inside of your engine, then all of a sudden you're dumping oxygen in the engine. Does it mean does it blow up or what? And so we purposely put cracks in engines and ran them and it never blew up, and there were many, many reports written about it. And oxygen cooling, we felt was a very viable way of cooling an engine. I might add an asterisk it was later on when the cold war sort of ended, and we got more friendly with the Russians, that we found out that their Energia rocket was a LOX cooled engine. So, they had an engine they actually ran.

In the early 1990s and going for like five years, we got involved in something a little different than we normally do. We were always doing in-house research programs, and in this particular case we had a company, TRW, that came to us and said, we have a 15,000 pound thrust liquid hydrogen engine that we want to test, and we want to bring it here in a joint government contractor, kind of a contract, where they put in some money, and we put in money. And so I had the opportunity to be pretty much the lead on that, design the thrust end to hold it and also because of our vast experience with liquid hydrogen engines, we kind of told TRW some of the things that they had on their engine weren't too good. So there was a little bit of stuff going on between us, but in the end their engine ran fine and we kind of showed them things that helped it. So they were so pleased with that, they came back for a second program which was a 40,000 pound thrust rocket, pretty good size rocket for the South 40. We tested that successfully, and they got a lot of data off of it. They then came back and did a 13,000 pound thrust RP-LOX engine, and that program came out pretty well. Again, an asterisk, is they went on, then in 1995, that was the end of their involvement with NASA Lewis. They subsequently did go on and build a 650,000 pound thrust rocket which was tested at Stennis, based on the design that they did at NASA Lewis.

Following...the plug engine, that we did so many of them, we looked at materials and we looked at ceramic coatings and all that. We also looked at the geometry of the channel, and we were quite surprised to find that a channel with a high aspect ratio, sort of like skinny and long, versus short and fat, tended to cool better. And obviously anybody in the private industry is going to build a rocket engine if we can give them some kind of little extra help and little extra tip on how to get their engine cooled better, that's important, and that's the kind of important research we're supposed to be doing. So the ultimate engine was there in this high aspect ratio engine behind me where we started off with 400 channels, I believe, and went down to 200 and then…no we had 400, 200, 100, and that was tested in April after the TRW program. And they got a lot of data from it. There were reports written. I have subsequently been aware of the fact of other engines that have been built now since that time that utilize high aspect ratio channels. But anyway, that information was shared with the industry. And once that program was over, that's when they shut down South 40. And that sort of coincided with my retiring from NASA.

The closing down of the South 40 was a rather abrupt thing from what I could tell. I had already left, so I was not privileged to what went on there. But I did come back to the Center a few times, perhaps two or three years later after I had done some consulting work out in California. And I was really appalled to see that basically the place was simply shut down, log books were scattered on the floor. There were pictures thrown in the men's room. There was no organized shutdown at all. I thought it was tragic that there were a lot of records that were lost, pictures, and it bothered my heart to see this place that I worked at for 30 some years look so shabby.

We at the NASA Lewis Research Center did a lot of work on injectors starting from way back when the rocket lab was starting up, and then when the early days of the South 40, and there are various ways of injecting propellants. Basically, an injector, that's a carburetor that takes the two propellants and puts them inside of the engine. We came up with triplets, and doublets and quadruplets and impinging things and all that, but when it came to liquid oxygen and liquid hydrogen rocket engines, it appeared that the very best way to do it was a thing called concentric tube. And essentially what it was, was there was a hole and there was a tube in it, and the oxygen went down this tube, and hydrogen went around the hole. It's amazing that that particular concept was thought up by a guy named Sam Stein who had been working over in the wind tunnel at the 10 by 10, he called and asked us if we would come and help him a little bit because he was a builder of hardware for the wind tunnel, and they wanted to have a model of the Saturn 5, and they wanted five engines in the back of it that actually were firing.

And these were small engines, and so he came up with the idea of the concentric tube. And he built it into these little rockets, and we kind of helped him build the rockets. We did an investment casting. Anyway, it was tested, worked great. Sam was smart enough to put in for a patent, and when Pratt & Whitney built the first operational liquid hydrogen rocket engine in the world, it was a concentric tube injector. And because Sam had the patent on it, of course, we didn't have to pay any royalties. So it turns out that most hydrogen and oxygen engines are concentric tubes. It just turns out that's the best way to go. There are other engines like triplets and doublets that work better with liquid oxygen and RP or kerosene. So, we kind of characterize it that whatever propellant you're using, this is probably the right injection technique to use. The space shuttle main engine that everybody sees on television has a concentric tube injector engine in it.

Well, you're injecting all your propellants and all that, but this face has to be cooled as well, and you can do it by putting fluid across it, and we tried doing all kinds of various ways, but one way that worked very well was to buy a material called Ridgamesh (sp?), which is taking wire mesh, laying it down and rolling it, and making it into sort of like a plate. If you blow into the plate, you can blow through it. So you put this plate there, and the hydrogen goes through the hole, well, some of it goes through the plate and cools the plate. So we did a lot of work with Ridgamesh. Many of the injectors that I designed. I might, if you allow me to brag just a little bit, I might tell you that when I first started working at NASA Lewis, the serial number of the injector that we were using was 58 and when I left working there, it was like 320 or something like that. Anyway, a lot of them were Ridgamesh face plate injectors. I made about 300.

GD: You made them all the way from 58 up to 320?

GR: Yes, that's that list I brought you...

GD: Oh, wow. [do over]

GR:
There were very many different designs of injectors that we tried in the early days to make the combustion instability go away, and also we were looking at efficiency and also a better way to cool it and whatever. One method that worked out very well was to use a face plate called Ridgamesh which is like a wire mesh, that as some of the hydrogen goes through it, it cools it, the rest of the hydrogen goes through the concentric tube element that we talked about. And the RL-10 engine which was the very first engine that was ever built for flight using liquid hydrogen and liquid oxygen had a concentric tube injector with a Ridgamesh face plate. And over the years, starting from perhaps, from 1963 when I started building hardware, even though I did do operations work and actually ran the facility, I also found time to build quite a few injectors, not only for the South 40, but for the rocket lab and whatever. When I first came on board, the serial number was 58. When I retired in 1995, the serial number was somewhere around 320, so I would guess that I had built about 250, somewhere in there, injectors, during my career.

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George Repas

Interview by Virginia Dawson
with Dennis Brown
January 23, 2003

One of a series of filmed interviews conducted on January 23, 2003 with former Rocket Engine Test Facility employees for the documentary video "Fueling Space Exploration." Dennis Brown is the videographer.

DAWSON: I'd like to say your name and spell it, please.

REPAS: My name is George Repas, and it's R-E-P as in Paul - A-S as in Sam.

DAWSON: And when did you first come to Lewis Laboratory?

REPAS: I started in May of 1963.

DAWSON: And did you actually start at the Rocket Engine Test Facility?

REPAS: Yes, I was hired to be an operations engineer, but it turned out they needed people to build hardware more than operations, so I basically became a hardware designer and builder. See, I started working at the NASA Lewis Research Center in May of 1963. I was hired to work at the South 40 as an operations engineer because that had been my background. But they needed people to do hardware design and fabrication. So I sort of got into that. I did some operations work, but I -- the majority of my work was designing and building hardware.

DAWSON: A number of people have told me that you really have a gift for designing and building hardware. And I wondered if there was something in your background that contributed to this? I mean, did you build things in your garage or how did that come about? And did you go to -- did you have any like formal training for that? But you have to you repeat.

REPAS: I guess -- I guess it's a little strange, but I probably was 10 years old when I knew I wanted to get involved in rockets. And I built rockets when I was in high school, and I launched them. And I got the scars when the propellant blew up one time. And you know, the mad rocket kid. And then, of course, I went on to college and got my college degree. And then, of course, I wanted to get into rockets in the worst way. And I went directly to the New Mexico White Sands Missile Range where they let me fire a whole bunch of rockets. And then, they had a big rocket called the Pershing. And it was too big to fire out there, so then I moved to Florida, and I worked there and launched the Pershing rocket out over the Atlantic. At that particular time the program ended, and so I was essentially out of a job. And it seemed like a convenient time to come back to Ohio where my wife's family was. And our family was starting up, and I got a job here. And I was happy to have a job at the Lewis Center.

DAWSON: Oh, that's fascinating. We didn't know that. You're the first person who's given me that kind of experience. Can you tell me about some of the test programs that were run in those -- the early '60s? And you have to say --

REPAS: You're talking about at the South 40?

DAWSON: Yeah, at the South 40. If you could say -- start with, you know, your answer -- some of the tests that we ran at the South 40 in the '60s.

REPAS: Yeah, basically --

DAWSON: No, you have say some of the tests that --

REPAS: The person that was running the South 40 from the time that it was built until when I came on board, it was about a five year period there. The facility had been built, and they fired some kerosene and liquid oxygen engines to check out the facility. And then they immediately installed the liquid hydrogen tank and were spending a lot of time firing rockets to determine the efficiency and, you know, what's the best way to build it? You know, how can this stay together? They were a liability. We were learning about liquid hydrogen rockets. And that, of course was a thing that the Lewis Research Center was famous for, was that we pioneered the use of liquid hydrogen rockets. So there was a five year period in there where they were doing these testing. And then I showed up and said, “I'm ready to push the button and be a rocket guy.” But they had too many operation engineers, so -- and they were short of people building hardware for them, so they asked me to kind of go into that area. And hey, I was happy to do that.

DAWSON: So what kinds of hardware did you build in those early tests? Like, I know in the '60s it was combustion instability.

REPAS: Yeah, so when I first came onboard, there was a research person named Tom Godwin. And he was looking more at, I think, efficiency and a few other things. That program was followed up by what was called the Screech program, which was the combustion instability. And that was a very important program because most of the rockets that they were in the process of designing for the Apollo program had combustion instability problems. And so we began building all kind of different liquid hydrogen or hydrogen operated injectors, you know? Some of them with this velocity ratio and some with that. And this one with a baffle and that one with a liner. And it was a very extensive program, a very intense program. We often worked very late hours. You know, I mean, an eight hour day was not normal. And we found the answer to a lot of questions. There is one report from a person named Pete Wanhainen and I believe Al Palvi was a second author, I'm not sure. But in that particular report we disclosed some very, very important parameters that you must use if you're going to build a liquid hydrogen engine. It was involved with velocity ratio and temperature of the hydrogen and all that. That report, I mean, I don't think there was a rocket company in the world that doesn't have a copy of that report somewhere. So that was the kind of work that we did in those days.

DAWSON: Excellent, excellent. Wow. This is just the sort of thing we need to know. Moving on in your career, after the combustion instability days, you got into I think it was like fatigue. What -- can you think of the '70s?

REPAS: We made our contribution to the Apollo program and then all of a sudden that was terminating. And we started looking at research for the shuttle. Because now we were talking about a reusable rocket engine. Prior to this time, every rocket you fired, it went up and landed in the ocean or something. And when you have a reusable rocket engine, it fires and it moves, and it fires and moves. And it's sort like if you take a paper clip and start doing that, pretty soon it breaks. So, you have to be very careful about how many times can you fire it before it's going to blow up. So, that's called low-cycle fatigue. And we began to attack that problem in about three different ways. First was this plug engine, which is in behind me, which was a very simple way of putting a lot of different materials, building them into these little spool pieces and then firing the engine and shutting it off, and firing it and shutting it off and giving it a sort of a heat cycle. And it was actually pretty simplistic. You'd just stand there and listen. And after 70 cycles, it would start wheezing, and ah, okay, you know? It's got a hole in it and so you shut it down. We also built some larger engines, I think kind of like that copper thing there, where we put limited number of cycles, perhaps like 26 or 30 or 40 cycles. And then it would get a leak. And then we also worked with materials to try to find out what materials were good. And then we also looked at the cooling passage, you know? Should it be a square package or a high-aspect ratio or whatever? So we did a lot of work, which was directly applicable to expendable engines like you would find on the space shuttle. And so basically, in that particular time frame, the late '60s, early '70s, that was the kind of work we were into.

DAWSON: Nice.

REPAS: I think we also did some work on multi-layer insulation, which is what you put on tanks to keep the liquid from boiling off. And there was some other programs going on. It seemed to me like you always had a lot of things going. The director of the Center, Bruce Lundin at the time. There had been a Reduction In Force, a number of people were reduced. And we were looking for work, so we did work for the Department of Energy, which was a new energy. I wound up working on the Chrysler turbine car, which is a little strange from being in rockets. But you know, you do what you've got to do.

DAWSON: So, in other words, then you left the South 40 at that time?

REPAS: Uh, yeah. Well, I mean, I was -- I worked at the South 40, but I built hardware for PSL No. 1 and 2 and in the Rocket Lab and other places.

DAWSON: So you had -- as I understand, you had a fabrication shop that was in the basement? Is that where you [inaudible].

REPAS: No, I was a -- I was like a designer. I would design the part. I would have the drafting people make drawings of it. Then, in those days, we had a very large shop. And a lot of times you'd just go to the shop and give them the prints and they would build it. Sometimes they'd go out with it, but most of the time the parts were built in-house. And then I would take them over to whatever facility I was supporting. In the case of the Chrysler turbine car, it was Building 15 or something, behind the Fab hop there. And we'd put the hardware together and then the research engineer would test it and get his data and whatever. So even though I was essentially assigned to the South 40, it was not unusual for me to design and build hardware for other facilities, and in some case, other NASA facilities.

DAWSON: Were you involved in the design and construction of Test Stand B?

REPAS: Yes, Test Stand B [at RETF] was an altitude facility that we had been given permission to build. The basic idea of Test Stand B was to test high area ratio nozzles. And when you get into outer space it has the vacuum and goes down. If you can expand a little bit more, you can pick up a little extra thrust. And therefore a little more efficiency. But then, if the nozzle becomes too big, it almost becomes too heavy, so the little extra that you pick up is worth it. So we wanted to know where's the best place to be? Should we be at 60 to 1 ratio or 1000 to 1 ratio? So the facility was built to handle 1000 area ratio rocket nozzles. And the low thrust was around 1000 pounds thrust. I later on modified some injectors and put in some new systems and ran around 4000 pounds resting. But it was a rather unique facility. I think even today it's rather unique in that you're able to fire a rocket engine at sea level, and it's operating like it's in outer space. And we were able to do it because we had picked up some very large liquid -- very large gaseous nitrogen bottles, pressurized bottles. We found them on the surplus list and managed to scrounge and then repair them. And since we had such great nitrogen capacity, we were able to sell this facility to Washington because we had the nitrogen for the ejectors that were needed to, you know, suck down this facility as you fired the rocket. So yes, that was an interesting program. The other thing I did there was, they were quite anxious to know thrust very accurately. And I was involved in the design, or at least the procurement and final installation of the thrust end.

DAWSON: And what kind -- you said that -- well, somebody told me that there weren't too many tests in that Test Stand B before it was actually shut down. But, I guess what was accomplished there was significant. Can you talk a little bit about it?

REPAS: Yeah, I would say so --

DAWSON: Well, can you say in Test Stand B something blah, blah.

REPAS: Okay. In Test Stand B, we started off with some heat sink hardware which we found out wasn't quite going to make it. It wasn't -- it didn't' run long enough. So I went ahead –

BROWN: Cut.