CHUCK YEAGER'S TALK TO SPERRY VICKERS,

MISSISSIPPI, DECEMBER 1980

- WWII
- X-1
- Mig 15
- X-1A
- NF-104

Tonight's guest speaker asked me not to go through the seven pages of biography I had started to accumulate on him, but for a man like myself who is in the aircraft business and who enjoys it, he is one of the pillars of the aviation community and has been for a good many years; and when I was reflecting on how one might introduce him, inasmuch as I am from California, I thought, hey, if I really wanted to do a great film on somebody, like this is your kind of a life, I would pick this man. So, if we looked at him from the standpoint of a producer/director trying to set up the basic broad outline of a script, you would look down and you would write the script this way. Well, you could put him from a small town in West Virginia; humble birth, average American.....I'm hurrying, I'm hurrying...enlisted in the U.S. Army in 1941 as a private and that was the day when we had the sergeant pilots in the Army and we had chief petty officer pilots in the Navy. He rose from that to a pilot officer, commissioned officer in World War II. He was shot down over France and escaped back to England and four months later and.....I'm cutting this down, Chuck....I think he ran a lot, I'm not sure. He was selected for experimental flight test training at Wright Field in 1945, selected as a test pilot for the nation's first rocket aircraft, the Bell X-1, and he was the first man to break the speed of sound on October 14, 1947, and the first man to fly at more than twice the speed of sound on December 12, 1953. He graduated from the Air War College in 1961; became the commandant of the Aerospace Research Pilot School in 1961 where all the U.S. astronauts were trained; he flew 127 missions in the Vietnam war; he was sent over to Korea during the Pueblo crisis in charge of the F-4 wing that went over in support; served a third term of duty in Germany in 1969 as a vice commander of the 17th Air Force and is a plethora of other exciting things very seriously that he has done. I will list about one page only very quickly of the awards he has received: Distinguished Service Medal,

Silver Star with Oak Leaf Cluster, Legion of Merit, Distinguished Flying Cross with Oak Leaf Clusters, Bronze Star Medal with the V Device, Air Medal with ten Oak Leaf Clusters, and I'm getting dry mouth, Air Force Commendation Medal, Purple Heart, Distinguished Unit Citation, Air Force Outstanding Unit Award, the MacKay Trophy of 1940 and for those of you who really follow aviation, Collier Trophy in 48 ~~and~~ and a Harmon Trophy in 54. He holds an honorary Doctor of Science degree from West Virginia and honorary Doctor of Science degree from Marshall University of Huntington, West Virginia, so for a man who is uncommonly uncommon he is perhaps the most famous for being a sincerely humble man and it is my pleasure this evening to introduce General, Brigadier General, Charles Yeager.

Thank you very much, Bob. I don't know if you all noticed...I went out to the men's room because I got a four hour speech and no one else went. That's tough. I was extremely happy when Bob called me and asked me would I come down and talk to a bunch of people associated with airplanes. You know, you all are in a special job when you work for Lockheed and Boeing and Douglas, McDonnell Douglas, now, because although I knew a lot of your test pilots, I never did get the pleasure of working with people like you in big airplanes because if an airplane has more than one engine I couldn't fly it, much less understand it. I got to sit in on one of your sessions this afternoon on 8,000 lb hydraulic systems and still I don't know what he was talking about but I suppose it's all right.

I would like to take you back a little bit tonight, back probably when George Moore was propping ~~carnies~~ Carnes instead of trying to fix inflight movie projectors on a 1011. You know, actually, after 34 years in the Air Force,

the majority of it in research flying, my name has become synonymous with test work but I would like to show you how ridiculous some of the things were that we got associated back in the early days of test flying...it really wasn't flying. In World War II I went over to England in November 43 with the Mustang outfit that was flying out of England against the Germans and in the spring of '44, before I got shot down, we were called upon to evaluate a new G-suit. In the early days of the war when we got in dog-fights with 109s and 190s, of course, you could pull a lot of Gs in a P-51 if you were diving and up to 400 - 450 miles an hour you could hold as much as 6 Gs for a few seconds before the drag slows your airplane down, ~~and most pilots, pretty baseline average for the amount of Gs you can pull~~, most pilots normally can sit there with 4 Gs or four times the pull of gravity and be on the verge of blacking out...you lose a little bit of your peripheral vision but normally at four Gs you can still fly your airplane and track another guy and shoot at him; but if you go beyond 4 Gs of course your peripheral vision closes in and they call that blackout. You can't see anything because primarily, not for you expert pilots but for primarily the women in here so they will understand what I am talking about, basically what happens when you pull more than 4 Gs the blood vessels in the legs and the lower extremities of your body...they will expand and the blood will drain away from your heart and it will quit pumping it up to your head bone and you don't get the blood to your brain to keep you really alert. So, if you pull more than 4 Gs, of course, less blood gets up to your brain and you can't see. If you hold it much longer, of course, you become unconscious and if you become unconscious you relax and let off on the Gs and the blood pumps back up and you come back to. In 1944 the Air Force had been doing a lot of research on Anti-G suits, or suits to wear to give pilots a greater G tolerance, and they brought two types of suits over to England in the spring

of '44 and asked us who were in the Mustangs to wear them. ~~and~~ the first suit they brought to us was a Canadian suit...it was based on the water principle and the theory was they could emerge you in water up to your heart then when you pull Gs water having the same specific gravity as blood, of course, would tend to hold and compress the blood vessels and hold the blood up to your heart and you could pull 5 Gs, 5 1/2 or 6 Gs without blacking out. Well, the suit was very much like a pair of chest waders only with dual wall and you put it on over your underwear and put your flying suit on over it and then your jacket and then went out and got into your parachute and sat down in the cockpit of your P-51. You had a filler nipple on the top of this right under your chin and the crew chief would bring this five gallon bag of water out and would screw it in to the top of the filler nipple just under your chin and hold it up and all this water would gurgle down around you into the double wall suit. ~~Once he got~~, if you had a good crew chief he would bring warm water. If he didn't like you he would bring cold water. Once you got all this water down around you theoretically you were supposed to take off and go off and get into combat and you could pull a lot more Gs than the German pilots so you could evade them more, you could follow them through violent maneuvers and shoot them down. But the fabric that we had in those days back in '44 being a nylon fabric, rubberized, wasn't very good and it stretched and in about a half an hour, in fact about the time we got across the Channel and broke land in ~~England~~ France and Holland all this fabric had stretched and all this water would drain down around your legs and every time you would push a rudder there would be this big slosh, slosh. But the funny thing about it, we came back and you would lift yourself out of the cockpit onto the wing and they had a valve on the bottom of the right leg and you would open that valve and get a stream of water going, you'd open the valve on the bottom of the left leg and get another stream of water

going and you would have been up about seven or eight hours in your Mustang and having drunk coffee early in the morning and no way to get rid of it you would sort of relieve yourself....I think that's where the reputation of the American fighter pilot in England was enhanced with three streams of water flying across the wing. That really wasn't test work but that was my first taste of evaluation. Also, in World War II, we got our first exposure to compressibility and in dog fights we normally flew somewhere between 35-37,000 feet when we were escorting the bombers in order to have a tactical advantage over the Germans who were coming up. That's where we were exposed to our first compressibility - when we get in a dogfight or go into a high speed dive and get up to 80% of the speed of sound, the shock waves that are formed on the very thick wings on the P-51 and behind these shock waves would be turbulent air and you get into a lot of buffeting and a lot of feedback on your controls and although we didn't know what was causing it that was our first association with the effects of the speed of sound on an airplane. I came home in February '45 and went into Wright Field, not as a test pilot but as a maintenance officer in ~~a~~ the fighter test section and was given the opportunity in the spring of '46 to go through the Test Pilot School, which I did, and started working on test programs. I spent many many days down at Burbank flying the first P80s when we ran the first service test on the first ~~Dallas and~~ Allison J33 engines that the P80s were equipped with. ~~them.~~ And then when the X-1 came out in the summer of '47 when the Air Force took it over, I was assigned. But to go back a little bit, fortunately there were enough people in NACA, the industry and the Air Force who knew the problems that airplanes were faced with when they got into ~~regions~~ this region. We found that the XS-1 was designed in 1943 and the contract was let with Bell Aircraft Company to build the X-1. Now Bell had to do a awful lot of guesswork and research in coming up with the design for the X-1

itself. Now in those days, in '43 we didn't have jet engines that would drive the X-1 into the speeds we were interested in evaluating the airplane or in the region of the speed of sound so the X-1 was equipped with a liquid rocket engine and the rocket engine, naturally being built by the Navy, never did quite get built on time to be put in the FIRST X-1, but the first X-1 was completed in the spring of '46 and Bell Aircraft, without the rocket engine, took it to Pine Castle, Florida, and since it was designed to have only two and a half minutes of power, it was designed to be dropped from a B-29 and since they didn't have the rocket engine available they did a lot of glide flights and a pilot by the name of Jack ~~Welmans~~ Woolams did the first six flights on the X-1 being launched from the belly of the B-29 and normally, he would have gone on through the complete program but he got killed in the spring of '46 at the Cleveland Air Races in a P-39. He and Tex Johnson were flying it and some of you Boeing guys knew Tex very well. Jack got clobbered and then Bell assigned their next test pilot, Slick ~~Goodwin~~ Goodlin, to the X-1 program, who made 20 powered flights on the X-1 - took it up to .8 mach number and 40,000 feet and Tex Johnson made one powered flight on the X-1 himself. And then Slick was negotiating because, up until this time, no blue-suiter or Army Air Corps type had done any research flying whatsoever. All research flying was done by contractor pilots who worked with the contractors and Slick had a contract with Bell to complete Phase I on the X-1 to take it up to.8 mach number and 40,000 feet and 20 powered flights to sort of man-rate it. And then his Phase II, he HAD collected about 50,000 DOLLAR bonus on his Phase I, and Phase II called for him to take the airplane up to 1.1 and he was negotiating with Bell and dragging his feet a little bit because he had a contract for ABOUT $150,000 and he wanted it paid over a five year period. Income tax problems, obviously. He was delaying the program a little bit and in the spring of '47 the Air Force moved in and took over the X-1 program because

they were a little bit disturbed about the delay in the program itself. When the Air Force took it over there were probably about 25 of us pilots in the fighter test section at Wright Field who were qualified to fly the airplane and we ended up, Colonel Boyd picked me as the primary pilot. I was a captain at the time and 24 years old and had quite a bit of flying under my belt and my backup pilot was Lt Bob Hoover whom a lot of you know. We went to Edwards and started work on the X-1. Now the first thing that I made it a point to do was to learn everything I possibly could about the X-1 so I'll give you a slide, if I can have that first slide, give you a feel for what we had in the airplane itself. Okay, that's the X-1 as it sat on the lakebed the day it broke mach 1. You can see the airplane is about 28 feet long and has a wing span of about 30 feet and you can see the cockpit - visibility is pretty poor and right behind the cockpit itself is a spherical tank that holds 300 gallons of liquid oxygen. Above the wing is the instrumentation bay and behind the wing is another spherical ~~thing~~ tank that holds 288 gallons of a mixture five parts alcohol to one part water and the rocket engine in the tail itself. ~~An~~ The empty airplane weighed roughly 6,000 pounds. The rocket engine in it gave us 6,000 pounds of thrust. Fully loaded it grossed out almost 13,000 pounds and had a stalling speed of 240 miles an hour, ~~fully loaded~~; empty it stalled at 190 miles an hour and we put it on the lakebed at about 195. Now, up in the nose in front of the cockpit, it was funny to listen to Joe talk about an 8,000 pound psi hydraulic system today because in the X-1 we had no hydraulic system or electrical power other than the battery that ran the radio and the instrumentation and telemetry system but for power we used 5,000 pounds of nitrogen gas in a manifold and ran that nitrogen gas through a dome regulator in the cockpit and reduced it to 1500 pounds which we used to raise and lower the landing gear and then we reduced that 1500 pounds

through two more dome regulators, one controlling the pressure to the liquid oxygen tank which was 300 psi and to the water alcohol tank after the wing which was 288 pounds roughly. Then we took that 300 psi, took it to the tail and if you'll notice, on the side of the vertial stabilizer, on the leading edge of the horizontal stabilizer, you can see that the leading edge of the horizontal stabilizer has a fairing over it, it was designed to move up and down and the way we moved or changed angle of ~~instance~~ incidence on ~~a~~ the horizontal stabilizer was, the leading edge of the stabilizer was hooked into a jackscrew and on top of the jackscrew was an air motor and on the bottom was an air motor and I could control 100 psi of gas that went to the top motor through a solenoid switch controlled on the wheel in the cockpit, I could let air to the top motor turning it clockwise looking down at it or divert gas to the bottom motor and turn it counter-clockwise and change the angle of ~~instance~~ incidence to the horizontal stabilizer. Then we took that 100 psi and ran it back to the cockpit through an orifice and reduced that to 4 psi and we used that nitrogen gas to run the gyro on the needle and the flight indicator and dumped that into the cockpit to pressurize the cockpit with. I tell you, OSHA wouldn't buy something like that today. But that's the way the X-1 was. It was basically pretty simple. We had 16 channels of telemetry and most of the data we got was transmitted to the ground before we landed. On the next slide, you get an idea looking head-on to the X-1 to see what pretty sorry visibility we had out of the front. We really didn't need much because you landed on the lakebed all the time and you can see how narrow the main gear is and it did have brakes on it, not boosted brakes, just plain mechanical brakes but we usually had a rollout of about three miles on the lakebed itself. You can see the door on the right wing. You can see the lever on the door and once you came down the ladder in the B-29 and crawled inside the X-1 they held the door against it and you locked it

on from the inside with that lever and you were in it, you couldn't get out of it. Next slide. That's basically the nose of the airplane and the side of the cockpit where you went in to it. I named the airplane after my wife the same as my Mustangs I had during World War II. You can see the liquid oxygen, how cold it is on the hose we are refueling the liquid oxygen tank. Next slide. There you can see the airplane hanging under the B-29 mother ship and you see the door. When we got up to 10,000 feet I would get on a ladder and they would let the ladder down opposite the door on the right side, slide in it somewhere between 10,000 and 12,000 feet and the reason we didn't take off in the cockpit of the X-1 is because as I mentioned before, the stalling speed of the X-1 was 240 indicated and the climbing speed on the B-29 was 180. If you had an inadvertent shackle release or had to drop the X-1 below that speed you would probably end up in a spin at too low an altitude to recover and get out of. Next shot. I had four chambers on the rocket motor, each chamber putting out 1500 pounds of thrust. Here you can see all four of them running with the standing shock waves in it and as I mentioned before, with all four chambers running we had only two and one half minutes of power or with one chamber running ten minutes, two, five and so on. Next shot. Here you get an idea how big the X-1 is. That was taken the day I broke mach one. I was 24 years old and had damn near as much hair as Bob has on his face. May I have the lights please.

That's the way we started with the X-1 and as I mentioned before I made it a point. and probably the reason I was selected to fly the X-1 was because of my maintenance background. I had been a crew chief when I enlisted in 1941 before the war; I had been a crew chief and after I got my wings and went into the fighter outfit I was always the assistant maintenance officer and then when I came into Wright Field in '45 before I went to the Test Pilot

School I was the maintenance officer in the fighter test section and so, learning mechanical devices was easy for me and probably that was the reason I was selected to fly the airplane by Colonel Al Boyd who was then chief of Flight Test. We began...I remember the X-1 had been up to .8 mach number and had flown 20 powered flights so it was no sweat to fly. So we began. A typical flight, as I mentioned before, we would back the X-1 down into a pit and pull the B-29 over it and hoist it up under the B-29 hookup with a B-7 bomb shackle and then we had the nitrogen system already pressurized and usually it would take us about two days to pressurize it because of the heat generated in pressurizing because we were using evaporative system to evaporate liquid nitrogen to get the high pressure gas to put into the X-1 and it would get pretty hot. And we would let it cool down over night and then top it off the next morning in order to get a full 5,000 psi because that gas was the life system of your airplane. Without it you couldn't get the gear down, no flaps and nothing worked, not even your propellant valves and the actuator on the horizontal stabilizer. So after, when I got in the B-29, they'd fire up the B-29 and taxi out and take off and as I mentioned before, at 12,000 feet I'd go back and get on the ladder and they'd let me down and I would crawl in the cockpit and they'd hold the door on and press against it and I would lock it on. Then we'd ~~ground~~ grind on up to about 20,000 to 25,000 feet and then the B-29 driver would level off and dive the B-29 until it got above 240 indicated and release me. When I fell out of the 29 it was real bright because I had been up in a dark hole and ~~take~~ it took me a fraction of a second to become acclimitized and once I dropped, then I fired off one, or two, or three or four chambers of my rocket motor that I wanted to get me out to the speed I was aiming for that day. Now, some of you have flown high performance aircraft and some of you understand aerodynamics. Now, as a young test pilot at Wright Field and flying P-80s, P-84s most

straight wing aircraft, the early jets that we had had relatively thick wings, about 14% thickness to chord ratio. Now those airplanes, when you got them to say .8 mach number would begin to buffet as the shock waves would form on the thick part of the wing. If you showed up to say .75 mach number or 75% of the speed of sound where the airplane flew very smooth and roll the airplane over and pull about three Gs, under this condition at .7 mach number you ran into the same buffeting that you did straight and level at .8 mach number. So knowing these little tricks of the trade, with the X-1, if the test that day called for taking the plane out to say .87 or .88 mach number, when I hit .87 or .88 and we always did all of the flying in a slight climb, somewhere between 38,000 to 45,000 feet, so that if I ran into problems I could chop everything off and the airplane would slow down quick, unlike the DH 108s and the unfortunate accident that killed Geoffrey DeHavilland and another pilot - they were doing all their work in a vertical position and once they got into problems they just disintegrated. They had no way of slowing down once the airplane went divergent. In my case, when I hit say .87 mach number, which was the mach number I was aiming for that day, I'd roll the airplane over and pull about 3 Gs which would give me a feel for what I would run into probably the next day straight and level at a higher mach number. And this system went fine. It took me nine flights, nine powered flights, to work up to .94 mach number. At about 88% of the speed of sound the airplane ran into its first buffeting because it had an 8% wing which was relatively thin in those days and the buffeting got worse and buffeting in an airplane, just like driving a car over a rough, pot-holed road, it just shakes the whole airplane. You get a lot of feedback in the controls and the like. At the end of each one of these runs I would roll the airplane over and pull about 3 Gs. Well, this went fine up until about .94 mach number. On the .94 mach number flight, I was about 43,000

feet in a slight climb. I rolled the airplane over, and it was rather sluggish on the roll; pulled back on the control and nothing happened. The airplane went the way it was headed. You could flop the controls back and forth. I shut off the rocket engine and jettisoned the remainder of the fuel and came down and landed on the lakebed and while we are talking about lakebeds, a lot of you have flown over Rogers Dry Lake there at Edwards. Then it was Muroc Air Base. Rogers Dry Lake is 13 miles long and five miles wide. It has ~~same~~ A weight bearing capabilities of about 285 pounds per square inch. When it rains in January and February each year it puts about six inches of water on the lake and the wind blows it back and forth and gives you a new surface for the rest of the year, and without the lakebed we would have been unable to fly the rockets that we did like the X-1, X-1A, X-2, and X-15 and the lifting bodies, because mainly when you work off the lakebed you just sit up there fat, dumb and happy and aim for the middle of the lake and if you undershoot or overshoot four or five miles it really doesn't make much difference because you have 13 miles of runway, five miles wide, and on this particular flight we ran out of elevator and came down and landed. It had been really impressed upon us that we really didn't want to have any accidents with the X-1 because we sat there the year previous and watched the DH108 disintegrate, two of them, killing two test pilots, and most all of the Great Britain's aircraft industry came to a screeching halt. We didn't want this to happen to our aerodynamic research program with the X-1 because we knew it would string us out a long long time. ~~and when this happened with the X-1,~~ We had drilled in the top and bottom of the wing, about a foot out from the fuselage, and in the horizontal stabilizer, about a foot out from the fuselage, little 1/8 inch holes every inch. We had these holes connected by tubes to a monometer pressure recorder. We could see because when a shock wave forms on the airplane, in front of the shock

wave the air is supersonic, behind it is subsonic. The supersonic and subsonic air left different pressures over the holes. We could see where the shock wave had formed at about .88 mach number on the wing as well as the horizontal stabilizer and as we increased the mach number the shock wave not only laid down but it ~~laid~~ MOVED back and we were tracing it along the wing and on the tail and at .94 mach number the shock wave on the horizontal stabilizer was right at the hinge point of the elevator which means we lost our elevator effectiveness. So we looked at this data and really, I was a little worried about the whole outcome because Colonel Boyd came out to Edwards and we looked at the data and I told him I didn't have any way of controlling the airplane. It had been predicted by the engineers that the airplane would either pitch up or pitch down when it got in the region of the speed of sound and I didn't want to have any part of that, not being able to control my airplane. We thought that would probably be the end of our research program but Jack Ridley then he was a captain the same as I was and he had his masters out of Cal Tech under Doctor Von Karman, terrific engineer as well as a pilot. We sat down and looked at the capability of moving the horizontal stabilizer with this jackscrew and little air motor. It was a pretty crude system but was about the only thing we had left. So we looked at it, we had never used this system previous in any flight conditions so we squirted a little WD-40 or three-in-one oil on it and got it pretty well working. It got so I could control my angle of incidence of the horizontal stabilizer about a quarter of a degree just by this solenoid controlling the air to the motor on top or the one on the bottom and we decided we'd go up and try that system out. We went up to about .85 mach number where I still had elevator control and I changed the leading edge of the horizontal stabilizer down one degree. I had an instrument in the instrument panel that told me what degrees I had it and I cranked it down

one degree and the airplane pulled 3 Gs without moving the elevator so I retrimmed it, let it accelerate on out to .9 mach number, made the same change and got the same Gs and retrimmed and let it go out to .94 where I HAD lost the elevator effectiveness and made the same change, ~~in~~ AND the airplane pitched up to 3Gs just like it had at ~~subsonic~~ LOWER speeds, so I came down and told Colonel Boyd and Jack ~~and I discussed it and said~~ THAT as far as I was concerned we had the thing licked because if the airplane had a tendency to pitch up or down I could fly it with the horizontal stabilizer. Actually, it only took two more flights. The next flight I took it out to .955 and the airplane began to nose up a little bit as we got increased supersonic flow over more of the wing and I just trimmed the leading edge up on the horizontal stabilizer and held the nose down and then on the flight on October 14, 47, I sat there and had three chambers on at about 41,000 ~~olr~~ or 42,000 feet, the mach meter went out at about .96 or .965 and fluctuated and went off the scale. The mach meter only went to 1.0. I don't think they had a hell of a lot of confidence in ~~it,~~ US to tell you the truth. The thing went off the scale and when it did, all the buffeting quit and I got back some of the elevator effectiveness and we made our first sonic boom. The biggest mistake I ever made was not patenting it. That was our first supersonic flight and when I shut the thing off and it decelerated back into the region of the speed of sound the buffeting picked back up and I lost the elevator effectiveness and THEN IT came back. ~~Got it back and~~ I came back and landed, and to me, one of the most important things that came out of the whole X-1 program was finding out that you needed a flying tail on an airplane that would operate in the region of the speed of sound, other than finding out that your ears didn't fall off or nothing drastic happened in the region of the speed of sound. The reason I say this about the horizontal stabilizer, IS THAT all the data we were getting with the X-1 program, if we flew on day, the

next day the data was reduced and fed right straight in to the aircraft companies like North American, Douglas, Lockheed, Boeing, Grumann and the like, Republic, and at that time, North American had the F-86 on the drawing boards and it was designed with the swept wing to fly in the region of the speed of sound, of course in vertical dives from high altitude. Knowing we needed a flying tail on the airplane they build a trimmable horizontal stabilizer on the F-86A. Then, of course, following the A in ~~the~~ 1950 they came out with the E which had a flying tail hooked directly to the stick and it was amusing to me in '53 when this lieutenant in the North Korean Air Force brought a MiG 15 down to South Korea I was sent over there from Edwards to do the evaluation on the MiG 15 and when I first walked up and looked at the aircraft it was obvious what the hell his problem was - it had a fixed horizontal stabilizer just like a T-33 or P80. ~~and then flying the MiG 15 which I did about 11 flights, mostly on the gages because the weather was so bad there at Okinawa.~~

Flying the MiG 15 which I did about eleven flights, mostly on the gages, because the weather was so bad there at Okinawa, any time, for instance, the MiG 15 would go about .905 mach straight and level and you could drop the nose and pick up speed at about 36,000 feet and if you got into the region of .93 mach number the airplane would begin to buffet and would buffet, rattle and ~~dive~~ CLIMB even with the stick against the instrument panel. To get higher mach number we went in inverted about 45,000 feet and once you got above .93 you had no elevator control whatsoever. Although the airplane would dive to about .98 or .985, above .93 it had no control whatsoever longitudinally. In the F-86 having A flying tail, we shot down roughly 12 MiG 15s for every F-86 we lost, ~~but~~ all for that reason. And that's the reason I say that's where R&D paid off. We flew the X-1, I flew it some 80 flights over the next couple of years; took it up to about 1.5 mach number ~~at~~ TO 1,000 miles an hour and up to about 70,000 feet and then we retired it to the Smithsonian, now the Air and Space Museum, where it hangs. After the X-1 we went through a whole family of research airplanes. If you go back, the X-1 was called the XS-1, X-meaning research and S-supersonic and 1-was the first contract the Air Force let for research airplanes. X-2 was the second contract, 3-4-5 the X-15 was the 15th contract and that's where you get these numbers for the airplane. After the X-1 I think the next airplane we looked at was the X-4 built by Northrop which was semi-tailless and exactly the same plan form as the ~~X~~D H108 but it had much more powerful engines than the ~~X~~D H108, which was a single engine airplane. We had twins in the X-4. ~~About~~ AT 40,000 feet you could accelerate out to its critical mach number in a slight climb because of your excess thrust and AT about .92 mach number the X-4 began to pitch, yaw and roll and if you didn't pop the speed brakes and decelerate under that mach number it would go divergent immediately and that's probably what wiped out the ~~X~~D H108s but they were in a vertical dive

and couldn't slow the airplane up and also very high Q, after the X-4 the X-5 came out built by Bell. We could sweep the wings from twenty degrees to sixty degrees in flight and with the wings in a straight position could get .82 mach number and by sweeping it you could get .91 mach number. A lot of data that came out of the X-5 went into the development of the F-111. Then after that Douglas came out with the X-3 which basically was designed for supersonic intake duct research and by then, hell, we had F-100s smoking around at supersonic speeds so it was a rather useless airplane. It was way underpowered and didn't have the Westinghouse J34C engines that the airplanes were designed for and being underpowered it was funny to fly; had very, very small wings on it and you started at the south end of the lakebed and when you got up to about 260 knots you raised the nosegear off the ground and about 290 knots you got airborne and raised the gear and as you crossed Mojave, heading toward Tehachapi up to about 500 knots you would start a shallow turn and the airplane would buffet and you'd roll back out and wait until you got up past Bakersfield and had the speed to turn the airplane. It never did get much above 20,000 feet and very little above mach 1. So it was retired and put in front of some high school to get kids to enlist in the Air Force with, as most research airplanes are, but after that then Bell went back and lengthened the fuselage on the X-1 seven feet and they called it the X-1A and went to a different propulsion system or pump system, rather than having very thick walls spherical tanks in the fuselage we went to a conical aluminum tank and went to a hydrogen peroxide pump as you well understand the system of decomposing peroxide INTO steam and using that steam to run the turbine pump with a shaft to two other pumps, one pumping liquid oxygen and the other water alcohol and that gave us a much lighter system. The X-1A had basically almost double the fuel capacity we had in the X-1. Otherwise, instead of two and one half minutes

of power we had four and a half minutes of power. We had the same wing, same tail and same engine and we had a B-50 to drop it from so we would take us up to 30,000 feet. This again....Bell had a civilian test pilot named Skip Ziegler who worked for North American. They hired him to do the research flying on the X-1A and he killed himself in an X-2 top-off test back of Bell. He had flown the X-1A some six flights but he never got ~~into~~ IT supersonic because of the buffeting and he didn't have any experience in that regime so when he got clobbered then the Air Force assigned me to the program and I only made four flights on the X-1A. Primarily it was in November and December 1953. Coming up on the 50th anniversary of powered flight and the Navy had taken the D558, Navy Douglas Sky Rocket, almost up to mach 2 and we were trying to get the X-1A up to a much higher speed so all I did, Jack Ridley and I sat down and worked a profile flight out for the X-1A, ~~basically where~~ we dropped it AT 30,000 feet at about .65 mach number which was the max speed on the B-50, and dropped out and fired three of the four chambers, accelerated to .8 and climbed at .8 to 45; fired the fourth chamber which gave ~~him~~ US full thrust ~~to~~ AND level out at 45, accelerate to 1.1 and then pull the airplane up in a 45 degree climb angle and went to 50 at about 1.3 and to 60 at 1.5. And then you pushed over. Now in the early days the airplane like the X-1 or X-1A, the liquid oxygen just laid in the tank. If you went to zero Gs it would cavitate or boil so you had to keep at least one tenth of a G on your tank to keep the liquid oxygen in the bottom to run out the ~~hose~~ PIPE that ran to the engine. With the X-1A, I made ~~the~~ MY first flight on it in Nov 53 and took the airplane up to 1.3 mach number and it flew exactly like the old X-1 did, the buffeting, lost the elevator effectiveness, you had to use the trim ~~to use the flight with~~ on the horizontal stabilizer in the region of the speed of sound. When you got supersonic it all smoothed out and everything came back to you. The second flight I took

it to 50,000 feet up to 1.5 which was fastest we'd ever had the old X-1, the only straight wing airplane that was flying at that time. Then on the third flight I took it to it to 60,000 feet and held it level up to 1.9. In those days although we were quite a ways ahead of most aircraft we had the life support equipment available to us like even in the X-1 I had a pressure suit and any time I operated above 50,000 feet, because I worked on them in 1945 in the pressure chambers at Wright Field. So I had a pressure suit in the X-1A and on the fourth and last flight everything went like clockwork. I was launched at 30,000, got beautiful top-off, got all my chambers to full thrust and everything went like clockwork except the only thing that I goofed on was, you're sitting there with a pressure suit on and looking through a visor that has filaments on because these little filaments of wire in your visor connected to a rheostat on the instrument panel, and when you do this sort of thing you breathe a little bit fast and this rheostat, you've got to turn it up when you begin to fog up on the inside and you really can't see too good out of the old pressure suits that we were wearing. The only thing that you've got as an attitude reference in the X-1A was a little 8-ball gyro about the size of a baseball. When we're climbing at 45 degrees you can't see the ground and you're just looking at a black sky and trying to keep one eyeball on the flight indicator and the rest on the pressure on your rockets and I got the airplane a little bit steep. Instead of 45 degrees I had it probably up to 55. When I went to 60,000 feet the object was to push over to one tenth of a G and become ~~lateral~~ level at 70,000 feet and then hold it at 70,000 to burn out. Being a little bit steep and not being able to get the nose down I floated on up to 80,000 feet and became level at 80,000, I was sitting there looking at 1.9 mach number and our mach meter this time optimistically went up to mach three. I sat there and the thing accelerated quite rapidly because we were getting down where we had a little

more thrust than we had weight and we were picking up about 31 miles per hour per second. So the old mach meter was really winding up and I sat there. I had been told by Bell engineers that the X-1, because of the very small tail that it had, when we went to 2.3 mach number you better pay attention to what you are doing because we think it's going to lose stability on all three axis. Being programmed to take the airplane as fast as it would go, I sat there fat, dumb and happy as I went through 2.3 mach number, sitting there looking at it, this airplane began to yaw to the left and I couldn't believe it. The airplane just began to flatly yaw to the left and I pushed the right rudder, like I'd been taught in flying school and nothing happened. When the thing went through about 30 degrees the outside wing started coming up because of the dihederal effect. I cranked in full aileron and nothing happened. Time at 2.55 mach number at just under 80,000 feet, that's about 1650 true, the airplane was yawed 40 degrees and the wing was just starting up. I had full right rudder, full aileron and was breathing hard. The thing flipped all the way inverted and when it went inverted it pulled about two negative Gs and the canopy busted and my suit inflated. From there it yawed 40 degrees the opposite direction and that thing really wound up in some of the hairiest gyrations I'd ever been exposed to. I've got about a ten second film that was taken from a camera on the right side of the airplane out across the top wing. It's short but it gives you an idea...this is in real time so it gives you an idea of what it looks like from a cockpit so if you'll run that thing by and then turn the lights back on....Here you'll see an airplane tumble. Okay, if I can have the lights back on.

I really didn't know what happened until I saw this film. We got the cause the airplane as it got up, went through 2.3, the shock waves, see a shock

wave forms on the nose of the airplane, becomes a cone, it lays down and becomes smaller and smaller. At 2.3 roughly, the shock wave was coming off the nose of our X-1 with just outside the tips of the horizontal stabilizer and vertical stabilizer. At this point we lost stability on all three axis and we got rates of roll of some 588 degrees per second or almost twice per second. What was happening, when the airplane is yawed 40 degrees and it is rolling that fast when you get the bottom up you get about 9 positive Gs, about 2Gs side load, about 3 negative, 2 side and 9 positive. WHEN You go through two cycles of this a second you get a little disoriented. My problem, I thought the tail had come off the airplane. I had no idea what was going on, and IN the X-1A, the same as the X-1 we had no ejection seats and no way of getting out of it so you are part of the airplane. I was wondering what part of the Tehachapis I was going to hit in but I fortunately rode the thing out and the first thing that I recognized WAS an inverted spin at about 34,000 feet and I put the controls with the spin and flipped it into a normal spin and popped it out of that with opposite rudder and elevator at about 27,000 feet. At 25,000 feet then I looked around and found the lakebed and glided back in. After they replaced the canopy and got a new pilot ....The main thing, both the X-1 and the X-1A were BOTH stressed for 18 Gs positive or negative and they were very well made airplanes. As I mentioned before, probably had I had a seat or capsule, I probably would have ejected but I didn't so I stayed with it and fortunately brought the airplane back. On the nose, the side of the nose of the airplane, when the airplane yawed at 2.55 mach number, we had 24 ST or aluminum durall skin, very thin, and the whole side of the nose GOT VERY HOT because of the heat in excess of 400 degrees, ...which is the limit OF aluminum airplanes.

(changed sides of tape)

~~heat in excess of 400 degrees which is the limit to aluminum airplanes.~~ After the X-1A Bell came out with the X-2 and knowing what they did, they built it out of stainless steel and with that airplane we went out to 3.2 mach number and up to about 126,000 feet. ~~there and by covering~~ DISCOVERING the need for reaction controls which were put in the X-15 and the X-15 was one of the ~~very~~ MOST successful research airplanes, ~~that went out without a ceramic coating on the leading edge for re-entry heating~~. The #1 and #3 X-15s got up to just above ~~point~~ mach six or around 3600 or 3700 miles an hour and the #2 X-15 with Pete ~~and I~~ Knight flying it they put a ceramic coating on the leading edge of the wings and nose and it got out to about ~~7.6~~ 6.7 mach number and during re-entry it had heat that would, it could melt steel, the airplane could not stand it but for the ceramic coating, ablative type cooling til it decelerated under mach 6 of course, protected the airplane and that was the fastest winged vehicle we had ever flown. It got up to about 64 miles. Of course, after that, came out ~~with~~ Kelly Johnson ~~in~~ with Lockheed's YF-12, that being of titanium operates at about 3.2 mach number maximum like the B-70 made of honeycomb stainless steel and of course the shuttle which we are all pretty familiar with. Basically it's interesting to see how airplanes have evolved today versus what we used to fly with the old P-51s and the development of gunsights and radar, range computing and now I currently am a test pilot consultant to the commander of the Flight Test Center at Edwards so I still get to fly Air Force airplanes. The amusing thing to me is to fly both the F-16 which I have quite a bit and the Navy F-18 which I flew about three months ago back at McDonnell Douglas, both fly-by-wire systems computer operated, especially the F-16 with the side armed controller with a strain gage and

all you're telling the computer is give me two Gs, 3Gs, 4Gs or 200 degree per second rate of roll, the computer analyzes everything, comes back and gives it to you. In the case of the F-18 the amusing thing about it, you get in the cockpit and you have no instruments in there; you have cathode ray tubes; any of the three can be projected on your heads up display, ~~and get~~ up ~~and~~ turn the master switch on and it comes up with a checklist. It's got a 12,000 word memory bank in the computer and when you start your airplane up the checklist disappears and if you have a malfunction it tells you what your malfunction is, the best course of action, and all these things are beautiful. It's 1980 technology and it's fun to fly them. If you have any questions, I'll be happy to answer them. If you're tired of sitting, I'll gladly sit down.

Thank you very much.

I've got a question that's really been eating me up. I read in a magazine some time ago about the XS-1, and the design and the facts at that time we had accumulated in the design technology for supersonic flight. As the Bell engineers looked around trying to conceive a body shape that would be socially acceptable at that speed, the only thing they could comfortably come to was a 50 caliber machine gun projectile which was the only bullet at that time which had achieved the speed of sound. Is that correct?

Yeah, the nose of the airplane had the same ~~old guise~~ GIVE as a 50 caliber bullet. And it was successful. Obviously, if we knew then what we know now anything could fly supersonic if you put enough thrust behind IT ~~F-4 or something like that~~. We had no data....unlike some of the magazines in Germany said, a lot of the data we got back from Germany was used in the design of the X-1. The X-1 was designed in 1943, construction was started on

the airplane in 1944 and all this was in-house by Bell Aircraft Company and they did a beautiful job - a guy by the name of Woods and Stan Smith and people like that.

Would it be.....would you like to go on....I've got a couple more film strips about him, flying, which he really didn't want us to show unless somebody was interested.

You want me to narrate them

Could you talk briefly about the broomstick? You know, when you broke the speed of sound.

On October 12, was a Sunday night and Glennis and I went to Pancho Barnes' to look around. Surely a few of you people remember Pancho Barnes' place. We were out horseback riding, which we liked to do out there, that night after dinner, we went out the gate and someone closed the gate and we were racing on the way back and I was in the lead and wasn't seeing too good. I saw the closed gate and I laid my horse down but he missed the gate and hit the fence about one post over and flipped and threw me about, I don't know, a few feet, and I landed on my right side and ended up busting two ribs. That was on Sunday night, the 12th and although we were a very small detachment there at Muroc we were isolated and no one paid a heck of a lot to what we were doing but I really was hurting pretty bad so Monday I went in to the doctor at Rosamond and he said yes, you've got two broken ribs and he taped me up and I went out to the base that afternoon and got with Jack Ridley and told him my problem, and we had the X-1 hanging on the B-29 in preparation - we had pressurized the nitrogen system in preparation for the October 14th flight. We really didn't know we were going to get the airplane above mach one on that particular flight, it just happened to work

out that way. I got in the cockpit of the X-1. I could go down the ladder OK and I could get into the cockpit. You had to bend over real tight, and it hurt, but I could handle it. Then when Jack held the door down and, you saw that lever, you had to take your right arm and raise it in order to lock the rollers on the door. I just couldn't do it. I couldn't get enough strength in my right side. I told Jack my problem; he was looking down through the window and he said we'd just look at the thing awhile so we went in. Now the lever on the door of the X-1 had a little slide out where two rods came close to each other, about six inches apart, so old Jack went in and get a ten inch broom stick and sawed it off and brought it back and when I got that lever started up I could stick that broom stick between these two rods and get a ten inch mechanical advantage with my left hand and close it. When I did this I knew I had it licked because it's no problem flying an airplane sitting in a normal position. It hurts a little bit but it's no...it doesn't slow you down any and with this broom.....I always wondered what happened to that broom after the excitement of getting above mach one but that's the way it happened. That's the way things went in the old days. Bob is this the NF104?

This is still on Bell.....One thing I wanted to point out is we sometimes think that we've always been very modern, very sophisticated in aero design. There's one sequence here that shows Chuck going down_____ elevator down to the X-7 or X-1A. You've got to see it because it's strictly manpower_____. This is a _____film so maybe Chuck you could say a few words.

I can't see it and be close to a mike too. That's the X-1 with the flaps down which you will notice and basically, a lot of this is propaganda because it was taken in 48. That's looking into the cockpit and I point out

I was exactly 24 years old when I broke mach one. That's the flight control system, it was a wheel instead of a stick and there's the entrance to the X-1 that shows just walking around the wings of the airplane we had a pitch and yaw indicator on the right tip of the airplane, and ~~it~~ WE TOWED ~~toned~~ it down for a ground run and you saw a slide of the 6,000 lb thrust rocket engine. These films probably were taken in 48, the year after we broke mach one and when they started releasing the data on the airplane. We're looking at the rocket engine in the TAIL ~~back~~ itself. Incidentally, the alcohol we used was grain alcohol and we had to put a 3% poison solution in it to keep the guys from drinking it. That's the instrument panel of the X-1. That's the liquid nitrogen evaporator, I'm sorry, that's how we got our 5,000 psi was evaporating liquid nitrogen to the HEAT ~~sheet~~ exchangers and putting the pressure in the X-1. There you see the chambers running and the standing shock waves in the flame itself. This film, I think Bell took it on....yeah, that's 6063, that's the #2 X-1, it wasn't the first one we flew at supersonic speed. That airplane being lowered down into the pit and then the B-29 will be pulled over it and it will be hoisted up under the bombbay of the B-29. We had especially modified B-29 with part of the bombbay cut away and the wing tips themselves were actually just under the inboard engines of the B-29 and the leading edge of the wing was just a few inches back of the propel~~lants~~LERS. There's the B-29 taking off from the runway, the old South Base at Muroc Air Base. ~~_____~~ THE ~~your~~ tracking radar that used to receive our telemetry channels. He would dive, as I mentioned, THE ~~a~~ B-29 up above 240 indicator and then go ahead and pull a lever to release the X-1.

(question, couldn't hear on tape) IS THIS IN ACTUAL FLIGHT?

Actually it's just a little fake sitting on the ground cause there's no wind blowing through there. We didn't have any WD-40 in those days so everything

is stuck on it. Two or three times they pulled the lever to release the X-1 without pulling the safety pin out ~~with~~ OF THE shackled and we got jammed up. As I mentioned before, there was very little film coverage on the X-1 program. In fact, it was pretty sorry stuff. Normal contrails when you are above 36 - 38,000 feet with the rocket. As a matter of interest, my first three flights in the X-1 were glide flights without fuel and ~~we~~ I ended up dog-fighting with Hoover in a P80 all the way down. Beautiful airplane to roll. As I mentioned before, your touchdown was somewheres around 193 - 195 miles an hour. All your landings were dead stick of course. I was sitting against a liquid oxygen tank full of liquid oxygen and that was the coldest cockpit I've ever been in in my life, it was really bad. I think you all have been sitting here long enough.

BOB Would you like one more short movie?

Which one is that, Bob? Oh, the NF-104. Give me a little lead in into this...when I was calling the action at the Astronaut School out there we were trying to develop an airplane that would operate above 100,000 feet to give us two minutes of zero G in an environment that you needed a pressure suit on with a sidearm control, very much like a space capsule and we took three 104As and put a 6,000 pound thrust LR-57 engine in the tail and we equipped the airplane with two ports on the top and bottom and each side of the nose and one in the top and bottom of each of the wings where we used hydrogen peroxide reaction controls with the sidearm controller because when you, in a typical flight in the NF we would accelerate out to oh, roughly mach two at 41,000 feet on the afterburner engine and ignite the rocket engine and go out to 2.4, pull 4 Gs to 72 degrees and then as you went through about 65 - 68,000 feet the afterburner blew out on the J79 engine on the 104 and then you'd have to watch your tailpipe temperature, come back on the throttle. As

you went through about 78,000 feet you would start over-temping and you would have to shut the J79 down and the rocket engine would take you on over. We got the airplane up to 118,000 feet. Now when you go through roughly 100,000 feet in that attitude if you do nothing, see as you go above 100,000 feet your aerodynamic controls are no good and so the airplane will go right up there and fall back in tail first so what you do when you start coming this way, you rotate your side arm controller ~~hoping~~ opening the top thrusters, hydrogen peroxide thrusters on the nose and that will rotate the airplane say if you have them open for two seconds, it starts rotating the airplane about the CG. If you do nothing the airplane will sit there and rotate about a CG all day but when you reach the attitude that you are aiming for when you open the bottom ports the same length of time you had them open at the top and that stops the airplane there. You can control it laterally, directionally and longitudinally. You keep stepping this thing down until you come back into the atmosphere at 100,000 feet and then come back down through 40,000 feet and relight your engine because the wind blowing through the intake will windmill the engine. ~~and~~ On this particular accident we were trying to establish at what altitude would we get aerodynamic pitch up because the 104 will pitch up at angles of attack above 30 degrees because of the T tail and we were trying to establish at what altitude would this aerodynamic pitchup be equal to the thrust on the top hydrogen peroxide rockets and we had anticipated it would occur at about 93,000 feet. I made a flight that morning with full pressure suits, full pressure suits very much like the astronauts wore, and I made a flight that morning to 108,000 feet at 50 degrees angle of attack, and could overcome it with the hydrogen peroxide rockets and then I kept the suit on because you get pretty sweaty inside of a suit and went back up after lunch and went over the top at 104,000 feet at 50 degrees and ended up in a no-wind

condition. The airplane set there and I had both thrusters open on top and I couldn't get the nose down so the airplane went back flat, ended up flat at 104,000 feet and from there on I made 14 flat turns to impact; the airplane did, I didn't. The reason we were in such deep trouble was because being flat, the engine RPM wound down and we had no hydralic pressure, not even the 8,000 lbs. Consequently, it locked up all of our flight controls because it was an irreversable system. As I tried at 34,000 feet, I popped the drag chute which came out and righted the airplane, dropped the nose, and as we went through 180 knots the shear link on the drag chute is designed to fail so at 180 I released the drag chute but the engine RPM was zero and the hydraulic pressure was zero and the leading edge of the horizontal stabilizer was full down because that's where it locked. The airplane pitched back flat in less than two tenths of a second and from roughly 34,000 feet it didn't even turn, it just fell flat at 100 miles an hour and at roughly 11,000 feet above the ground I decided me and my airplane better part company and so I ejected. Now we use a rocket seat in the NF-104 that gives you about 100 mile an hour straight up, ~~and about ten feet and~~ I pulled the D ring and the canopy went and the rocket seat blew me out. Well, the airplane is falling at about 100 miles an hour so the seat gives you about 90 straight up so you're suspended there. The type of chutes that we wear the back packs that we wear have quarter bags on the canopies. That's for high speed ejections, where we come out at 400 knots. OR MORE. The quarter bag on that canopy, until the pilot chute pulls that quarter bag off the canopy, your canopy, if you didn't have the quarter bag it would pop and would probably split and fly into a million pieces. The quarter bags keeps it reefed until you gradually slow down and it opens gradually. When I ejected ~~roughly was suspended~~ two tenths of a second or two seconds after you leave the airplane a timer cuts your stirrups on your leg

restrainers on your heels and rleases your leg from the seat and the lap belt blows open and a butt kicker kicks you out of the seat. The seat had rotated when it came out of the airplane roughly like this and kicked down. I'm falling after the airplane and the seat, I felt the F1 release go on my parachute but the qwuarter bag was over the canopy and the parachute just streamed and until you get up to about 60 miles an hour the pilot chute won't pull the quarter bag off the canopy. So I'm sitting thre in a good position falling straight down. I have a pressure suit on, it's pressurized, but the seat fell and became entangled in the shroud lines of my canopy and by the time I had fallen far enough to pick up 60 miles an hour to pull the quarter bag off the canopy then the canopy popped and that threw me like this and the seat came down through the shroud lines and hit me on the face and busted all the goldfish bowl off my pressure suit helmet and what hit me was the rocket, the end of the rocket on the back of the seat and it's burning, and being in 100% oxygen atmosphere the thing deposited warm propellant on the inside okf my pressure suit and all my seals began to burn and fortunately, when the thing hit me it cut my left eye down and my socket filled with blood so the flame didn't hurt my eyeball but I got quite a bit of skinwork on my neck and shoulders. The only way to shut my oxygen off was to raise the visor on the pressure suit, what was left of it, to shut off the oxygen in the parboil kit. So I went through this little exercise because I couldn't see because there was so much smoke and flame and by the time I got to the ground I had the visor up and shut it off to where I could see a little bit out of one eye and hit the ground, and that's basically what happened. Just a matter of luck and one of those one in a million accidents. The film itself was taken from a 16mm camera 67 miles away from the airplane with an oscand tracking system, automatic. This accident occurred on December 12 or 13, 63, and gives you an idea of

their camera tracking capability even in those days so if you run it through I don't know if it's sound or not, is it, Bob? You get an idea of what a F-104A, built by Lockheed, looks like compared to the NF-104. We put a 6,000 pound thrust rocket engine just about the J79 engine in the tail. You can see we extended the wing tips 24 inches in order to hold the hydrogen peroxide thrusters on the top and bottom of the wing tip itself. Incidently, I was the first military pilot to fly 104s. That was my test program in 1953. That airplane has been around a long time. Lockheed did a very good job with it. There you see the hydrogen peroxide thrust. Just stick your finger in that little hole and turn it. Incidently, those, the way we used pure 190, roughly 95% hydrogen peroxide, we did on the X-1A and the NF-104 for those thrusters. What you do run hydrogen peroxide liquid across the catalyst crystal, it can be either silver or platinum screen. It decomposes when it, the peroxide decomposes it expands roughly 1,000 pounds in volume and gets up to about 1200 degrees and turns into a very hot steam. As a matter of interest that's what we ~~are~~ were using on the Budweiser rocket car last year at Edwards; when we got the car up to roughly 739 miles an hour we were using the same system on that car as the propulsion system, getting roughly about 13,000 pounds of thrust out of a little tiny engine. These thrusters on the NF104 put out roughly 500 pounds of thrust in those little old chambers. We had two of them on the top and bottom and each side of the nose. Of course, the top and bottom of each wing tip. There you can see the thrusters on the side of the nose itself. There you see the rocket engine above the tail. The J79 roughly puts out 10,000 pounds of thrust without the AB, 15,000 with. And you get the additional 6,000 out of the rocket engine. We have about two minutes out of the rocket engine and of course, unlimited out of the J79 when we burn JP-4. A suit such as this is good in a complete vacuum. It's basically the same suit the astronauts wore

on their Mercury and Gemini flights. Before you get in an airplane, normally checkout the suit for leaks and that's what they were doing with the face piece down. I don't know why they have to show all the people standing around looking and gawking but that's the way it is. Use that box that's hooked into you with an umbilical cord is usually liquid oxygen that's evaporating to keep you cool in the suit because the suit doesn't breathe. We obviously could have used an electric driven hydraulic pump but we didn't have any such thing in the 104s. You take off normally with the afterburner running on the J79 when you get airborne and get the gear up you come out of afterburner and just use the mill power to take you up to about 35,000 and then ignite the afterburner and accelerate out. See the long nose boom with the yaw and pitch vane on the nose itself. You get an idea of a rocket engine running. Kinda leave your chase plane behind. Incidentally, that rocket engine burns JP-4 and hydrogen peroxide. This film here, the airplane is up, here we pull up but the film where you see after the rocket engine burns out and then I'm holding full nose peroxide thrusters open to push the nose down, that airplane is roughly 60 some miles away from the camera and it is amazing what good coverage it got. I've never seen this thing all in its entirety but they obviously got a bunch of stuff in it that have an awful lot to do with the flight. A lot of times we dead sticked the airplane in on the lakebed when we couldn't get an engine started. Sometimes the igniters failed which a lot of you maintenance types are familiar with. On a normal flight with the 104 you'd touch down around 145 knots with blow air on your flaps, without it 170 and when you deadstick it in you touch down around 220. Bob, is this the one that has the accident on it. You sure? Paul Mathes was up there on one of the flights in the cockpit. Now you are looking at the airplane at 180,000 feet. There's the hydrogen peroxide. I start out with _____ thrust trying to get the nose

down and then I open it up completely until I run out of hydrogen peroxide. Here you see the airplane beginning to rotate to the side. It's hard to see and really, in fact it's not good quality film because it's been reproduced so many times. But you can see the airplane spins quite flat. There you get an idea. It's typical of a T tail airplane what happens when you pitch over 30 degrees, the wing blankets out to flow to the horizontal stabilizer which is on the T tail and that's one of the problems of that design. As a matter of interest, what you need, we used to spin the 104 a lot and when you get the airplane in a flat spin you need about 98% engine RPM with the engine turned up like that the gyroscopic effect of that big engine in the little airplane causes when the airplane rotates flat to precess the nose down and that's the way you recover. But we had no engine in this flight. You see the drag chute come out and right the airplane but it flipped back flat when I jettisoned drag chute. There's a drag chute and when it jettisoned it goes back flat and then you see the mountains go by. You will see the puff of smoke where I ejected. There they come back and get the chute. That film right there is almost 20 miles from the camera. That's about all you will see. Might as well turn the lights on, Bob.

Looks like when you left the airplane, it got out of a flat spin and headed straight down.

No, the camera is almost looking straight at it. It's falling straight down. The cameras on the ground roughly 20 miles away from the impact.

Question (unable to hear on tape)

You've got a lakebed, you don't ground loop on a long runway like that. No it was directionally very stable. Bob, is it OK to knock it off now? If there's no other questions, thank you very much.

Thank you again. We appreciate it very much. Thank you for all coming this evening and the suite will be open for those of you who would like to imbibe. Thank you.