pick resistors, transistors, that work around cryogenic temperatures if you hand pick them. At that time we were probably, some concern.

How did you get along with Marshall people? Did you get along pretty well? No problem with any of them?

Me personally, no, no, _____ tell you if I did. I think one of the things that we've learned is that, I've worked with guys on S-IV and IVB and I think they were a pretty reasonable bunch of guys.

Okay, I was just about to take my time, we were just about to run the tape out here. Do you have anything you care to add before I shut down. Okay.

Side B — Felix

started using the Vanguard second stage engine which was an Aerojet hypergolic engine and a solid rocket third stage which we boosted the prime payload which was the same payload ~~that was~~ as on Atlas and Titan for a 5000-mile range. We pickle-barrelled it the first time out of the Cape. We had an operational vehicle, I'm way ahead of everyone else. But that turned into the Delta vehicle. And when NASA combined all their forces and made Delta, so we created from after two Thor-Able II's we created the Delta vehicle from the stack of combination of the _____ and we had developed spin tables and this is where the original shrouds, part of our special space field, where we developed the split clam shell type shrouds and whatnot to be used on many many vehicles, and we've been using on the Skylab mounts. The same basic principle, the same organizational group. So this was a good deal. In 1960 I came back to Tulsa, to Santa Monica really, to head ~~up~~ off the major subcontract engineering activity on Skybolt, to manage the Nortronics subcontract on the guidance system. And left the company in 61 to go back and be vice-president of engineering for Midwestern Instruments in Tulsa, which was almost a company subsidiary and ended up being a Talex

subsidiary, which then later merged with Talex and is now the Talex organization. I left them a year later in 1962 to go to Martin for four short months when Bob Johnson called me to come back as chief engineer at Tulsa, when Tulsa became a part of Missiles and Space Division, they split the company into missiles and space and aircraft, that's two separate organizations. Charlie Able heading off Missiles and Space and Jack McGowan heading off aircraft.

'64.

This was in '62.

'62 _____ okay.

So I became director of engineering at Tulsa then and we developed the special space and missile activity program at Tulsa, with special space shrouds, spin tables and what have you. We had the English Thors we brought back and refurbished into space launch vehicles. We had the Delta vehicle, second and third stage activity. We had the beginnings then of Saturn. We were doing certain small amounts of work there. But we also had the Skybolt diorama. _____ that we were doing in Tulsa. Skybolt got cancelled. A manpower cutback hit us again, and that was when they fed us considerably more Saturn activities, to keep our capability together. So we did the transporter for the S-IVB, which is the big deal. We did that design, we did the aft interstage design and fab. We did much of the GSE such as the hypergolic tanks and many things like that. So we became relatively familiar with it.

That explains it. I remember once seeing a picture of a helicopter bringing in an interstage.

That was from North American, in Tulsa.

Oh it was.

Our interstage we shipped in pieces and assembled out here. Now North American

moved into Tulsa in about 1962 and shared the building with us.

Boy I was really confused on that one, then.

And they built their full interstage from, which was to fit on top of ours, to their Command Service Module. They built that. And they developed the helicopter hippity-hop from Tulsa to the Cape. You buy the helicopter there; as a matter of fact they dropped their first one, right outside ...

But North American shared production lines with you?

Yes. Shared the Tulsa facility, which is a government owned plant.

Okay, well I didn't know that, didn't realize that.

And they had, for instance, their engineering building, they had the top floor, we had the second floor, where my office was. They had half the facility because that was a huge place there. And we were doing B-47, B-52 mods along with our other stuff. We didn't need much in the way of manufacturing facilities. So they took over the south half of the building and we had the north half of the building. We also rented some space over at Spartan, bringing in some of the other activities.

Is that a fairly unusual thing for two contractors like that sharing the same plant?

No, not when it's a government owned facility, and this was part of the overall emphasis that Senator Kerr had in building the Crescent activity if you recall, which started from the Tulsa area and went down through Texas and that area and this was a part of that overall crescent, NASA or space function. And there was quite a bit of activity including Lockheed down at one of the small towns there and so forth ... McAllister, for instance, Lockheed

had a facility down there, and it was all a part of the same program. So in 1964, when Tulsa became a part of the Aircraft Division, at the direction of our president, when Charlotte became a part of Missiles and Space, the aircraft people said we really don't want to fool with missile and space activities, divest yourself of it and move it back to Santa Monica. Well we did that, and at the same time I moved basically all of my engineering force to Santa Monica, found them jobs within the missile and space organization, because they were all really top notch people, and, myself ended up not in Santa Monica, via Santa Monica, to act in Sacramento as deputy director of the center up there, deputy to Bill Duvall, who I'd known for many many years and was a close friend of. And since that was the build-up then of the static firing program and there were about 1500 people. And he needed help and it was an interesting and challenging function.

Had 1500 people up there?

Yes. So I went up there at the beginning of 1965 and was Bill's deputy until in 66 he was named to head off the Mole operation at Vandenburg. They made him vice president. And I took over the operation as director of Sacramento in mid-1966 and ran that operation until the end of October of 1969, when I came down here to work on the various other Saturn activities such as the Skylab simulator and the SAS solaray system subcontract and now the PA-16 activities, again all associated with it. While at Sacramento, which was the key activity point, of course we did all the firings, developed some outstanding methodologies, we felt, in developing fully automated countdown and checkout of a stage for static firing I think was a highlight. It was a real struggle and I

I think we were the only ones that were as fully automated as anybody else, or more than anybody else, really.

Didn't Douglas kind of originate the fully-auto count, countdown checkout.

Well, we had on Skybolt an automatic checkout system, which we never really fully consumated, as a matter of fact, it was tied in to the Nortronics guidance subcontract where we had an Air Force supplied computer and we had an ancillary computer built to match into this automatic checkout, but we never really consumated it. We were somewhat pioneers in actually consumating a fully automatic checkout system. There we used the computer to go through the actual functions. We used another computer to verify that that function matched up to what we had established as a proper limit. We called it a SIM action or Safety Item Monitor. Here was where had tolerance limits for each function, in other words, if we opened the valve as a part of the procedure, then the pressure reactions, let's say, we're supposed to record and see what they were. We had these recorded in our SIM computer. And if, it was a gate-type thing, if the computer saw that this was within limits it moved on. Well this is the advantage of the computer. You can move fast enough that you can take _____ step. We did it slow enough, it was the same pace as the manual. What we could do was do all this cross checking against values swiftly with the computer so we knew each step was correct. This you can't do manually. We were in a position where if the computer failed a million times, you could pick up manually and move right on without any hitch and continue at the same basic pace. So our Safety Item Monitor system I think was the key where we had the really automated deal. In the last 26, 27 minutes of countdown, there was actually complete silence really except for reading of values in the voice network, because the computer was

doing everything. It was kind of amazing to watch this and listen to the values come out of there , instead of the usual procedure of countdown which we were familiar with on Thors and other vehicles where everybody was doing a job. What it did was allow the technicians who were expert to watch the system and monitor it closely. They were sure of what they were doing; they weren't diverted from the concentration of what's correct by knowing what they had to do. A guy down on the countdown deal is a, is very conscious of not making a mistake, well when the computer's doing the job and you're watching what it's doing, you can concentrate on it. When you're doing the job, you're always under the pressure and make a mistake. So you've got to change your concentration, and we found that using the computer left technical people more capable of monitoring what's going on and much sharper. So if something did happen, our reaction time and correction factor were so much better, it was just amazing.

So they were watching this thing and if they did see a red line value approaching or something they could actually put their finger on a button and stop the whole system right there.

Yes. We had our cutoff deals for all the red-line monitors. That's ... one of the things we developed there too was we took the cutoff buttons away from the other monitors. It used to be everybody had cutoffs, and we had two or three false cutoffs. Somebody thought they saw something. And that's good, but it also cost a lot of money and time. So we ended up providing the cutoff to just a couple of key spots, because we had the Safety Item Monitor, which was doing its job. Basically every one of our static firings when we ran into depletion was a Safety Item Monitor Cutoff from the actual depletion, you see. In other words you ran out of fuel, the Safety Item Monitor picked it up and cut off. And practically never manually cut off at the end of a run. It just picks it up and then

cuts off. Which is great. It's just exactly what we want it to do. And we could practically always pinpoint just where it was going to do it because we had us some very excellent countdowns. The team effort up there I think was superb. I've got to laud everybody . . . the NASA crews who came out, the ones who were there, our own. We had excellent team spirit. If there was some reason the team wasn't up to snuff, you could sense it. On one occasion, when Wally Schirra and his crew were there, just on a turnover and an inspection of their vehicle, we were doing a countdown and firing the same day, so we had a big ceremony at one part of the building and the crew was down there counting down. And I went down for the afternoon final part of the count, and it was raunchy. No question about it, and part of it was that they, everybody down there knew there was big goings on with the astronauts up there, and they missed their concentration. And you could sense the difference. And late in the afternoon we had a whole series of problems and I said, "Cut it." "Let's do it again next week." And the following week we went through fine count and _____. But here's a little case of that diversion. And von Braun was a particular master of this. He would never come and visit in the later stages of a, during a countdown or any critical function, because he knew that his presence there would tend to divert attention from the job.

That's very interesting.

Yeah, Wernher was a master at knowing . . . now he was personally interested in details. He dearly loved to get into details, and when he'd come up to visit, and he came several times with his crew, he'd ask technicians and engineers and mechanics detailed questions about valves and problems because he was very interested. But he also had that sixth sense of knowing the disruption

factor. And I admired him immensely for this, I thought this was just absolutely great. So, it was things we had to watch, it's just like, we we could build up an excellent crew. When Tom Stafford and his crew came up for the, it was after the Apollo 10, deal, we had a big thing with the governor and whatnot, it was _____. Of course they reacted to the people immensely and did a fabulous job of developing the spirit that we had up there. Another big factor that we did develop up there was a feeling of cost consciousness. We attained, almost all of our incentives were scheduleable firing and delivery, as a matter of fact it was almost embarrassing to us because we met our schedules.

Why was it embarrassing?

Well, it looked almost like we were taking advantage of the government by the kind of incentive fees that we did. It looked like it was too much to our advantage. Actually we negotiated a later contract to wipe out all the incentives on the static firing because we had attained them all. Because the name of an incentive contract should be that it's to the advantage of both parties, both the government and the contractor. And when the schedule starts slipping, the schedule dates didn't mean anything, for delivery and for static firing weren't to any advantage to the government, it was relatively improper for us as a corporation to take advantage of that, so we renegotiated to where we took these incentives out, or reduced them down to where they were minimal and went to the performance type of incentives and whatnot to where they were getting the benefit off of the thing.

I see.

Which makes sense, because, after all, that's the name of the game. That's the way you want to set up a program, to where both parties gain the advantage when you do get an incentive. This is the way way it should be. So we tried to

set this up. But we maintained an ideal schedule situation because we had a good operating crew. And we went into a countdown, although we had a, schedule was so important to NASA, we had a pad of a week involved in all our schedule dates, we invariably met our schedules. And everything worked out just ... we had an excellent team. We developed a system up there called an automated work plan, which helped us immensely. It was a computerized readout of our daily work schedule. In our morning meetings we evolved to a very simplified method of handling this. We had started out with a morning meeting, down in the blockhouse, with NASA and Air Force and everybody invited. We didn't try to keep anything from the customer; we said, "come in and join us, we'll discuss all our problems openly."

Yes _____. You were director of SACTO. Did that include both Air Force and NASA operations?

Yes.

NASA was Beta 1 and beta 3 test stand?

Well, they were the, NASA had the whole thing. When I said Air Force, Air Force has the quality cognizance; they were the AFPR here, Air Force quality organization is the government agent for acceptance of any government contract. So we had about 25 Air Force quality people up there to do the, to be the government agent for acceptance of all the work. In other words, turnover to the government was done by Air Force, not by NASA. Signing of a DD250, which is your turnover document, was by Air Force. They were designated certain responsibilities and things they had to do. And one of them was all quality action, primarily. Adherance to the contract was an Air Force problem. The NASA people that were there, and we had about 30, 35 people, were primarily technical people representative out of the laboratories and program offices in Huntsville. So, Steve _____, Cliff _____, were there primarily there to support this

thing technically. So Air Force people were there for that function. All of the Air Force facilities, that were there from the Thor days. like the two Alpha stands, were transfered to NASA. SACTO then, see it's one of these we did _____ initially. When we finished the S-IV firings on the Alpha stands, we said well what are we going to do with the stands? And we found that we had some good plans for them as far as component testing was concerned, because you know we had blown up Alpha 1 with the all-systems test, and it was really non-usable as a firing stand. We fired a couple, the last two of the S-IV's while I was still there on Alpha 2. But when we finished that, we said well what are we going to use them for. And it behooved, it made good sense on a government basis to transfer all of the accountability of the government property there to NASA. And we developed component testing on these stands, utilizing the facilities that were available to us. Such as, we developed, particularly after the 503 explosion of course. We had to do a lot of bottle testing, high pressure, 3000-pound testing.

These are helium bottles?

Yes. And here we had the facilities all there. It would be very simple for us to do the testing right, using the alpha 1 test equipment and instrumentation and whatnot to do all this testing, because revetments were down there and it became a good utilization of capability. And then we further developed, we did some of the insulation testing for the S-II, using live hydrogen. We did some of the bulkhead testing.

Of the S-II?

Oh yes. We did the actual cold-soak, we took a Thor tank; the North American people came in, applied the external insulation. You know when they came up with this new external insulation. They applied it to the tank and we did the cold test using actual hydrogen to determine the factors

of adhesion and all the problems that they might have. So we did the testing for North American.

Was this because Susie wasn't developed yet to handle that capability?

Well, this was North American, not Rocketdyne, you see.

Okay, yeah, I follow you now.

They developed a new tank insulation, a foam-on deal, instead of a block deal, where we put our insulation on the inside, they put theirs on the outside. And their first insulation, they had a lot of problems with. The second one became a very cost-effective approach. They had some problems of moisture bleeding of course, but that's what you get into on external insulation. When you chill it down, you get condensation, if you catch it in there you got no problems. But we worked with them closely _____ subcontract did this. We did some, also did some, common bulkhead testing of putting oxygen in the inside tank and hydrogen above it and putting pressure on and checking for leaks to see finding out what point it would be where you'd get a rupture and what would happen if it did rupture. So we went to the point where it blew up. But that is what we were intending to do is blow it up. But we had the facility we could do it at you see. Then later on we did some, we leased a 38,000-pound vibration table and monitored right down there near the base below where the deflection plate was. And did actual hypergolic testing of the attitude control system, in other words, live. We put the ACS unit on the shaker full of hypergolics. And went ahead and took it through the shaker _____ and it's , there aren't very many shake capabilities that you can shake either cryogenics or hypergolics in an actual condition. Because it takes a special type of deal. So these are the things that we

developed as separate types of actions other than the static firing itself. Also some of the production acceptance tests, where we had to use hydrogen in the actual testing, the acceptance testing of certain valves and components that were flight-critical items. We could do this type of testing out there using, because the Alpha-stands you see had it all, the hydrogen and oxygen capability, because they were converted from the Thor deal to the S-IV capability and had the hydrogen storage capability and fuel. So it became very simple for us to do a lot of this stuff. So we became relatively diversified in our testing capability as well, added to the Beta static firing capability.

Yeah, this was something I didn't recognize I guess, that all this was up there. We started out I guess talking about the Automated Work Plan, so I was leading you on in a different direction here.

Well the automated work plan started, was really it started out manually. Where we had developed a plan and then we developed a program for it to where we could put it on a computer and and send the services out to a computer agency to print out on a once a week basis. We could see the advantages of this on a daily basis of using it to manage the work that had to go on because the timing and the criticality of doing a job with respect to a test as we were progressing through getting ready for the static firing because you had to do all the susbsystems tests, you had to make certain modifications or certain installations of components that were _____ and whatnot. It had to be intricately worked out as far as the time was concerned. This was one of our major functions that we did up there. And the automatic work plan as it developed was one of our key functions to be able to be able to do it. And it was primarily developed by the people who had to do the work. It wasn't a one-man effort; it took the cooperation, the understanding, of the computerized operation.

Our people were more prone to make it work because they were familiar with the computer on the basis of the countdown operation. They weren't scared of the computer. I think the biggest problem with utilizing the computer is how the people who use it react to it. If they're afraid of it and don't understand it, they tend to shy away and won't make it work. If they understand it and want to use it, they'll make it work and work effectively, and they did on this in particular, to where I could justify a computer myself at Sacramento and got our financial management people to allow me to lease one, Model 20, on the basis that I could save in indirect costs what it cost to lease it. And I proved this and was allowed to lease it on that basis. It wasn't any direct cost basis or anything else, purely indirect cost. And with that then, we not only used it for the automated work plan on a daily printout basis. This then allowed us to really develop our morning and meeting into a management information center. Because we then had the printouts instead of getting into just a discussion on a morning basis. We had our work and we critiqued what we were going to do. And if there were something in error or some correction needed to be made or some new problem came up, we fed it into the work plan right then. And it just worked like a dream. And of course with a computer availability we found that by an extra shift we could start using it for quality functions we found the quality fire attack actions, we found that we could use it forstock control items, just a multitude of other little helpful deals to where people began to really use the computer instead of being afraid of it. All too often in computer usage. You got to make the thing pay for itself. That's a primary function, I think, we found out. So they were used to it, and it wasn't just a few engineers. The actual workers and manufacturing people and planners and whatnot, all got very dependent upon computer operation, because it became

an efficiency factor. So this of course helped us in improving our efficiency throughout the whole thing, and I think we did. We cut down our number of people, our actions, and whatnot, to where we continued to improve our overall cost-related operations.

That reminds me now, after we've gone all the way by here, but using this SIM method you actually had one computer flipping the valves, etc., and you had a second computer checking on it. I see. So you had three separate computer systems by the time you were done up there. Two in the SIM and this . . . .

One in the SIM. We used a common SIM because we had two, Beta 1 Beta 3, we had two test stands, so we had one computer for Beta 1, and one for Beta 3, driving the actual functions. We used a common SIM because we only would use a SIM during that final countdown phase. So we could switch it to either one, but we were using the countdown computer in subsystem checks as well as in the final countdown. All of our subsystem procedures were run by computer too. So we were using, in the preparation stages we started using the computer from the day that thing went on the stand. So we needed the two computers, one for each stand. Then for the inspection, if you will, or check point computer, which is what SIM was, we only really turned that on during the final, during the actual static firing countdown. So we used it again so we have three computers in the blockhouse.

I was just wondering, could you give a brief rundown of what really goes on in a test operation. What procedures do you go through, and are there certain parts of the countdown that are more critical than others, for example?

Yes, First we got a vehicle up from Huntington Beach, after it had gone through its checkout here, but we've had certain _____ to make on it, but

when we put it on the stand, we started our subsystem check procedure. We'd laid out a complete schedule of every subsystem check that had to be done. So we'd go through . . . . .