
THE HENRY FORD

COLLECTING INNOVATION TODAY

# TRANSCRIPT OF A VIDEO ORAL HISTORY

# INTERVIEW WITH

# JIM HALL

JANUARY 8, 2009

CHAPARRAL GALLERY IN THE PERMIAN PETROLEUM MUSEUM,

AT CHAPARRAL CARS

AND ON THE RATTLESNAKE RACE TRACK

MIDLAND, TX



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# 01 - THE BEGINNING OF CHAPARRAL CARS

QUESTION:

12:00:34;00 Yeah. We're walking around and looking at all these great innovations. Just tell us a little bit about how you and your fellow racers and builders became so innovative when Chaparral started.

JIM HALL:

12:00:44;17 Well, it's always a longer story than you originally think of. I had a really good partner in Chaparral cars, a guy that I got along well with. He was smart. We talked about it a lot. We went out to eat together. We had a drink together. So we spent a lot of time together. And we talked about cars most of the time.

12:01:02;16 And I think that's where a lot of it came from. I got to know some people that were very knowledgeable in automobiles and vehicles. And that helped me. I made an attempt to learn as much as I could about vehicle dynamics, the way cars handle and perform. And I enjoyed learning it. So I spent a lot of time at it, because it tied right in with what I was doing. I could go out and

feel it. And I could look at the equations and understand it. I think that was an important part of it.

02 - AERODYNAMIC DISCOVERY

QUESTION:

12:01:38;27 Well, what led you to the aerodynamics and the downforces, and sort of discovered a breakthrough in racing? Was there a certain moment when it just became clear in your head, and...

JIM HALL:

12:01:49;25 Yeah. There was actually one of those moments when I would've just said, "Oh, wow. That's it." I'd built a car in 1963 that was very poor in its aerodynamic characteristics. It had a lot of front-end lift. And so I needed to fix that. And I took it out and raced it for the first time towards the end of the season in 1963.

12:02:15;15 And during the winter between '63 and '64 I did a lot of testing on it here at Rattlesnake. And I reshaped the front of the car to reduce the lift in front. When I did that I realized that I'd made a substantial change in the

characteristics of the car. And I decided that what I wanted to do is build a car that had zero-lift.

12:02:42;07 Let's say, it had the same weight at speed that it had when it was sitting still. So I did that actually. And after I did that I realized it wasn't a very good race car. So then that got my mind going about, well, what really needs to happen here? And the first time that we actually produced a car where I'd pushed down on it with aerodynamics the whole game changed.

12:03:08;17 The lap times at the track went down substantially. I could adjust the way the car felt in the corner. I could increase its cornering capabilities. And that was just a wild minute. You know? Oh, man. This is really something. So from that point on, really, is where I began to study the real aerodynamics and how it affects the performance and handling of the car.

03 - PROCESS OF INNOVATION

QUESTION:

12:03:36;22 Tell me a little bit about that process, of how that sort of breakthrough moment led you to start applying those principles to other innovations. And what's that process? Is it experiment? Is it trial and error? Or is it measurement? Is it scientific method? How does that work?

JIM HALL:

12:03:52;00 It's Chaparral and my own career. It's a little more scientific. I was a mechanical engineer, a graduate engineer. And I started racing after well, actually during college. But that's when my career was, after I had the degree. And so I applied what I'd learned to what I was doing.

12:04:16;02 And as I said, I made a point of trying to understand the control and stability of cars. And so it was some trial and error for sure. But usually it was a plan. We had a plan and a theory, and I went after it to see if I could prove it. And did a lot of measurement actually.

12:04:40;25 Had a test track right there where I could run. And it was very useful. That's probably an advantage that we had during those days. I could just go out and run during the mornings, say, and then come back in and make some changes, go back out in the evening and check it. Where I think a lot of teams we were racing against in the '60s didn't have that capability.

04 - MOTIVATION

QUESTION:

12:05:06;17 Now what was motivating you? Was it the sheer, I want to find out how this works? Or was it to beat the guys on the track? A little bit of both? What's that all about?

JIM HALL:

12:05:18;18 Yeah. I think the basic motivation was to beat the other guys. Making the car really nice to drive was something that I recognized as an important feature of a race car. Because after the races that we ran in those days were two-hour races. And at the end of two hours of full concentration you were fatigued.

12:05:40;17 And if the car was difficult in any way your performance towards the end of the race, I thought, suffered. So I decided it was really an important feature to make the car not only predictable and good, but also easy. And that's something that I worked on all the time.

05 - RACING AGAINST AL UNSER, SR.

QUESTION:

12:06:00;10 Okay. I have some names of people from your career. I'd like to ask you your impressions of them.

QUESTION:

12:06:12;21 So I'll just give you somebody's name. You just give us your impression or maybe a story about them. Any anything you feel like. Al Unser, Sr.

JIM HALL:

12:06:20;22 Al drove for me in the late '70s. He did a great job. I was lucky to get him. We decided to go to Indianapolis because I'd never done it. And I had an opportunity to hire Al right from the beginning.

12:06:50;03 I had raced against Al in road racing, and he knew my

capabilities and Chaparral's capabilities. So it wasn't a tough sell. He was looking for a new ride, and I got together with him. And we ended up startin' that season with really a total team. We had a really good driver. We had the right equipment. And we did really well from the very beginning. So I had a very good experience with Al.

06 - RESPECT FOR DAN GURNEY (PART 1)

QUESTION:

12:07:17;14 Okay. What about Dan Gurney?

JIM HALL:

12:07:22;26 Gosh, Dan's a wonderful guy that I've raced against over a long period of time. He was a road racer at the same time I was. And in fact Dan and I drove together at LeMans in 1963. And usually I drove as a competitor of his. And he was a competitor of mine. And I have to say, I have an awful lot of respect for Dan on the track and off.

12:07:44;16 He's a guy that you drive right up next to any time and know that he was gonna take, make every effort not to touch or bump you or anything like that. He was a great

ethical driver. And I liked racing against him a lot.

QUESTION:

12:08:02;05 He was an innovator, as well. Wasn't he?

JIM HALL:

12:08:03;21 He was. In a little different kind of way than me, but he really took some steps in a different direction from what other people were doing. He was very good at it.

07 - A GOOD FRIEND: ROGER PENSKE

QUESTION:

12:08:12;29 What about Roger Penske?

JIM HALL:

12:08:18;01 Roger and I probably started racing about the same time. We raced against each other a lot as amateurs. Had some good races against Roger. He was talented in a race car, which a lot of people don't think about now. But he was quite good. I had an injury in 1964, where I couldn't finish the season.

12:08:37;07 And I thought we had the best car. So I got Roger to finish the season for me that year. And he won two or

three races right towards the end of 1964 in a Chaparral 2. And at the end of the season he said, "You know? I think I've done it." And he quit racing. So Roger drove his last competitive race in one of our cars and won it.

12:09:05;29 So that was a nice feature. Roger's been a good friend of mine since then. And of course he's a tough competitor. He stays in racing, and has stayed. And is still going. I don't know how he does it all. But he does it. And he still enjoys it. And that's great.

08 - LEARNING FROM CARROLL SHELBY

QUESTION:

12:09:20;18 Another guy that still seems to be going, Carroll Shelby. What's your thinking about him?

JIM HALL:

12:09:30;16 Well, let me go back just a little bit. And I want to cover something else while we're talking about…. My brother Dick, my older brother, was really instrumental in a lot of what I did in the beginning. I was a young guy. Dick was several years older. Had a little money and he bought a

sports car.

12:09:51;05 And I got to drive that. My first race was actually in my brother's Austin-Healey in 1953. So that was my introduction. Dick was interested in racing all the time, interested in cars like I was as a kid. And he actually helped Bobby Unser. We lived in Albuquerque when I was a young man. And knew the Unsers.

12:10:17;12 And Bobby was about, I think about my age. Anyway Dick helped Bobby get started in, oh, Jalopy racin' and then maybe even stock cars a little. So Dick had a little experience at that. And when I graduated from college in 1957 I had had a job interview and thought I was gonna go up to Chevrolet.

12:10:42;15 And they had one of those cutbacks and they just said, "Well, we're not hiring." So I was surprised and along came graduation and Dick called me. He said, "Well, I've made a deal with Carroll Shelby in Dallas to open a sports

car dealership. And it's not really doing as well as I thought it would. Would you be interested in going down there and just taking a look at it and see what you think?"

12:11:09;01 So I was looking for something to do. And Carroll Shelby sounded interesting to me. So I said, "Sure." And that's what I did when I graduated. I moved to Dallas and was in the business, Carroll Shelby Sports Cars, with Carroll, for a couple of years. And I learned, I have to admit I probably learned more about racing than I did learn about the retail car business.

12:11:33;27 But I had a good start there also. Because I got to drive a lot of the cars that we sold. I was kind of a good demonstrator because I was an unknown and yet I could perform pretty well in a car. So it worked out to be a really interesting start for me.

09 - BEING AROUND CARS AT A YOUNG AGE

QUESTION:

12:11:51;06 Why do you think you were able to drive so well? Was it

some natural thing? Did you study it?

JIM HALL:

12:12:00;06 Well, I guess I'd been around cars a long time. My uncle helped me build a Soap Box Derby car. My dad and I put together a hot rod in Albuquerque. And when I was going to school, a little Model A. And then my brother got me started in sports car racing and I just continued from there. I had thought about it a lot obviously. And it was pretty natural for me. I seemed to do quite well at it. If I put my mind to it.

10 - A HISTORY OF CHAPARRAL CARS

QUESTION:

12:12:32;06 A lot of people who haven't studied the history of racing don't really know what Chaparral was all about. We want them to have the knowledge. Could you just sort of give us an overview of how it started and some of the great successes and innovations? I'm not asking for two hours. I realize it's a lifetime's work.

JIM HALL:

12:12:53;29 I, or the way Chaparral started, let me stop and think

about that.

QUESTION:

12:13:08;01 Just tell us the story. We're ready.

JIM HALL:

12:13:10;14 I raced sports cars as an amateur up until, oh, 1962. And during the last couple of years I realized that the cars that we were driving were not the latest thing from Europe. The Europeans, Stirling Moss and from England, and some of the other guys would come over with the latest cars.

12:13:34;15 And we couldn't handle 'em. Well, number one, they were better drivers. And number two, they had later equipment. And what they sold to American amateurs was last year's car basically. So I was approached by a couple of guys, Dick Troutman and Tom Barnes, in California who wanted to build a car. And I said, "Yeah. I'd be interested in that."

12:14:01;01 And I sat down with 'em. And they proposed a car that I thought would make a pretty good sports racing car, was

reasonably priced [and] used American stock block engine. It had some good ideas. So I went ahead with them. And I bought the first one. They said, "Well, what are we gonna call it?"

12:14:20;01 And I said, "Well, I don't know." And when I thought about it, and we ended up with a name, Chaparral, because it's indigenous to this area of the southwest. The roadrunner. I thought it was an appropriate name for a road-racing car. So that's where the name came from. I drove that car for a couple of years. And developed it considerably during that time.

12:14:45;19 It wasn't particularly great at the start, but it got better and better. And that's one of the times I was more and more interested in why cars do what they do. I met Hap Sharp, sold him a couple of cars when I worked in Dallas. And then I moved to Midland. And when I came out here after about a year Hap and I decided that the thing to do was to build a car here.

12:15:15;14 And he thought I knew enough about it. And that we could probably build a competitive race car. So in 1962 we started building a Chaparral car here in Midland. And that's really the start of it. And we joined together. We were competitors up until that time, amateur competitors. And we joined together to create Chaparral cars with the purpose of building a competitive sports racing car that could compete against anywhere in the world. So that's the start of it.

11 - STUDYING AIRPLANES TO BUILD BETTER CARS

QUESTION:

12:15:49;21 And then tell us about some of the famous cars that came out of Chaparral.

JIM HALL:

12:15:55;01 Well, I guess they all had their moments and their good and bad points. The first car that we built was, it turned out to be quite an innovation because we decided we'd use the latest materials and construction techniques available. So we made a tour of all the aerospace companies.

12:16:14;23 I guess they were called the aircraft companies in those days that were producing rockets. They were producing the latest in airplanes. And whatever they'd let us see we went and looked at. We met a guy in Ft. Worth, at General Dynamics, that was a structures engineer, that was working on B-58. And we talked to him a long time about it.

12:16:37;28 And he was really interested and thought that fiberglass-reinforced plastic was a great way to go for a very small production item, because the tooling costs were low. And the more we talked to him we decided to go in and partner with him actually. He wanted to build boats. And get him to do the structural work on our chassis. And that's how we built the first car actually. Andy Green designed the structure of Chaparral 2.

12:17:09;14 And actually manufactured it in Ft. Worth. Of course with our, all our design parameters.

JIM HALL:

12:17:40;19 Andy built the first Chaparral chassis to our specifications, but he was the engineer that stressed it. So and it turned out to be very reliable, a very good and innovative chassis. It's the first time that people in the racing industry had used stressed skin like an aircraft for the structure of the car.

12:18:02;24 And it lightened the car considerably. It was also very durable and not too expensive, so it turned out to be quite a good thing. That car and that chassis actually was used by Chaparral up through, in various models, up through 1966. So it had a good life. And it was very, very successful. The Chaparral 2 took me to the U.S. Road Racing Championship in 1964, and again in 1965, in the Unlimited Class. So maybe we won more races with the original car we built than in any other car we built.

12 - CHAPARRAL INNOVATIONS

QUESTION:

12:18:44;03 Was it also aerodynamically, you were starting to mess with some principles of science?

JIM HALL:

12:18:51;20 That's really where I got my start on the aerodynamics, was Chaparral 2. When I made the changes to the lift characteristics of that car, is where I got interested in that.

QUESTION:

12:19:04;02 Okay. What about some of the other things? Just that came over to the next several years? And when the wing, you know, the automatic transmission?

JIM HALL:

12:19:17;13 Actually the automatic transmission was Hap's original idea. He drove my first car, the Chaparral 2 that had a 327 Chevy and, of course, a big gearbox, and quite small tires in those days. That's what was available. And it would spin the wheels in just about any gear up to fourth.

12:19:43;02 And he said, "Well, what's the transmission for?" He got out of it, and he said, "Why do we have a transmission?" And so that got us started. And we thought, "Well, if we

use a torque converter to multiply torque for starting and we started with just a single-speed design. And we were working on that pretty hard when I got associated with a fellow at Chevrolet in Detroit, who was in charge of Chevy's R&D department.

12:20:13;18 His name is Frank Winchell. And I want to mention Frank particularly 'cause he was very, very instrumental in my engineering career. I got to know him well and he happened to be a transmission engineer. And he said, "Golly. Let me, I've got some ideas about that." So he started some ideas himself.

12:20:32;23 And he actually came up with that transmission for a prototype car that they built in 1964. And I tested it. I tested the transmission in our car. And it was very, very good, and easy to drive. And we thought it had a lot of potential. So they made a deal with us to let us test that as a piece, you know, best piece of test equipment.

12:21:01;14 Frank was in a little tricky position because GM had signed an agreement that they were not gonna get involved in racing. And so this was an engineering program they didn't race, and they didn't provide us with race cars. What they did is they struck up a testing agreement with us.

12:21:22;14 And it turned out to be a really good thing for me. Because they'd send equipment to Midland during the winter when they couldn't test in Detroit. And an engineer or two and some mechanics, and we'd run it, and run it, and run it. And learn an awful lot about it. So that gave me an opportunity to hone my skills, both as a development person and as a driver. It was a wonderful thing for me.

QUESTION:

12:21:48;01 And some of the things you did they wind up back in the passenger cars for GM?

JIM HALL:

12:21:51;09 Well, I think they did. Particularly some of the aero stuff

later. And we developed that transmission a long time, and we ended up putting a lock-up converter, and sort of, to make it more efficient at speed. And that's one of the things that was added to all passenger cars later on when the economy feature became important. So I don't know whether we were the first ones to do it or not. But we may very well have done it.

13 - CARS AS WINGS

QUESTION:

12:22:22;16 And what did, tell me a little bit about the wing.

JIM HALL:

12:22:31;08 The wings, of course, not anything new. Wings had been run on race cars before. But I don't think when they were put on cars that the person that did it made an analysis of what he was doing, and thought about the total effect. I think they put wings on cars for a particular reason, I know a guy put one on a car to run it [at] a very high speed oval track in Germany way early.

12:23:00;24 And it worked. But you know, that was the end of it.

Nobody paid any attention particularly, the wing came off when they went away from there. And so there wasn't a real understanding of what happens when you apply a vertical aerodynamic force to a car.

12:23:17;27 When you do that you completely change its characteristics. And up until the time we started putting aerodynamic downforce on cars I think most engineers thought of cars as lifting bodies. They said, "You know? They're flat on the bottom. They're round on the top like a wing so they're gonna lift.

12:23:36;19 "And we'll try to minimize that lift. And we'll try to reduce the drag and do all the things we can to make the car more efficient." But they never really said, "Well, what happens when you push down?" And that's what happened to me. I realized what happened when you push down. And what happens is you increase the traction capabilities substantially so the car corners faster.

12:23:58;03 It breaks faster, and accelerates faster. And you can change the stability so that I know, I saw a lot of aerodynamic studies. Again, GM, where they looked at yaw stability of their cars. And they were interested in what happens in a side gust and how is the car controllable on the highway, the right things. But they really weren't thinking about the vertical forces.

12:24:23;24 They were thinking about the lateral forces. And so it's really amazing what you can do once you change the vertical forces a little bit, that lateral forces become almost second order. So it's amazing what it did to both race cars, and I think, passenger car technology eventually.

## 14 - COLLABORATING WITH GENERAL MOTORS

JIM HALL:

13:00:09;19 The whole reason I got involved with Chevrolet is they were interested in their Corvair handling. Because they had some lawsuits in 1962 and '63. And that's when I got to know Frank Winchell and he wanted to hire some expert drivers and in particular he wanted to talk to me because I

had an engineering education.

13:00:29;21 So I did a lot of work for him, driving Corvairs to understand what they did at the limits of a control. And that's where my education started in this, actually. There's another guy involved that was really important, a fellow named Bill Milliken, who is a vehicle dynamics expert, Cornell Labs and then Cornell University, then Cornell Labs. Top, top guy. And that's where I started learning about cars and what makes them do what they do.

QUESTION:

13:00:59;05 Okay. Who...

JIM HALL:

13:01:02;20 People always ask us, "Well, why was Chevrolet doing this when they weren't supposed to be in racing?" Well, they didn't get in it to do that. They got in it because they wanted to understand Corvair, exactly what it does at the limit. And they wanted somebody to drive it.

13:01:18;07 I drove a lot of Corvairs right out to the limit of adhesion. And well, then we let the tire pressure down and I'd drive them around the skid pad with the wheel touching the ground. You know? And then we were preparing expert witnesses for their trials. We took a lot of top engineers from around the country with reputations out and demonstrated it all. And that's how I got involved with Chevrolet.

QUESTION:

13:01:42;08 And a lot of those lessons you translated into racing, didn’t you?

JIM HALL:

13:01:44;09 I did. Yeah. And I'd go back to Frank 'cause I knew he knew a lot. And I'd say, "Well, Frank, when I do that, this is what happens. You got any ideas about that?" We had long discussions. We became very close friends. And he was really my mentor and helped me a lot to understand the engineering that goes on in a car.

JIM HALL:

13:02:08;16 I think that's a good point, you know, people always ask,

"Well, why did you have this relationship with Chevrolet? And they weren't supposed to be in racing." Well, it was really a test and a relationship. And it grew into a little more, I have to say. But, you know, we both got interested...

JIM HALL:

13:02:24;11 ...in what each other was doing. And that's how it worked.

QUESTION:

13:02:29;02 They weren't in racing, why are they sending things to Midland? Is it top secret? What is going on? So that's the story here. Right?

JIM HALL:

13:02:36;06 Yeah.

QUESTION:

13:02:36;08 It started with the Corvair?

JIM HALL:

13:02:38;05 It started with the Corvair.

15 - RESPECT FOR DAN GURNEY (PART 2)

QUESTION:

13:02:39;19 Okay. Another name?

QUESTION:

13:03:05;24 When we were talking about Dan Gurney, you said he was innovative but in a different way. So we'd like to know specifically how your innovative style and his innovative style were different.

JIM HALL:

13:03:12;24 You know? I don't know an awful lot about what he did. But I do know a little bit.

JIM HALL:

13:03:27;09 Well, Dan Gurney was an innovator in his own right. One of the things that he did that I thought was important is he was interested in the engine development for an Indy car, and for Formula One. And he just took the bull by the horns, and he went to England, where he knew the work could be done a little more reasonably.

13:03:48;29 There's a kind of a cottage industry in racing in England. And he hired a fellow named Weslake to design the first cylinder heads for the Ford engine. And then I think they built a complete Formula One engine, of which Dan was

totally successful with. I think he did a great job. He certainly had a lot on the ball.

QUESTION:

13:04:12;05 And how does that compare to what you did? I mean, the method sounds like he was scientific in engineering about it, or applied engineering principles. I mean, you were doing the same thing with your style. Do you see the styles maybe being similar or different?

JIM HALL:

13:04:34;19 I don't have anything really, any way to answer that, I don't know enough about it.

QUESTION:

13:04:40;22 Okay. That's fair. That's fair. All right.

16 - DESIGNING CHAPARRAL 2

QUESTION:

13:05:09;16 All right. Tell us a little bit about this. This was the car you said that all the basic principles and everything here. And also tell us about how you were kind of the chief cook and bottle washer for all this rather than delegate, you like to do it yourself.

JIM HALL:

13:05:21;29 This is a 1965 Chaparral 2. And it's been derived from the car that we built in 1963. When I changed the shape of the nose to decrease the lift I lowered the peak line from up here to down here. And I used a dam on the front to split the air and make it go around the car rather than under it. The other thing I did was I took the air in for radiator underneath and exited it out the top.

13:05:54;02 All those things produced negative force on the front of the car, and got it down to where he lift was gone and we were actually pushing down on it. Once I did that I realized that I had to balance that in the back. It didn't work out just to be a zero-lift car. So we started changing the back of it.

13:06:15;13 And the first thing we did, which is we kind of copied somebody else, we put a little kick-up on the back of it. And it's in reality, it turns out it's a flap. It's like an airplane flap. It turns the air up. And it causes a high-

pressure area right in here, and pushes down on the car. The rest of what you see on here is kind of development for 1965. We added bigger surfaces. We vented the low-pressure areas on the car.

13:06:46;06 These louvers, we measured the pressure on the underside of the fender, and then on the top. And then we vented from the high pressure to the low pressure. All that produced a negative-down, a negative force on the car, which allowed it to grip the road better. And the car went faster and faster, and faster.

13:07:11;19 Now, when I say faster, I mean faster around the racetrack. We put a lot of drag on this car. It got slower on the straight away. And so our next step was to build a car that had a lot of downforce on it, but didn't have the drag on the straight away. And that's where we went from here.

17 - FUN

QUESTION:

13:07:30;06 Okay. But tell me about this process. You were delegating all of this? You had a team of 100? I mean, you were doing it all yourself? How did that work?

JIM HALL:

13:07:35;28 Chaparral was a small, small team in those days. One of the things that I think was an advantage for me was I was a designer. I was a test driver, and I was a fabricator, in a lot of it, I shaped the bodies actually. I'm the guy that went out there and shaped 'em. I had some help. Usually, actually my wife and I'd come back after dinner and I'd go to work on the clay or whatever medium we were working on.

13:08:04;03 And I'd make the changes that I thought were necessary. I'd rough 'em in. And then the guys would come back in the morning and they'd go through it the next day and smooth it all out, and make it look okay. And then I'd critique it and do it again. So, yeah, I did have help. But most of the shapes that are done on Chaparrals were my sculpture.

13:08:23;02 I'm a good fabricator. I can make parts. I get out with the guys and do it. And I see why they can't make something a certain way. So that when I design it I think I design something that can be built. And then I go test it. So, you know, I think that

13:08:39;27 ...gives me immediate feedback as to what happens. And I think it was a real advantage for me to be able to do that. And it was a way I ran Chaparral. I was the leader in the sense that I said, "Come on guys, we're gonna do this." And if we stayed till midnight, I'd stay to midnight.

13:08:54;06 I didn't say, "Okay, you guys finish it up. I'm going home." That was just, my wife, Sandy, always said, "Well, I don't see how you did it. You could work, you know, on four or five hours [of] sleep." And I could. I could work 15 hours a day, all the time. It was so much fun. And I was learning so much that it didn't seem like work to me. And I just stayed with it.

QUESTION:

13:09:16;13 Did you have to motivate the others to share this desire you had?

JIM HALL:

13:09:19;06 I think the guys I had working for me were doing it with me. And they were as motivated as I, well, they, you know, they wanted to beat the other guys out there. And we were the small team from Texas that rolled in, with a pickup and a trailer and ran our races and left. And it was fun.

18 - LOOKING AT CHAPARRAL 2E

JIM HALL:

13:10:07;02 Now, we're looking at Chaparral 2E, which is our 1966 Can-Am car. In 1966 we decided to build a car that embodied everything we'd learned about aerodynamics up to that point, and maybe a little bit about vehicle dynamics, too. So we did a lot of things with 2E that are different from the earlier cars.

13:10:29;21 It was very successful in the sense that it was fast and

easy to set up when we went to the racetrack. I think it was a really versatile good race car. It was not very reliable. And we didn't win many races. So from that standpoint it wasn't as good. And we probably introduced it a little too early. Should've had more testing on it before we took it.

13:10:50;26 But that's the way we did things. We were a small team. We built the cars in the winter and took 'em racing in the summer. And that was it. 2E, of course had the major feature, the wing. And you see that it's a major feature of the car. In order to balance that wing it's got a similar system in the front.

13:11:13;18 It's got a duct like our radiator duct, that comes in underneath, and exits the top. But there's no radiator in there. So we can control the air flow in there with a flap that modulates the amount of air flow through there and changes the aerodynamic character of the car. That matches what happens in the back when we go to a low-

drag position for the straight away.

13:11:38;06 And we go with a more or less trim airfoil. We reduce the downforce in the front, the car is fast on the straight away. And yet when we come to the corner it goes to a high drag position, a high downforce position, where it has very good braking. It corners at a very high speed.

13:12:00;09 And that system worked well. The other thing we did on it, we wanted to move the radiators there for several reasons. So we put 'em in the side pods. And that gives us more rearward weight distribution. Car gets off the corner a little faster because it's got more weight on the drive wheels. I think, from my standpoint, it was a really good design. There again, the major reason for a race car is to win races. And since we didn't prove it too much that people argue with me about it.

19 - SELF-CONFIDENCE

QUESTION:

13:12:41;01 And what did the other guys think when you showed up

with this, at the time, probably a funny looking contraption? Right?

JIM HALL:

13:12:46;26 Yeah. Well, they laughed first. When we first showed up at the racetrack a lot of guys laughed at the wing. But I noticed that the knowledgeable people didn't. Bruce McLaren was down laying underneath looking back up in there, to see where those struts went.

13:13:10;01 And Dan Gurney was standing there, too. So the guys that really knew, they weren't laughing. But a lot of people did. And then there were a lot of complaints. They said, "Oh, we can't see. It's blocking our vision. And it's gonna fall off and hit us." And so, you know, there was a lot of complaining about it originally. But after about the second race all that stopped when everybody realized how fast it was, and that it didn't fall apart.

QUESTION:

13:13:41;05 You think sometimes when you're inventing or being innovative you have to go against the conventional wisdom

and stick your neck out there?

JIM HALL:

13:13:51;02 You know, I didn't think about it in terms of going against what was going on. What I thought about it, is how are we gonna do it better next time. And so it didn't look to me like it was a major change for us. It was a natural progression of what we were doing.

13:14:10;28 And then when you show up with it, you realize, "Well, boy, it is different. And there are gonna be some explanations and people wonder about a lot of things." But from the standpoint of where we did it and how we did it, it was a very natural progression of what we were doing.

20 - LOYALTY

QUESTION:

13:14:30;20 What about internally? The people on your own team. Did they ever?

QUESTION:

13:14:46;11 When you bring an idea to the team? Did they ever look

and say, "Come on, Jim, this is a waste of time"?

JIM HALL:

13:14:52;01 Yeah. I got a little of that. Some of the guys particularly when they're tired. They've been working long hours. And I'd say, "Gee, I'd really like to get this done before we go to the race next week." "Is it worth it?" But, you know usually I could convince 'em. I found that if you can convince somebody that what you want to do is the right thing it usually is. If you can't, then maybe you'd better rethink it. So that happened some for sure.

QUESTION:

13:15:19;29 And what about the...

QUESTION:

13:15:32;00 What about this guy, Justin, this team of people, did you add to the team? Did you keep the same close-knit team? How did that work to keep this sort of innovative process working?

JIM HALL:

13:15:40;28 We had a lot of real loyal people in those days. They came to Midland and worked for us, and stayed. And I think

they enjoyed where they worked, even though we worked awful hard. You'd talk to 'em today, they say, "Boy, we worked hard." And they did. I think harder than most people do.

13:15:59;03 But I think we all enjoyed what we were doing and we had a lot of loyalty. Now, as the team grew bigger, then that changes. You know, originally it was six or seven people. And a lot of those guys stayed with me a long time. But as it grows, then you tend to have some interchange of people.

QUESTION:

13:16:19;25 And were you trying to manage those, was it harder to manage when you had all the different sizes?

JIM HALL:

13:16:26;02 Yeah. I think it's quite a bit [harder], management becomes a people-managing business. And our Indy teams, for instance, were probably twice the size of our road-racing team. And you do a lot of races in a short period of time. So it takes a lot of other things, such as

the travel and just to organize and to get it done.

13:16:44;26 And you need people to do that, which I did. I didn't do that part. But it was more difficult and you can't keep those people, or maybe the psychology changed a bit over that period of time, where the guys were in racing to maybe get the best job or the best pay, and they moved around a little bit.

21 - BAD IDEAS CAN LEAD TO GOOD IDEAS

QUESTION:

13:17:06;02 Now, is it, correct this, but this car, the next version you learned something from this that you started to fertilize in your mind? What's it like? "Oh, now, I've got an even better idea." Is that how it happens?

JIM HALL:

13:17:16;11 Yeah. That’s how it happens. Still building on downforce all the time. We used this in 1966, '67, '68. And had a different idea for '68 originally. That's my worst idea, I think. And you know, we can look at that, if you'd like to, or we can just go right by it.

QUESTION:

13:17:42;17 All right. Jim, let's go look at it. Well, let me see your worst.

QUESTION:

13:17:47;00 So you were telling us about the struts and how the drivers were controlling the pedal.

JIM HALL:

13:17:52;12 An important feature of the wing is that the load that comes out of the wing is loaded onto these struts, which go down and hook onto the rear suspension. So that it's not transmitted through the body and the spring system of the car. It actually goes directly to the rear wheels.

13:18:08;05 So that now you can control the pitch angle of the car very much better because you don't have to worry about this big force going into the body work. The other feature of it is this is controllable by the driver in the cockpit. And it's kind of a neat system, in my opinion.

JIM HALL:

13:18:39;08 The center pressure of the wing is forward of the pivot. So

that it always wants to turn away from where it's hinged. So if it's in this position it wants to stay there. The driver has a pedal next to the brake pedal. And when he gets out on the straight away and he realizes that he's not accelerating as fast as he'd like to, he just takes his foot over and pushes on the pedal.

13:19:02;06 That trims the wing out and adjusts the front downforce. When he gets to the end of the straight away and realizes that he's gonna stop, he takes his foot off that pedal and puts it on the brake. So it's automatic. It's a fail-safe, you can't go into the corner with the wing in the wrong position. Now, we did left-foot brake. We didn't have a clutch, with the auto transmission. So we left-foot braked and right-foot accelerator.

22 - UNDERSTANDING AERODYNAMICS

QUESTION:

13:20:36;06 Tell us, how does the wing actually affect the air that causes the downforce that makes the car stick better?

JIM HALL:

13:20:43;25 Well, the way a wing works is the air flow takes a longer path on the low-pressure side than the high-pressure side. The air comes into the wing and goes up like this on the high-pressure side. On the bottom it comes in and goes around on a longer path like that. So it spreads the molecules of air and makes lower pressure on the bottom side. If it's an airplane that's the top side. But in this case it's the bottom side. So when that happens you create a big force between the pressure on top and on the bottom of the wing.

QUESTION:

13:21:22;06 So this is like science? It's math, it’s reading, it’s school, you’ve got to learn how this all works? Principle of physics?

QUESTION:

13:21:36;15 I mean, where did you learn all, where did you learn how this all worked? Tell us about that.

JIM HALL:

13:21:39;29 Well, I studied aerodynamics and thermodynamics in college. And I learned to fly as a teenager. So I had

experience with airplanes. And so all of that went together for me. I can look at an airfoil or go get an airfoil book and calculate the amount of force we're gonna get out of this size wing, which is the way Chaparrals were built, as opposed to just trying one and seeing how it worked. We actually knew approximately what kind of force this wing was gonna produce before we actually built it.

23 - OVERCOMING OBSTACLES (PART 1)

QUESTION:

13:22:33;01 Tell us, though, even though this maybe didn't work out the way you want, did you learn a lot from it? But also your management style you said didn't work very well with this car 'cause of what happened. Tell us that story.

JIM HALL:

13:22:42;01 This car was designed and built for the '68 Can-Am season. It's our most unsuccessful car. I was injured in …, we didn't actually get to run it in 1968 'cause we didn't finish it in time. And then I was injured towards the end of 1968, and laid in the hospital for quite a while that winter while this car was being finished.

13:23:05;25 And I didn't get to do the test work initially. So I wasn't as hands-on involved. And when we got ready to run it, it wasn't as ready as our cars typically were. We hired a good driver to drive it. But he didn't like it. And we didn't seem to be able to get it set up for him so that he could drive it very well.

13:23:27;04 And I couldn't drive it to see what I thought was wrong with it. So we had a period that just didn't work for us very well. It's got some unusual features that are interesting. This, the whole front end of the car is a monocoque structure. In other words, the fenders, the seats, everything up here is structure back to the engine bulkhead.

13:23:53;02 So that this car is considerably lighter than any other car up till this time that we built because we used all this material, thinner and better qualities to produce the strength that we needed in the front part of the car. The

wing you'll notice, is actually, it goes on struts. But those struts go into the body. And the reason that is, is in 1969, they made a rule that said we could no longer do what I did in 1966.

13:24:24;20 The reason for that is not a particularly good one, in my opinion. The Formula One guys adopted high-mounted wings for the 1968 season. It took 'em two years, which surprised me. And they had some catastrophic failures on the racetrack, and some spectators injured and killed. And so the FIA, the sanctioning body, made a rule that they wouldn't run those anymore.

24 - OVERCOMING OBSTACLES (PART 2)

13:24:54;08 And it's for safety reasons. And I mean, that's okay, but you can build it safe. So anyway, they changed the rules for all the cars. So we couldn't run the wing-mounted onto the strut. This car actually has load levelers on it, so that we took the pitch out of it again.

13:25:15;24 It's got dynamic load leveling. It's done with hydraulics.

So when it goes to its high downforce position, it also turns on a hydraulic system that puts the car right back where it belongs. So there were a lot of interesting features on this car. It's got even more rear-weight distribution.

13:25:35;21 It's got the radiator clear in the back. The air flow has to come all the way over the car, and into the radiator. That worked okay. People commented about the little vortex generators. Vortex generators are used to cause a swirl to mix the air flow, because as the air flow travels along surfaces it loses some energy. So that the first part of the energy going in that hole, first part of the air going in that hole that lacks energy. So if you mix it up, you get better air flow into the radiator. It's just some incidentals about it. John Surtees drove it for us in 1969, very, very unsuccessfully.

25 - DOWNFORCE

QUESTION:

13:26:22;18 Just tell me, for most people who have never driven a race car, which is, you know, a few of us, the downforce, it

makes the tires stick to the track better, so that you go faster? Or how does that help you win? Pretend I'm a seventh grader asking you the question. Tell us how that works.

JIM HALL:

13:26:37;05 Okay. Well, the way downforce makes a car perform better is it increases the traction between the tire and the road. In other words, if you push down on the tire, it increases the traction, but it doesn't increase the mass of the car. And what you balance in the corner is the mass that you're trying to get around the corner versus the traction that you have. So without increasing the mass substantially you increase the tractive capabilities so the car just corners faster. Well, if you can go around the corner faster substantially than the other cars, you're gonna win.

QUESTION:

13:27:11;21 Now, how much faster would a car like this be at the time have gone?

JIM HALL:

13:27:16;15 Than a car without downforce?

QUESTION:

13:27:17;18 Yeah.

JIM HALL:

13:27:18;00 Oh, it would surprise you. It would be of the order of several percent faster in the corner. It might go as much as ten or 15 miles an hour faster in some corners, in the higher speed corners, it's a big number.

QUESTION:

13:27:35;23 And was anybody else onto this? Or did you a...

JIM HALL:

13:27:37;13 Oh, yeah. It happens quick in racing. As soon as it's recognized what's going on, people go their own way and try to do what they think will help 'em. And so by this time there were other people that were using quite a bit of downforce. And so we kept continuing to try to increase it because we knew that was a way to increase the performance of the car.

26 - SAFETY RULES

QUESTION:

13:28:03;04 And when you were trying to be innovative, you mentioned the rules and sometimes it's for safety. Is there always this battle between trying to push the envelope of innovation and going faster with these people making rules to stop ya?

JIM HALL:

13:28:14;20 Well, that's what happens. You look at the rule book and you say, "Is this within the rules?" And if you decide it is, then you go ahead and build it. Sometimes you're not sure enough, so you ask, and I've done that a time or two. But, and then when the rules makers---and you don't talk to everybody obviously---come along and they see that

13:28:37;01 the car they think has an advantage or a disadvantage of some kind, maybe a safety problem, well, then they're gonna make a rule to change that. And of course the tracks are pretty much fixed so if you make a car go too much faster then it becomes a safety problem in itself, because the energy and impact is gonna be higher.

13:29:02;06 And people, the drivers are possibly [going to] be hurt

more because you're just going faster. So that's the job that the rules makers are always torn about, "Is this fast enough? And what do we do to slow these guys down?" And then there's guys like us that are saying, "Well, what do we do to make 'em go faster it's just a natural progression of things."

27 - GROUND EFFECTS CAR (PART 1)

QUESTION:

14:00:05;14 All right, tell us about the legendary sucker car. Is it known as the sucker car?

JIM HALL:

14:00:10;19 Well, we called it the ground effects car, vacuum ground effects. But people called it the sucker car. So, it's been named that. We brought this car to the 1970 Cam Am series. And first time it had been shown in public it was impressive, I'll say that. But it didn't win the race. This car has a tremendous amount of downforce. It's a follow on to our other ideas. Wings got chopped off in a certain way.

14:00:44;10 And so, we decided maybe there was another way to go at it. And it is, in effect, an upside down hovercraft. Hovercraft principle is that you pump air into a space below it, and you pick it up just off the ground, and it glides around at low friction, almost none. This car, we've got a chamber where we suck the air out of it, and pull it down.

14:01:09;28 The way we seal it is with skirts that run close to the ground. They're actually articulated. They go up and down with the wheels, so that they don't wear particularly. But they keep that small gap. There's one that runs across, right behind the front wheels. And there's one that runs across the back of the car, so that this whole area is sealed off. We then extract the air from that chamber with an auxiliary engine in here, and a couple of big fans.

14:01:47;16 And we could pull in a racing trim about four to five inches of water underneath the vacuum. And that translates to 2,000 pounds of downforce. The car weighs about 2,000

pounds. So, by just tweaking it a little, we could've driven it on the ceiling or on the wall. And as a matter of fact, those skirts are made out of a polycarbonate named Lexan. And we propositioned GE about making a commercial and driving it on the ceiling.

14:02:23;26 We said, "You know, we could make a helix shaped road, and we could just drive it up on the ceiling. And a guy could get out and shinny down a rope, and leave it there." But when we quoted the price they said they didn't want to do that. So we didn't do it. And of course, it probably would've been tricky 'cause you'd have to have done a lot of safety devices to make sure you didn't break it, or hurt somebody. Anyway, it would've been capable of that.

28 - GROUND EFFECTS CAR (PART 2)

14:02:48;13 The car was extremely fast. It qualified on the pole, or ran the fastest lap at every track it went to. It never finished a race with all systems working. It finished a couple of races, but up in the top three or four. It didn't win any races. It was outlawed at the end of the 1970 season by

the international racing sanctioning body in France, the FIA. And so suction vacuum, car suction, ground effects car, could no longer be run. So, it only had a one year life.

QUESTION:

14:03:36;12 Why did they outlaw it? What was wrong with it?

JIM HALL:

14:03:40;04 I think it scared them. I think it would go so fast around the corners that it had everybody afraid of what it might do. It's the capabilities of this car, given development, are almost as fast as a driver could stand. You could pull enough G's on him that he'd black out, you know, in every turn. So, there were some reasons.

QUESTION:

14:04:04;28 But you used...

JIM HALL:

14:04:07;23 Well, they did it on a technicality, and that irritated me because we had actually taken this to the American sanctioning body, the idea, and said, "We'd like to do this. What do you think?" They all said, "Well, I think it's within the rules," just like we did. But the FIA found a

technicality. They called the fans or maybe the skirts, I've forgotten which, to be moving aerodynamic devices. And articulated aerodynamic devices.

14:04:39;23 And their description of the chassis prior to that time had been from the wheel center line up. But they then included the skirts in as part of the chassis after that. So it was just a little change in how you read it, and that's the way they did it.

29 - GROUND EFFECTS CAR (PART 3)

QUESTION:

14:05:01;13 But did it discourage you enough that you threw your hands up and said, "I've had it, I'm going to open an ice cream…"

JIM HALL:

14:05:08;00 I'm sorry, I didn't understand that question.

QUESTION:

14:05:09;15 Did this sort of make you think, "Well, why even bother anymore with all these rules? I'm getting out of this?"

JIM HALL:

14:05:13;07 Well this was a real setback for Chaparral because if you look at the last few years before this, we'd had the high articulated wing banned by the FIA again on safety reasons, because in my opinion, when formula one guys adopted it, they didn't do it very well, and they had some accidents. So, that was the reason they initially banned it. And then, at the end of the year, they just said, "Well, we're not gonna run articulated wings."

14:05:46;26 And I think that created a big problem, because that's when airflow was really under consideration. And all of a sudden you know, I think the racing teams spent just as much on the wind tunnel work as they did on the rest of the car. At least, they do that today. And that's one of the reasons is because you can't run articulated wings.

14:06:05;20 Anyway, we had that disallowed. We took a high wing car to Europe to run the manufacture's Endurance World Championship. Our Chaparral 2F, with articulated wing. And it was quite a thrill for the crowd over there. And it

was quite a good car. We won the BOAC 500 in England.

14:06:38;10 And at the end of that year, in my opinion, because Ford had such a successful year, and in that class, the Europeans again decided to eliminate the big stock blocks that we Americans ran. So that hurt us. And then, in 1970, they disallowed this car. So, in three years, they just about eliminated everything we'd done for the last period of time. Anyway, it was a discouraging factor for us, and very, very costly.

QUESTION:

14:07:15;21 And did you throw your hands up and say, " I'm leaving?" Or what happened?

JIM HALL:

14:07:19;03 Well actually, I did. I said, "Well, maybe this is not the sport I ought to be in, or the game I ought to be in, because it seems like everything that we've done in the last few years is now illegal." And I didn't have anything on the board that I was really interested in pursuing at the moment, so I just said, "I think I'll just take off for a

couple of years. And get out of this, and take a look at it from the outside and see if that's what I really want to do."

QUESTION:

14:07:50;29 But obviously it was. You came back.

JIM HALL:

14:07:55;19 Yeah. Yeah.

30 - JACKIE STEWART AND SAFETY

QUESTION:

14:08:35;20 Tell me, Jackie was the first driver to pilot this?

JIM HALL:

14:08:40;01 I got Jackie Stewart to introduce this when we first brought it out. And the reason I could get him is he wanted to know what it was. He was really interested himself. And Jackie commanded too high a price for us. Chaparral couldn't afford Jackie. But he made us a deal for this first race, so he could come over and run it, and see what it was.

14:09:00;21 And he did a great job. I really admired Jackie a lot. He was a good sportsman, and a really good race driver. And

I had a little kind of pause with him there, because when we got there, all he talked about was safety. And he went through the car, and he looked at the seatbelts, and the shoulder harness, and the steering wheel.

14:09:19;11 One of the things we had done over the years is we'd come up with a removable steering wheel. And the reason we did that is so the driver could exit the car if he needed to in a hurry. And that's another Chaparral innovation, actually. And it's used by almost everybody now. So, he liked that. And he wanted us to change a few things. And then, he started going around the track, looking at everything. And he would talk to the organizers about the guardrails here, and this and that. And I thought, "Oh, man, this guy is really hung up on this safety. I don't know whether he's gonna get in there and drive it or not."

14:09:57;01 Well, I want to tell you that as soon as he got his work done there, he jumped in there, and strapped on his helmet, and boy, he was on it. And he did a great job of

driving it. He had some trouble. It ran out of brakes. But he did establish fastest lap in the race. And had a great time. So, it was a good introduction. And I really admired the guy.

31 - GRIP

QUESTION:

14:10:18;28 Well, what did he actually say about the way the car handled?

JIM HALL:

14:10:22;19 Well, I think everybody was shocked at the grip. You're not used to having a capability of running almost two G's in the corner. In those days, our tires were only capable of about 1.1 or something like that. In some corners with this, we were up to 1.7 or 1.8 G's, which is, you know, 50 percent. So, you know, I mean, that's a lot.

14:10:47;16 And braking. I tested it a lot. But I could never make myself drive it into the corner far enough. I mean, you see the corner coming at the speed you're going. You say, "Well, it's time to get on the brakes." And you put your

foot on the brake, and the car stops, and you say, "Oh, gee, I could've gone a little deeper."

14:11:07;18 And you come around, and you do it the next time, and you have exactly the same reaction. I mean, I didn't drive it enough to get to where I could actually drive it deep enough in braking. Because you're gonna corner faster than you're used to. And it'll stop so much faster. This car was high drag anyway. But it would stop faster. A little interesting sidelight. If the engine quits, and you can't get back to the pits in this car, the little fans will drive it about 30 miles an hour.

QUESTION:

14:11:40;12 And nowadays, that might actually be the innovation we need, 'cause we're running out of oil, right? Now, was this tested at Rattlesnake?

JIM HALL:

14:11:49;14 Yes, it was. We did all the test work at Rattlesnake.

32 - RETURNING TO THE TRACK

QUESTION:

14:12:05;18 So, you went away for a couple, three year to see if you were really interested. Somehow, you came back. Tell us about that.

JIM HALL:

14:12:10;25 Well, actually, I had some guys at a cocktail party say, "Why don't we go Indy racing." And I said, "What's this, we." And, they were serious. Local guys. And so, I thought about that a day or two, and I wrote a business proposal. And I took it around to all six or eight of 'em, and I said, "Look, if you guys will put up the money, I'll be the general manager. I'll take your liability out of it. And let's go Indy car racing."

14:12:38;13 And about half of 'em said yes. And we put it together. And we went Indy car racing. We had a really good time and we ended up building Chaparral 2K, our own Indy car. And we did some innovating with it.

QUESTION:

14:12:56;10 All right, now, a lot of people think that, you know, the engineering is sort of a boring thing. You're stuck in an

office with a slide rule, or maybe a hand calculator nowadays. It's actually a pretty exciting business, especially for young people to get into, isn't it?

JIM HALL:

14:13:05;06 Well, boy, it's exciting for me, I'll tell you that. I don't think I would've been a success in my life really without my degree. I don't understand how people live without an engineering degree. I mean, you understand the world around you, and how things work, and it really was important in my work. I think you can have a lot of fun with it if you get into the right vocation.

33 - APPLIED PHYSICS (PART 1)

QUESTION:

14:13:31;29 Tell us about how you create what's underneath this car, and take us back there and show us.

JIM HALL:

14:13:38;19 Okay. When we built this car for the 1979 Indy race, we had seen what the Formula One guys had done with passive ground effects. That is, the shape of the car underneath. And we realized right away that for the high

speed track at Indianapolis, it was the only thing to do. So, we built one pretty much by guess and by gosh. We didn't have a lot of data. But we knew what it needed to do, and we didn't think it had to be right at the very top end of its performance the first time.

14:14:14;02 This car was built that way. And it was very, very quick. [Al Unser] had it on the front row in 1979. And he led the race. It was so interesting. The first lap, he started on the outside, rather than the pole. But when he came around to turn one, he didn't back off, and everybody else did. And he just motored around the outside. And by the time he came around the finish of the first lap, he had a 200 yard lead on the rest of the cars. And he just drove away from 'em for 250 miles.

14:14:50;01 And it had a transmission seal burn up, and lost its oil in the transmission then. And so, we didn't finish the race. We went back in 1980 with the same car that had been developed. We'd worked on it. Change the aerodynamics

enough to improve its downforce capability. Johnny Rutherford put it on the pole, and won the race going away in it. So, I feel really happy about having built this car, and gone back to racing.

QUESTION:

14:15:25;02 Tell us about this we're looking at. How, there's what, the air comes in the front, and it pulls the car down. How's that work? What is this?

JIM HALL:

14:15:28;14 Well, it's actually all done in the sides. The driver and the engine sit in the middle. The side pods are where the radiators are, and you can see the shape underneath the car. It's a venturi shape. It comes in underneath the radiator, runs along the bottom of the car, and then exits out that funnel in the back. And what that does is if you take the top of it as one half of the venturi, and the road as the other half of the venturi, it's just like Bernoulli said. "When you get the throat, that's where you get the low pressure." So, all this area right here is throat. And this car, surprisingly enough, at 200 miles an hour, produces

just as much downforce as the sucker car.

34 - APPLIED PHYSICS (PART 2)

QUESTION:

14:16:43;07 Tell us again how the air's handled in here to make the car have more down flow?

JIM HALL:

14:16:46;25 Well, the way this car makes more downforce is through a channel on the bottom of the car, where the air flows. And it all happens in the side pods, not in the middle. It happens underneath the radiator opening. There that's the entry to the throat of a venturi, in effect. And then, it exits out the back, where you see the triangular shaped area.

14:17:10;23 It expands to the exit. This is a venturi and it uses the Bernoulli principle. So, the low pressure is in the throat. And the throat is up here, right in the center of the car, actually towards the rear. So, that you put balanced downforce on the car. And the way you make the venturi is the shape of the car, plus the road. And that's what

makes the venturi shape, and then, the downforce is provided by the low pressure underneath the car.

QUESTION:

14:17:45;25 And this car above us is actually the Indy winner, did we say?

JIM HALL:

14:17:49;29 This car won Indy in 1980 with Johnny Rutherford driving.

QUESTION:

14:17:53;25 How'd you feel about that?

JIM HALL:

14:17:57;27 Oh, we were proud.

QUESTION:

14:17:56;22 And did it go a lot faster, 'cause this was the first year it was on?

JIM HALL:

14:18:04;13 Well, this car was plenty fast to win the race. There's no question about that. It was actually more impressive against the field in '79, but we failed to finish. If we'd been a little smarter, we'd a won it two years in a row.

QUESTION:

14:18:15;21 When you say impressive, I mean, was it in terms of lap speed, miles per hour? I mean, give us an indication of how much better it was in '79?

JIM HALL:

14:18:24;01 I have the feeling that it was probably worth three to five miles hour at Indy, yeah.

35 - AERODYNAMIC TESTING (PART 1)

JIM HALL:

14:18:49;26 We used such an archaic method of aerodynamic testing, that I think it's interesting. I did a talk at Cal Tech for their 100th anniversary of the ME department. And I showed 'em pictures and everything. I said, "You guys that are out there doing these tests now won't believe what we did." But this is what we did.

14:19:05;15 And we just drilled holes in the body, and ran like surgical tubing to the bottom of the hole. And I made a manometer. You know what a manometer is. With about 20 tubes on it. So, I plugged those all in, and mounted it on the dashboard on the seat beside me, with a Polaroid

camera behind it. And then, I'd go out and run, say, 60 miles an hour, and then I'd click the camera. And then I'd go run 100 miles an hour, and click the camera. And then I saw I had a pressure distribution over the part of the car that I was testing.

14:19:26;24 And then I'd move it to a new spot. But I had the test track, so I could cover like the whole front of the car in a day, if I really worked at it. Of course, it makes the body work not too good after that, 'cause you've got a bunch of holes in it. But anyway, that's what we did.

14:19:34;20 And then in order to measure downforce, we just ran a cable. Actually, the first way I ever measured downforce was I just wrapped a piece of welding rod around the front suspension, drilled a hole in the fender, and ran it up through there, and calibrated it by putting weights on the car. And then, I'd go out and run, and look at it. And say, "Oh, gee, you know, it's running this far. How much is that? Well, that's 100 pounds. Wow."

14:20:04;27 You know, and then run it 150 miles an hour. "Well, that's 170 pounds." Or, "That's 200." "Well, that takes the front wheels off the ground." So, you know, that's how I first did that. And then, we used to run a cable just like a throttle cable. From that same suspension point back into the cockpit. And I made a little recorder that ran paper just across, and a pencil, and then, I had one fixed one.

14:20:32;20 So, I'd make a zero line, and I'd start out, and just shake the car, and run it about ten feet so I got a little wiggle for where zero was. And then, I'd go out again, and I'd run 60, and 90, and 100 and something. So, I'd get a downforce curve. And you know, we had to adjust the shocks, and run on the smooth part of the track, and not run when it was too windy. And we learned a lot of things. But after doing all that stuff, I knew a lot about that car. And it was those simple tools that were infallible, really. I mean, you didn't have to have an electronics degree, or figure out whether it was really calibrated or not. 'Cause

you knew.

36 - AERODYNAMIC TESTING (PART 2)

QUESTION:

14:21:16;01 Did you sort of invent your own measurement equipment is what you're calling it?

JIM HALL:

14:21:18;20 Well, in a way. One thing we learned about that is that you have to do it versus airspeed rather than groundspeed. We first just did it by the tachometer. We didn't have any speedometer or anything, but we had the of course, and just run various speeds. Well, then we figured out we really needed to be running to get it closer to what you're really measuring. We had to run it at airspeed, so we wanted to run an airspeed indicator on the car.

14:21:48;00 Well, I found out I had to get out in front, and up about ten feet from the car to keep it from being very much affected by the car running through the air in order to get dynamic pressure out there. And then, you have to

establish a static pressure source.

14:22:05;07 And this is fun. I read this one. Back in the old days, in airplanes, before they had instrumentation, a guy was trying to measure speed. And so, he wanted static pressure source. Engineer, a good smart guy. And he said, "Well, I know how to do it." So, he took a thermos bottle, put that on one side of the manometer, and what he wanted to measure on the other, he'd open the thermos bottle, shut it, go make his test, come back, and check to see that it'd zeroed out. And of course, he took static pressure with him.

14:22:37;21 I mean, he knew he had static pressure because he got it when he was sitting there on the ground. So, that's the way I first calibrated our air speed indicator. In the same way. I used a thermos bottle. And then, we found a static source on the pitot tube that matched that, so that we knew we had a correct measurement.

14:22:55;20 I mean, it's all pretty simple stuff. But if you use it right, and you understand what you're measuring, you can go a long ways with just that much information.

QUESTION:

14:23:09;08 It's important to have good information, though, right?

JIM HALL:

14:23:12;29 Yeah, it is. You don't want to kid yourself on the data.

37 - DO WHAT YOU LOVE

QUESTION:

14:23:30;04 So, this is the famous place where it all happened. Tell us a little bit about where we are and what happened here.

JIM HALL:

14:23:33;13 Well, we're standing in front of the Chaparral offices and shops where these cars were built and developed and maintained. This is the spot.

QUESTION:

14:23:41;28 And there's a racetrack behind here?

JIM HALL:

14:23:44;00 Yeah, there's a test track behind it. I guess, yeah, it's been a racetrack. Called Rattlesnake Raceway. Basically

been used for testing for a long time.

QUESTION:

14:23:52;00 Tell us [about the] partnership with your wife who helped quite a bit on the development of these innovations.

JIM HALL:

14:23:57;20 Actually, Sandy was a big part of this. She was an executive secretary when I met her.

JIM HALL:

14:24:11;17 Yeah, Sandy, my wife's, been a big part of Chaparral. When I met her, she was an executive secretary and I brought her to Midland. And she walked in and saw my desk and said one day, "Would you like me to straighten up your desk?" And I said, "Well, yeah," and she never left. That was her first day at work and she worked here the whole time. And she did everything. She helped me style the cars. She answered the phone.

14:24:40;14 Did all the mail. Did bookkeeping. Made the upholstery in the cars. She's put up with me all these years. She used to say, ya know, she called me when she wasn't here.

Said, "Did you eat lunch?" And I said, "Well, no." And she'd say, "Well, you better get something." And that's the way I was about this job.

14:25:01;22 I came to work and I worked. And, ya know, we'd break off. We usually spent long days. But part of the time, we'd break off at five or 6:00 and the guys would go home and I'd go get something to eat and come back. And we'd work awhile and then go home, ya know. And that's just what my life was. And I wouldn't give it up for anything. I loved it. I didn't wanna go anywhere else.

38 - RATTLESNAKE RACEWAY (PART 1)

QUESTION:

14:25:25;20 Now, the process of innovation, how did this Rattlesnake Raceway help you, maybe give you a little bit of extra competitive edge?

JIM HALL:

14:25:33;19 Oh, I think there's no question that Rattlesnake Raceway helped us. We were able to go out just like today. We're standing here, first part of January. It's about 55 degrees,

sunny and mild. And we could test a lot of times during the winter. So that, we got a lot of test work done here. And we could just go right out and do it. It's right in our backyard.

14:25:55;17 You get the car ready and you take it out. You don't have to load it on a trailer. You just go out there and run it. Come back in where the shop is. Make whatever changes you wanna do. Go right back out and run it again. I think it was a big advantage.

QUESTION:

14:26:07;00 Now, what would a more typical team have had to have done?

JIM HALL:

14:26:10;29 Well, that's what they would've had to do. They would've had to design a test program, figure out what all they were gonna test. Load it up, take it somewhere. Test it, do their [thing], come home. Then they'd go through the same thing again. So, they're looking at maybe spending a week doing something that I could do in a day.

QUESTION:

14:26:28;02 So again, just sort of tell me how the speed of getting the information, helps your process of coming up with these innovations.

JIM HALL:

14:26:36;06 Well, I think one of the things I had was a really short feedback loop. I was doing most of the design work. I did a lot of the fabrication. Then I'd get in and test the car. So that I knew right away what the changes had done to the car. And then I'd come back and fix it and do it again.

14:26:53;07 So, I think that speed of feedback really helped my career a lot. Some people have said it maybe changed my focus a little bit as a driver so that I wasn't as concentrated as a driver as I could've been. But I don't know. I only found my mind wandering sometimes on the racetrack. And only when it was a comfortable situation.

14:27:16;11 If I got out in the lead and everything was going smooth, sometimes I'd start thinking about, well, how can I make

the car a little better. But if you're in the thick of it, I don't think I ever did that. At race driving, I think your concentration has to be full.

JIM HALL:

14:27:54;07 When I saw that camera, a guy came to do a story about me and he found I had an aerobatic airplane. So he wanted to go out and shoot some pictures.

JIM HALL:

14:59:58;00 Anyway, this guy looked at me serious, and said, "Do you suppose we get a saddle, and put it on the back there, and I can just ride around with you while you did the maneuvers." And I thought, "Golly." 'Cause for anybody in his business to not understand more about what kind of forces were gonna be involved in that, is amazing. Anyway, we ended up installing the camera. Our guys went out and installed a camera in the front cockpit, and I flew it from the rear one, and you know, did the aerobatics that he wanted.

39 - RATTLESNAKE RACEWAY (PART 2)

JIM HALL:

15:00:05;14 This is Rattlesnake Raceway. It's, as you can see, not maintained. It's had a lot of weeds grow up through it. And it doesn't look too good now. Chaparral hadn't had the budget to maintain this thing. It's a little sad to me. But it's deteriorating.

QUESTION:

15:00:27;11 What are some of things that you remember discovering on this? Sort of Eureka moments?

JIM HALL:

15:00:33;14 Well one of the things that we built here when we got involved with Chevrolet and testing the Corvairs, we built a skid pad. So that we could run a circular path. And this is a skid pad. I let the model airplane radio control guys use it for an airfield right now. But we learned an awful lot on that skid pad, most racing people don't run skid pads. But we learned an awful lot about tires, camber, what happens when you load one corner of the car differently from another corner.

15:01:10;07 We learned quite a bit of that right on the skid pad before

we ever took the car out on the track. And so, it got to be a routine with me before the car went to a race. We always tested it. It never went to a race cold. We bring it out here. We'd run the skid pad both directions. Just to make sure the car was balanced coming off the setup plate. And then, we'd bring it out, and run a few laps on the track just to make sure everything worked properly, and that the aerodynamics was about right.

15:01:42;27 And then, we'd take it back, and leak check it and then, load it to go racing. So, when we got to the racetrack, we were ready to run right off the trailer. And I think Phil Hill commented about that when he drove for us. He said, "You know, it's the first time I ever got in a racecar that was really ready to run when I got to the racetrack." So, I think that was an advantage that we had. And a procedure that we did that was useful.

15:02:16;00 We're on the fastest part of the track now. This is the second half of what we call the back straightaway. It's got

a little kink in the middle of it. And then, this turn at the end is so deceptive and hard to drive that it's probably not a good thing for a test track. But it's what we had, and it's what we used. I used to think it took me about 30 laps to get my timing right to get through this corner consistently.

15:02:39;10 It just starts out being straight, and looks like a French curve, and decreases in radius all the way around to the end of it, ever changing radius and speed, until you go from say, 180 miles an hour down to about 70 miles an hour right here. So, it's a very difficult turn to drive, but also an interesting one.

15:03:03;28 The reason it was here is because we drove it on the track in Mexico City, and we thought it was so hard to drive, we wanted to learn how to drive something like that. And that's the reason Hap and I put it here. The rest of the track is very, very fast. That was the slowest turn. Average speed here [is] quite high. A hundred miles an hour very early in the game. We used to run it in the high

57 second range for a two mile track.

QUESTION:

15:03:39;09 Tell us, tell us again...

JIM HALL:

15:03:39;20 That's 120 mile an hour average.

40 - THE LEGACY OF CHAPARRAL CARS (PART 1)

QUESTION:

15:03:43;07 Jim, let's pretend we had some students in here who are just starting out in their thinking of what they want to do with their lives. And they were kind of, you know, looking at your model. And what would you tell them about going into some kind of business like this that would take engineering? Why they might want to do it?

JIM HALL:

15:03:55;23 Well, I mean, engineering is really physical science applied. So, you learn the laws of nature, and what makes the world go around, really. And that's the reason that you have enough knowledge to make decisions that make sense when you're working with mechanical equipment. And I just feel like an engineering education is a wonderful

tool for anybody in business, but particularly if you're in the performance kind of business, like aircraft. Any kind of performance. Boating. Cars. All that kind of thing requires that knowledge.

QUESTION:

15:04:51;19 And let me ask you this. Of all these great innovations, and the victories, and the racing, what are the things you're most proud of? Not necessarily the ones that were most successful, but the things where you really felt, "A-ha, that deserves a feather in my cap. I liked that?"

JIM HALL:

15:05:11;02 Well, the biggest impact that we had on racing that maybe I personally did was when I realized the importance of vertical aerodynamic force on a racecar, and what could be done by placing the center of that force in the right place on the racecar. You can increase the performance by a tremendous amount, it's cornering, and braking, and acceleration performance. And you can make the car handle the way that the driver would like it to handle. That is predictable.

15:05:46;07 That's what the driver really wants. He wants the car to be predictable so that it does what he thinks it's gonna do when he makes a control motion. And you can do that with aerodynamic vertical force. And it really changed the whole racing future from that point on. It made a tremendous impact. And I don't know why I happened to be in the right place, the right time to really realize that, but it was fortunate. And I had the background. I had the experience. And the time was right. So it was something that I'm most proud of.

41 - THE LEGACY OF CHAPARRAL CARS (PART 2)

JIM HALL:

15:06:42;20 This corner is about 110 miles an hour in the cars we ran in the '60s. Quite high speed. You drive to the inside of the corner right in here, stay out a little for the S back the other direction, and then, you try to get down where the camber's a little better, down in here. This part of it was about the same speed. Both turns about 110. And then, you want to make sure and get on the power early, to

accelerate out, and use all the road to the outside.

15:07:13;01 We pitted here. And this is what our pit area was. This little straightaway we reached about 125 miles an hour. This turn, you had to brake really hard straight into, it was about a 90 mile an hour turn in those days. Go clear to the inside, back out almost to the end. But the camber gets bad out there, so you don't go all the way, and then back in or down. This one's 85. It's just a little slower. And so, you had to adjust your speed between corners.

15:07:46;05 And then, you want to make sure and get on it early coming off of that one, because this is the longest, straightest part of the course, where you're gonna accelerate, and carry your maximum speed for the longest distance. So, when our cars were aerodynamically correct, we could get through this little kink flat out. So, we just kept our foot in it, right down along this line, and very easily turned through this corner, without upsetting the car, and we never had to lift.

15:08:18;10 Now, before aerodynamics downforce, we couldn't do that at all. That turn was quite slower. And this is the difficult decreasing radius turn I talked about before. We reached about 180 miles an hour. And then I had to brake really hard right here. And then, establish a radius about in the middle of the corner for a long time. Held my speed, held my speed, held and then I'd let it start to bleed off a little bit. When I saw the church, I braked. And I braked out here like this. And then I had the right speed for about 60 to 70 miles an hour, right, the slowest part right there.

15:09:02;23 And then, back this way, and again, accelerate over the hump. The wheels got a little airborne here, and it'd spin the wheels when it came down, and complete the acceleration on into the first of the S turn that we started filming a minute ago.

42 - TESTING THE GROUND EFFECTS CAR

QUESTION:

15:09:20;25 Tell me a little bit about the sucker car when you tested it

out here. What did it feel like?

JIM HALL:

15:09:39;01 The major thing that you could feel is a tremendous increase in grip, and the performance in braking. You couldn't believe how deep you could drive the car into the corner before you had to put on the brakes, because it got so much grip when it was stopping. And it was just something that amazed you.

JIM HALL:

15:10:11;29 All your senses were telling you that you needed to brake, but you didn't really need to brake yet. So it was a real challenge to drive the car in deep enough. I didn't get to do enough laps with it myself, really hard laps, for me to get comfortable driving it at the limit.

15:10:27;09 And I know Jackie said he didn't. And Vic Elford who drove it the rest of the season, I think, got pretty good at it. That's where he did a lot of passing, was under braking. And he got to where he was very comfortable going in as deep as you could go with it. But he may be the only man

that ever did it.

43 - MEMORIES OF RATTLESNAKE RACEWAY

QUESTION:

15:10:47;17 How long's it been since you've driven this track?

JIM HALL:

15:10:50;09 Oh, I drove it in the '80s some.

QUESTION:

15:11:00;09 What kind of memories are coming back today? Anything? Is it nostalgic?

JIM HALL:

15:11:01;04 Well, I've got thousands of laps here. So, I know each little piece of it, and where to go, and where not to go, and why I wore that little place out right there and it's all part of testing, and learning about the car, and trying to see what your capabilities are in the car. And you know I have so many memories, for instance, aerodynamics. I just used to come back on that straightaway, and run a set speed in order to make a data run. So, I did a lot of that kind of thing, in addition to trying to run at max performance all the time.

QUESTION:

15:11:49;01 So, you never forget the track, do you?

JIM HALL:

15:11:51;24 No. We thought about running it backwards some, and I tried it a few times, but you know, we had so much data on it the other way that we were hesitant to recalibrate and get the knowledge going the other direction.

QUESTION:

15:12:18;25 Did you ever drive it at night?

JIM HALL:

15:12:18;04 A little. You know, we ran the international races, Sebring, LeMans, Daytona. So, we had to make sure the lights were pointed correctly.

44 - THE KEY TO CHAPARRAL CARS' SUCCESS

QUESTION:

15:12:52;26 Tell us again, where we are, and what happened here, Jim.

JIM HALL:

15:12:57;20 Well, we're on Rattlesnake Raceway. And this is a good part of it. Actually, there's a little hump behind us that's coming down this way. Cars got a little airborne. And

then, into a right hander down here that's about 110 mile an hour turn. It's a good part of the test track. And we did an awful lot of work here. This is the kind of thing that I think made our team more successful, is we were able to come out here and test just almost any day.

QUESTION:

15:13:21;02 Now, what's some of the history? There was no and obviously, it's not in repair now. So, tell us about that.

JIM HALL:

15:13:28;06 Well, that's a long time ago. You know, the '60s and '70s area long time ago. And Chaparral has actually been in storage for quite a while. And we haven't had the budget to maintain the whole facility. And this is one of the parts that that's not being maintained very well. I'm disappointed in that. But that's the way life is.

45 - THE VALUE OF EDUCATION

QUESTION:

15:14:03;05 Let's talk again about what the lessons that maybe young people can learn from what you've done with your background and career. What would you say to some

young people if we had them here, they're out here at Rattlesnake Raceway?

JIM HALL:

15:14:15;07 Well, I can tell 'em that just because I studied engineering, it wasn't boring, and it wasn't all, there's a lot of work to it. But it wasn't all work. There's a lot of fun things about it. And I got involved in a sport, and in a career that I couldn't have done without it. I think it's fabulous that I had that education.

15:14:33;04 And I look back [on] it very kindly now. The time I spent studying math, and doing things that I couldn't quite see the use for when I was a youngster really turned out to be valuable to me. And I think that shows in our work.

46 - TAKE ADVANTAGE OF OPPORTUNTIES

QUESTION:

15:14:48;14 And let's walk a little bit.

15:14:51;09 And this is kind of a tricky one, but, you know, this is one of these interviews that theoretically will be preserved for

100 years. People will be able to go and look the thing up. What kind of message do you want to give to the people down the road?

JIM HALL:

15:15:05;22 Well, you could have asked me that earlier, and I could've thought about it. Well, the message that I might convey is that I'm really lucky and proud to have lived in America. Because this is a place where a guy like me can take advantage of our kind of free market system, and do something that's important. And do it on my own. Make my own decisions.

15:15:36;27 I think the freedom that we have to do what we want to do is the most valuable thing that we have. And I hope we can manage to maintain that. Because the world's getting more complicated all the time. But I think the American model is the one that has really allowed me to do what I want to do.

QUESTION:

15:15:57;03 Okay. And secondly, similar question. When people look

back, what would you like 'em to think about you?

JIM HALL:

15:16:11;19 Well, I think that's a difficult question. Everything you do, you don't think about in terms of what people are gonna think about it. I know I did my life in an ethical way, and I kept my reputation throughout my life. And I'm proud of it. And I think that's the most important thing.

47 - LEARN BY DOING

QUESTION:

15:16:38;16 And then just give me a couple more memories here. From when we were driving, you were talking about some of the things. You described every curve, every, tell me a few more things here about Rattlesnake that you're thinking about today when you look at it. Nice things, as opposed to disarray.

JIM HALL:

15:16:54;07 Yeah. Well, I guess the moment that that I realized that downforce was important happened right here. And so, that was a key item in my life. And I also began to understand quite a bit about the way automobiles

behaved. And that happened out here on the racetrack, really. You can do a lot of it in the office, looking at equations, and thinking about the dynamics of the thing. But to actually experience it really drives it home to you. And I think makes it more important to you.

48 - HARD WORK

QUESTION:

15:17:25;07 And what about if there were guys who were getting into the race business now, or any business now, trying to say, "We want to be innovative, we want to be cutting edge." What would you advise them to do?

JIM HALL:

15:17:33;05 I think it's a difficult business to get in. It's small. And there are a lot of people that are interested to get in. I think you just have to get around it. You probably have to volunteer a little bit in places in order to get somebody to see you. And then you have to work hard, and do a good job, and you'll be noticed. That's the way, I didn't go out and hire a PR firm. I went out and did a job. And I was recognized for results, not for talk.