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DEPARTMENT OF THE AIR FORCE
DEPARTMENT OF HISTORY
USAF ACADEMY, COLORADO 80840



REPLY TO
ATTN OF: DFH

10 JAN 1975

SUBJECT:

TO: Brig General Charles E. Yeager, USAF
Director of Aerospace Safety
AFISC/SE
Norton AFB CA 92409

Dear General Yeager:

We sincerely appreciate your cooperation in granting us an Oral History interview on 18 October 1974.

Attached is the transcript of your interview. Please make any additions or corrections you deem necessary. If there is anything you desire to delete, please indicate this in the margin opposite the material to be deleted. Once you have reviewed the manuscript, please specify on the access form attached the conditions under which it may be used and return both the form and the transcript to the Department of History. The complete interview, with access form attached, will be reproduced and deposited in the USAF Academy Library, the Columbia University Library, and the Office of Air Force History.

I recently talked to Lt Colonel "Max" Bushong at the USAF Military Personnel Center. He indicated that in the near future he would be sending us a set of transcripts regarding the X-1 project. As soon as we receive the transcripts, I will send you a copy for your personal files. Once again, we at the Academy would like to thank you for your generous gift of time as well as the sharing of your memoirs with both the faculty and the cadets.

Sincerely,

ROBERT S. BARTANOWICZ, Captain, USAF
Director, Oral History Program

2 Atchs
1. Transcript of interview
2. Access form

DK

U. S. AIR FORCE ACADEMY ORAL HISTORY PROGRAM.

Interviewee: Gen. Charles (Chuck) YEAGER

Interviewers: Lt Col MacIsaac, Capt Kline, Capt Bertanowicz

Date: 18 October 1974

Gen. Yeager: This is General Yeager, covering the X-1 program.

In 1945 when I returned from combat I was assigned to ^{PERRIN} Wright Field, Tex., as a basic instructor. The Air Force came out with a policy that ~~any~~ anyone who had gotten shot down, had been a prisoner of war or an evader, could ~~have~~ select any field in the United States to be assigned to. My home was West Virginia, and I looked at the map, and the closest Air Force ~~base~~ base to West Virginia was Wright Field, Ohio, and I asked that I be assigned to Wright field.

I got orders assigning me to Wright Field. I had about 1500 hours in P-39s and P-51s, but I did have a maintenance background -- I had been a crew chief on AT-6s and AT-11s. I had also been maintenance officer in our squadron when we flew P-39s, and I was the assistant maintenance officer in our squadron when we were in combat in Europe with P-51s.

So when the personnel people looked at my record, and I reported in to Wright Field, ~~wh~~ they saw that I had fighter time, they saw that I had maintenance background, so they assigned me to the fighter test section in the Flight Test Division, as the assistant maintenance officer in the fighter branch. And my job when I was assigned there was to run the functional flight test on all airplanes as they went through the maintenance program. ~~At~~ that time they had P-51s, P-38s, P-47s. The P-59 and the P-80 were just coming into the test program. This was July of 1945.

So I began, since I was ~~more or less~~ ^{maintenance qualified} more or less, and had quite a bit of P-51 time, and the P-63, I flew that airplane. I checked ~~it~~ out in a P-38, flew it, and I had flown the P-47, so I moved into that airplane, and the pilots checked me out in the ^{P-59} ~~P-39~~, the first jet airplane that I flew.

Then an accelerated service test took place at Muroc Air Base, on the old North Base, and I was sent out there in August 1945 as the maintenance officer in the test program, where we ~~were~~

testing P-80s, and being the maintenance officer and since it was a test program, the airplanes were involved in a lot of maintenance. Consequently I got to fly the P-80 a lot more than most of the test pilots, since I wasn't a test pilot -- I was strictly a maintenance officer.

Then after getting a lot of P-80 time in a couple of months, we had the mission to ferry one of the P-80s from Muroc back to Wright Field, and since I had the most time and probably knew the airplane better than Col. Boyd who was the flight test division commander, ~~gave~~ ^{gave} me the mission of moving the first P-80 to Wright Field. So I took it back -- it only took me a couple of days, and had no problem, so I delivered the airplane into Wright Field, and had no problem whatsoever.

Then we started putting on air shows in the fall of 1945, and he liked the way I flew, so he asked me if I'd like to attend test pilot school, and I said yes, very much, because I didn't know really an awful lot about the mission of testing ~~size~~ aircraft.

So I started into the Test Pilot School in the spring of 1946, along with Bob Hoover and other pilots who were new pilots in the Flight Test Division there.

After graduating from the Test Pilot School in the summer of 1946, then I was assigned to different test programs involving P-84 type aircraft. We flew a lot of German and Japanese aircraft that were captured after World War II. I evaluated ~~all~~ of the

P-82, the Twin Mustang and lots of other aircraft. And it was just a matter of Flying test programs as they came along.

Then in the summer of 1947 -- rather in late spring -- I had been following the Bell Program on the X-1 very closely. I really didn't know too much about the program. I knew it was a supersonic research airplane, and the aircraft was . . . really quite a strange program to me, I didn't understand the systems. I had seen the airplane at Muroc, so when the Bell Aircraft Company^o was delaying the program a little bit because of a bonus problem with their pilot, the Air Force stepped in and took the program over.

Now we heard ^{2a]} rumor ^{there} in the fighter test section in the Flight Test Division that the Air Force might take over this airplane, and then we began talking among ourselves about what was the mission of the aircraft. Obviously we knew a lot about the effects of compressibility on the P-80 and the P-84s that we were flying, and we knew the dangers of flying ^a an aircraft in the vicinity, if it got into compressibility, so . . .

That's about the extent of the knowledge that I had about the program. And finally the word came down that Col. Boyd was asking for volunteers to fly the X-1, and of course since it was a new program and looked interesting I volunteered my

services along with about 100^{others}. . . well, there wasn't really . . . I would say there was a total of 150 pilots in the Flight Test Division. There was only about 30 to 35 pilots in the fighter test division. There was bomber, cargo, helicopters were coming into ^{being} effect at that time, so all in all I would say there probably wasn't more than 25 or 30 guys who really volunteered for the program, because all of them were not qualified, meaning the guys who were flying heavy bombers or cargo obviously would be a little bit out of place in a small aircraft like that, that resembled a fighter.

So we went through the selection process, and I remember being called up to be interviewed by Col. Boyd and then Lieut. Col. Ascani, and he talked to me about why I wanted to get into the program, and my answer was that I thought it was a test program and that's our job and it looked interesting, so consequently . . . He asked about the family. I was married at the time, and had one son and Glennie was pregnant again. And he didn't pay too much attention to the fact that I was married -- he just wanted to know what my attitude was about flying the aircraft. He realized that I only had a high school education, I didn't have a degree, and it was more or less a man-to-man talk about why I wanted to be in the test program of the X-1.

Things went along for two or three weeks, and we heard nothing. Finally in the summer of . . . oh, about two months later I would say, we were called up, and Col. Boyd said, "You've been selected to be the pilot of the X-1, and I've selected Lt Bob Hoover to be your backup pilot, and Capt. Jack Ridley to be your test engineer." And he asked me, did I realize what this meant to my career if we were successful with the X-1. I really didn't know what he was talking about, because I was a rather young officer and hadn't been exposed much to publicity and things of this nature. He just went to say that "it will change your whole way of life if you are successful; this is a very important program of the Air Force, and we are stymied right now with the ^{so-called} ~~supersonic~~ sonic barrier and everything is coming to a screeching halt, ^{and} we can't do any planning in the supersonic range because we can't get an airplane ^{through} to the ~~so-called~~ sound barrier; instead, if we are successful with this program, it means that it opens up an entirely different area, and you'll go down in history," and all of this. He was a very wise old man, and everything that he said came true later on in life. He also impressed on me and Bob Hoover and Jack Ridley that safety was a primary factor in this whole test program of the X-1. He said, "If at any time you guys are unhappy with the way things are going, or in your mind the risk factor is getting quite

high, he ~~was~~ says, you can quit, stop the program, and we'll back you 100% and ~~there~~ there won't be a word said about it." He said, "You guys are the experts in this thing, and you are the guys that you are doing it, and it's your neck, and we want you to realize that and keep safety as a primary factor."

As this thing went on, the first thing that we did when we were selected as a team we flew up to the Bell Aircraft Company in Buffalo, N.Y., and we met Mr. ^{LARRY} ~~Laire~~ Bell at that time, who ^{PRESIDENT OF BELL} had built the X-1. I met Dick Frost, who was the test engineer on the airplane. I saw the X-1 intimately for the first time. We went over all of the systems. We sat down and Dick Frost went over all of the systems. Really when it was explained to us, and you look at the layout of the aircraft, I wasn't too /./. It really wasn't too complicated, it was quite a simple airplane, and the dome regulators that were controlled by the pilot in the cockpit -- I had been familiar with dome regulators since I was a kid because my father was in the natural gas business and he used dome regulators all the time. I had torn them down and put new diaphragms in them and rebuilt them, so it was really no problem to understand the systems of high pressure gas which I had been working with ever since I was a kid.

Then we made a ground run on the X-1, and this ^{is} really ~~impressand~~ impressive -- seeing them putting liquid oxygen ~~oxyxxygen~~ into the aircraft, and also pressurizing the tanks

and running the rocket motor. Of course Dick Frost was doing all of the handling of the igniters and the like, so after one ground run he shut it down and let Bob Hoover and me make a run ourselves. It really wasn't too complicated. You just had to monitor the systems, the chamber pressures and the light. After a visit up there of about four or five days I felt as if I knew the program, and I began to develop a confidence in the X-1 program that increased as the program went along, and that was confidence in the airplane itself, and really I always looked at an airplane as a piece of machinery that sort of responded. I always had a good feeling for machinery, I always respected it, I wasn't afraid of it, but I most certainly didn't abuse it, and that's the attitude I had that started there on my first ground run with the X-1 -- I think it was a confidence and a faith in the aircraft that kept developing as the program went along, and to the end I almost knew that the X-1 wouldn't either snap ends or bite me without giving me some sort of warning, and that's the kind of confidence and faith that I developed in the whole program that carried on throughout the program.

We loaded the X-1 under the B-29 there at Buffalo, and had Maj. Bob Cardenas who was the B-29 pilot. I've forgotten who the copilot was -- it changed quite a few times. But

normally Jack Ridley, who was an excellent pilot, flew copilot on ^{the} B-29, and later on in the program actually flew the B-29 itself from the left seat.

We took the X-1 from Buffalo -- I've forgotten where we landed, somewhere in the center of the United States, and spent the night, and then took off the next morning and flew on in to Muroc Air Base.

When we moved the ~~XXXXXX~~ X-1 to Rogers Dry Lake and started the program I wasn't too familiar with the landing speeds, the techniques and the patterns that had been developed with the X-1.

Now Bell Aircraft Company when they initially got the X-1 they started out with a pilot who was assigned to the program by the name of Jack Woolame, and Jack made the first glide flights in the X-1 in 1946, because it didn't have the rocket motor ready to put in the airplane, so the first few flights were made at Pine Castle, Fla., without a rocket engine in the airplane and also the aircraft was empty obviously because they couldn't use the propellants aboard.

And he had one accident where he got goofed up in a pattern that kind of wiped out the gear on the thing. Then they took it back to the factory, repaired ~~ix~~ the damaged gear. At that time they put the rocket motor which was ready to be installed in the airplane, in the X-1, and started the ground runs and checking out the systems.

Then in the fall of 1946, after Jack Woolams had made his glide flights and they were installing the motor in the X-1, Jack Woolams got killed in the Cleveland air races with a souped up P-39. Since he was out doing some high indicated air speed work in anticipation of the ^{THOMPSON} Topson closed circuit trophy races, it's thought that the windshield part blew in on him and killed him. So Bell lost their pilot. They had a backup pilot on the program by the name of Chalmers S. Goodlin -- "Slick" Goodlin was the pilot's name -- and he was an excellent pilot; he was 24 years old, same age as I was at that time, and he had been with Bell for quite some time. He had done some of the test work on the first swept-wing that was on the P-39. He had flown the P-59. So he was assigned to the X-1 program in the fall of 1946, and during the winter of ¹⁹⁴⁶ 1947. And he flew -- he had the first Phase I portion of the X-1 program. And that Phase I in the contract call^{ed} that Bell demonstrate the airplane on 20 powered flights, take it up to .8 mach number and 40,000 feet, and Slick did this Phase I. He collected a bonus in the order of \$ 50,000 bucks for phase I, and after he completed this Phase I in the spring of 1947, then they got into bickering about Phase 2. Phase 2 on the X-1 called that the airplane be taken to 1.1 mach number, or supersonic speed, and Slick since he was the pilot on the aircraft they got to discussing how dangerous it was. He had a contract in the order OF

150,000 bucks. I don't know exactly, but this was the amount that was ^{DISCUSSED} involved, and he had the contract with Bell. If he completed Phase 2 this was his bonus money. But his problem was that he wanted it paid over a five years period, so that he ^{would get} 30,000 a year, for income tax purposes, because obviously a single guy ~~if~~ ^{if} he was picking ^{up} a big hunk of money, the income tax would have taken a large share of it.

So -- that program was being delayed a little bit, and he was talking about how dangerous it was, and he wanted this bonus money paid over a five year period, and during that period ~~xxxx~~ ~~xxxx~~ Tex Johnson, ^{who} headed up the flight test for Bell Aircraft Company, ~~and then~~ flew the X-1 one powered flight, and he came down, and he more or less agreed with Goodlin that the airplane was dangerous, and he backed him up.

This is the way the thing was going as the late spring of 1947 began to roll on -- the airplane was being delayed, the whole test program was.

At this point then Col. Boyd stepped in, and through the old ~~xxxxxxxxxxxxxxxx~~ Air Matériel Command and the Air Technical Service Command, as I recall it in those days -- I can't name the people that were involved in this -- he went to them and said, "We think we can do this test program as good as a contractor can, we've got the pilots that have a lot of experience in jet aircraft. Why don't we take over that X-1

program and do the work ourselves?"

And you know, after a lot of meetings and weighing the pros and cons -- because even within the Air Force in those days there was a great deal of feeling that really the so-called sound barrier . . . you know, if an airplane got to the sound barrier then it would snap ends and disintegrate, ~~but~~ as had been demonstrated by the DH-108 DeHavilland Swallow -- and even within the industry we had a great number of scientists, you can almost say at least 50% of those were very doubtful about the outcome of the X-1 program or any airplane that approached the speed of sound.

Finally after a great ~~many~~ number of meetings the Air Force ^{Contracted} ~~was~~ Bell and took over the X-1, and since we knew nothing about it, that's when they hired, or asked Bell Aircraft Company to let Dick Frost be their liaison representative on the X-1, because he knew that airplane, every rivet in it, he knew the fuel system, the ~~propeller~~ ^{propellant} system, the motor -- he knew everything there was to know about the airplane, and he was an excellent teacher, since he was a pilot -- he had been a test pilot for Bell -- and during the X-1 program he had chased it in P-51, P-80s, and he was an excellent all around guy. So when the Air Force moved in, and then went through the selection process that I discussed earlier, that started it -- we had our hands on the X-1 program. And that's the way we arrived at Muroc Air

Base then, as a small detachment.

NACA -- the National Advisory Committee for Aeronautics -- had assigned Walt Williams to head up their detachment out there. His assistant was Mr. D. Beeler -- B.E.E.L.E.R. -- and the crew chief on the X-1 who had been the assistant crew chief with Bell Aircraft Company, when the Air Force took the airplane over was Mr. Jack Russell, and we were able to talk Jack to come into the civil service program and be by crew chief on the X-1. And then we hired a couple of other crewmen to work under Jack to maintain the X-1. And the instrumentation portions -- or the instruments on the aircraft and the data collecting capability of the aircraft came under the control of NACA. We had a Jerry Truzienski who handled all of the instrumentation on the aircraft. And normally that was the team that started out on the X-1 program with Dick Frost as a technical and maintenance type overseer, Jack Russell was the crew chief on the aircraft, I was assigned as a primary pilot, Bob Hoover was my backup pilot, and Jack ^{Ridley} Russell was the flight test engineer, or the guy who sort of monitored and who understood NACA's desire as well as being a pilot and understanding our capability to fly the airplane. And on the NACA side of the house, as I mentioned we had Walt Williams who headed up the NACA detachment, D. Beeler, his assistant, and Jerry Truzienski as the instrumentation man. And that's about the extent of the program.

Then we had the B-29 crew who flew the airplane normally. Maj. Bob Cardenas was the highest ranking Air Force officer we had in the program, and the copilot on the B-29 changed ^{AND} as the flight test engineer changed there once in a while, because they didn't have to know too much about the X-1 program: all they did was, after we loaded the X-1 which came under the responsibility of Jack Russell and serviced it, then the B-29 crew, their mission was just to carry the aircraft up to 25,000 feet and released it, ^{HEADED} ~~and head~~ ^{THE} it towards a lake bed.

We began the X-1 program, the flight test program.

Since I didn't know too much about the flying characteristics of the airplane or the speeds to use, I went to Slick Goodlin and asked him to give me a rundown on the air speeds that he had used, the techniques he had used on the aircraft, and as I recall Slick was a pretty bitter boy ~~because~~ because the Air Force had moved in and taken over this test program on the X-1, and he was sort of mercenary at the time, and he said, "If you want an official checkout we'll enter into a contract for 1000 bucks, and I'll give you a checkout." Well that kind of made me mad, because I figured, as I told you, that if he could fly the airplane, ~~and~~ I figured I could fly it. ~~and forget it.~~ So that's the way we started out with the program. Of course I read his test reports and the speed he used and the like. And we started out ^{and} the first flight in the X-1 was a glide flight. We dropped it empty

without any propellants aboard. It was just to give me a little orientation on the handling qualities of the airplane, and I set myself up with a pattern, and I've ^d done a lot of dead stick landings in P-80s during the test program, and we also had the lake bed which I used on all of my flights in the X-1. And the lake bed at that time had about seven miles of runway, two or three runways marked out on the lake bed itself that were as long as seven miles and three or four miles wide. So it was real easy to get the airplane down.

We dropped the X-1 on the first glide flight at 25,000 feet with no propellants aboard, and it ran 240 miles per hour. And I remember ~~since~~ ^{as soon as} we fell away from the B-29 the airplane really felt nice. There was absolutely no sound whatsoever, obviously -- it was just like flying a glider. Unfortunately up to that time I had never flown a glider. Later on I did, but that's as ^I go back and remember, it was just like flying a glider. And the aircraft itself, when I dropped out of the B-29 (?) the airplane felt so good that the first thing I did was, I did a slow roll with it, and Bob Hoover was on my wing with a P-80, and we ~~battered~~ ^{war} back and forth on the radio, and we ended up in a little bit of a lufbery on the way down, until we got down to about 10,000 feet. Seeing how well the airplane would turn I stalled it, then came over the

lake bed at about 5000 feet, somewhere around 350, miles per hour, turned on a downward leg, put the gear down at about 240 miles per hour, held around 220 in this circular pattern, and rolled out, and the airplane touched down on the lake somewhere around 190 miles per hour. But it handled very well, it felt good.

Then the next glide flight I did some more stall work. In fact I made three glide flights before we put any power in the airplane. I felt quite at home in the airplane after the first flight.

The fourth flight in the aircraft we put propellants aboard, a full load, and took the airplane up to 20,000 feet and dropped it at 240 miles per hour. After dropping out of the B-29 the first thing that I did, I had already loaded up by first stage pressures and the tank ~~pressurized~~ pressurized had been pressurized, had everything ready, to ignite the rocket motor, and had the data switches on so that we could check out our data acquisition system.

After dropping out of the B-29 I fired the number four chamber. There were four switches on the instrument panel: one on the left, two three and four. And you could start and stop a chamber in this four-chamber rocket motor as many times as you wanted to, or until you ran out of fuel. And each chamber would give you 1500 pounds of thrust, or a total of 6000 pounds of thrust with all four chambers on.

The airplane carried enough fuel to run that rocket motor one chamber for 10 minutes, two chambers for five minutes, or all four chambers for almost two and a half minutes of power. And after dropping from the B-29 I remember firing the number 4 chamber, watching the chamber pressure come up, and then just watching the systems. It felt very quiet and smooth. Then I ignited number 3 chamber, and after it got ignited I turned off number 4. Then I ignited number 2 chamber, turned off number 3, ignited number 1, turned off number 2, then turned off number 1 chamber. Now all the chambers were out.

The airplane had been demonstrated up to .8 mach number, and at this point we were at about 20,000 feet. I dropped the nose of the airplane, and since we had our ground crews on the ground there at Muroc, I came by indicating about 450 miles per hour from the long glide, and went down the runway. I reckoned I was 1000 feet up. Then I reached up and turned on in single sequence, starting with number 4 chamber. I turned on number 4, number 3, number 2 and number 1 and they all ignited beautifully, and I had them all four running. And the airplane began to accelerate quite fast. I pulled the nose up quite steep and tried to keep a few g's on the thing in a big corkcree type climb, and as I went through, as I recall, around 30-35,000 feet the nose got down on the airplane because I couldn't keep it vertical. I pulled it through to hold a few g's, and the old mach meter went up

to about .82 mach number. And we had been told by Col. W Boyd, you know, impressing upon us that safety was the primary factor, we were NOT to take the airplane over .8 mach number on its initial flight, and as it went through .82 I cut off the rocket motor cells and jettisoned the remainder of the fuel and came on down and landed. And I talked to Jack Ridley. We had data, and I knew we were in a little bit of trouble with Col. Boyd because I was shining my fanny a little bit, and we sat down and talked at great length about how we were going to tell Col. Boyd why we had gotten this airplane up to .82 mach number. And we talked and talked. Jack could write beautifully. The only thing that I could express to old Jack was that the airplane felt so good to me, and I had so much confidence in it that I didn't feel that we were exceeding any safety factor, it felt so good that I decided to let it go on up to .82 mach number.

Before we wrote this letter -- of course the flight test report, just cold, hard data, went straight to Col. Boyd and boy, the next day we ~~was~~ received a letter from him that was a real scorcher, about "you ~~xxxxxx~~ violated my direct order not to take the airplane up to .8, I told you . . ." It was a real scorcher. And we sat down and tried to answer this letter. And the attitude we took was that I felt so good in the airplane and had all the confidence in the world,

and that I didn't feel we had ~~any~~ violated any safety factor in taking the airplane up to .82. I reckon he bought it because he didn't come back, but in later years he was always very amused at the answer, because he being an outstanding pilot knew damn good and well what I had done. But he had enough confidence in it.

And then we started with the X-1 we would only fly it once ^{every} about three or four days because we had to reduce the data and sort of plan our next program.

We started out the second flight. We wanted to take it to .84 or .85 mach number -- we were going to leave it up to the pilot. But NACA was a little bit apprehensive about the whole X-1 program, so as we would sit down ~~XXXXXXX~~ and discuss our next flight plan, Walt Williams and the NACA bunch would say, "No, let's ~~say~~ take this thing in smaller increments, like if you went to .82, let's shoot for 83."

I felt a little better about the airplane and would always say, "I don't see why we don't go to 85 or 86 or what it feels like -- let that govern how far you go." And Jack Ridley being sort of the moderator between us and being very knowledgeable about aerodynamics, whereas we weren't too wise about the aerodynamic characteristics that we were going to run into with the X-1, we would usually settle -- if NACA said go 83 we said 85, we'd usually settle on about 82 mach number, and that's where we would aim for.

On the second powered flight of the airplane we would try to aim for 83 or 84 mach number, going into 200ths of a mach number increments.

After each flight we would come down and look at the data.

We developed -- or I developed -- a technique. Since I had flown the P-80s and the straight wing P-84s quite a bit, and both airplanes -- the P-80 and the P-84 -- has the capability of going up to .8 mach number where they would run into buffet at straight level, and we noticed during the work on the P-80 and the P-84 that if you backed off to about .76 mach number, which was in a smooth region, and pulled two or three g's, you ran into the same buffet at .76 mach number that you did at .8 mach number at straight level.

So what I did with the X-1 at the end of each run, when I achieved the mach number that we were aiming for -- if I had two chambers ~~xxxxxx~~ on or three, whatever was required to get this mach number -- and I hit, say, .84 mach number, I'd roll the airplane over and pull two or three g's at this mach number.

This gave me an indication of what I would run into straight and level, at say 2 or 300ths of a mach number higher.

Now the data -- we had the instrumentation on the X-1, we had^a camera shooting over the right shoulder of the pilot that took pictures of all the instruments on the instrument panel -- just a standard instrument group: altimeter, indicator of the air speed, mach number, chamber pressures, tank pressures,

and counter numbers for the data. We had internal recorders that recorded some 16 factors: control positions, altitude, indicated air speeds, ~~we had~~ ^{we had} strain gauges on the elevators, we had manometer pickups on the top of the right wing, and the top of the right horizontal stabilizer. And these 16 channels that were being recorded on the internal data recorder on the X-1 were also transmitted to the ground by a 16 channel telemetry system that we had. So that data was recorded on the ground itself. And it took a while to reduce this data and figure out what was happening so that we could plan the next flight.

In the meantime I was involved in a lot of just plain everyday dirty test work on P-80s, P-84s, different varieties, a lot of flying. In fact many months we approached 100 hours a month of flying jet aircraft there at Muroc Air Base.

The X-1 -- we had a few problems during these flights as we were advancing our mach numbers. For instance we had a leak in the static system, where the cockpit was pressurized with pure nitrogen, and we had a leak in, I think, either an altimeter or a radar climb indicator, where the cockpit pressure was being leaked into the static system, so we had an erroneous indication on altitude, and a couple of times I ended up at a much lower altitude. For instance I was supposed to be at 35,000 feet and I ended up at about 25,000, and I couldn't tell from looking at the ground because it's

not that easy -- you can't see that much of the ground out of the cockpit of the X-1.

We ran into rather severe buffet as we were getting up to .86-.88 mach number -- ~~p~~ .88 mach number -- and the lower altitude that we thought . . . we thought we were up at about 35,000 feet, and we were quite ~~surprised~~ surprised at the severity of this buffeting, and it kind of scared me.

So we came back and reduced our data, and it showed this leak, and we were actually down about 18-20,000 feet instead of being up at 35,000 feet, ^{Q's} and the ~~huge~~ effect of that higher density and the effects of the buffeting on the aircraft were quite a bit greater than they were at the higher altitude, so after we ~~had~~ reduced the data and it showed that we were at low altitude. We also had a couple or three fires in the airplane. The systems in the engine itself -- we had a gaseous oxygen and alcohol with the spark plug ~~igniter~~ igniter system, and usually when you flip that switch the ~~first~~ first thing that happened, celluloid valves open letting gaseous nitrogen and alcohol into the chamber through this igniter over the spark plug, and as soon as that ignited it raised the chamber pressures enough that a sensor valve then would open the main propellant valves and let this big flow of either liquid oxygen and alcohol in and then you'd get instant ignition, and get your instant ~~13px~~ 1500 pounds of thrust.

We had trouble keeping these igniters from leaking, and especially since the igniter went through the alcohol chamber in the chamber itself, a lot of times when you turned the igniter on and the igniter was hot, the the propellant ~~valves~~^{valves} would open letting the surge of high pressure alcohol into the chamber, then it would leak back across the igniter and would ignite the alcohol and it would squirt into the tail end of the X-1, and start burning. I had a fire warning indicator, but I couldn't figure what was burning. But fortunately as this would happen, since we used nitrogen gas to operate all of the propellant valves, usually this fire would burn through the nitrogen gas lines, and the nitrogen gas would put out the fire. So we'd end up that it was a self contained fire extinguisher system.

The type of system that we used -- I'll explain here a little bit about the systems on the X-1. We used gaseous pressure that was manifold in the X-1. Before we would load the X-1 under the B-29, we would pressurize this manifold up to 5000 psi, and that was the source of all of our power. That 5000 psi, I ran it through the first stage dome regulator and reduced it from 5000 psi to 1500 pounds of pressure. The 1500 pounds of pressure was used to raise the gear and actuate the gear and flaps. Then I had this 1500 pounds of pressure go to the other dome regulators, and reduced this 1500 pounds

down to roughly 270-280 pounds of tank pressure in the liquid oxygen tank and the water-alcohol tank. And this was the to pressurize the tank so that it would force the propellants back to the rocket ~~motor~~ motor at a high enough rate to give me the thrust.

Then I tapped off, as I recall, the liquid oxygen tank, some 280 to 300 pounds, and reduced that down through a manual dome regulator that I had no control over, that reduced that pressure down to 100 psi. That 100 psi did one thing -- it was piped back to two air motors, one was on top and one was on the bottom of a jack screw that was tied in to the leading edge of the horizontal stabilizer. And I could control through a switch in the cockpit -- I could open a solenoid that let the air motor on the top of the jack screw that turned it one way or led it through to the bottom motor that turned the jack screw the other way, and in this way I could change the angle of incidence of the horizontal stabilizer.

Then we tapped and further reduced the 100 psi through an orifice, reduced that down to about four psi that ran the gyros for the needle or slip, and the flight indicator for altitude control.

Then I had a switch that I could dump the air that came out of the gyros either overboard or into the cockpit to pressurize the cockpit with. So this gave us a 3 pound psi

but a little bit of a hazardous environment in the cockpit, since the cockpit was pressurized with pure nitrogen gas -- we only had one oxygen system in the airplane. We had no backup system and no redundancy, so there was a little bit of a hazard involved, but that was part of the program.

The airplane was very simple, and we had carried a battery that ran radio and the data recorders and the telemetry system. So that was basically the way the airplane operated.

On one flight we had, while we were hooked under the B-29, we were tied into the B-29 electrical system to save our battery. At dropaway the pullout plug would pull out, and on one flight we had a terminal that was corroded on the battery of the X-1, and although it worked okay on the ground check, during the flight the vibration under the B-29, when we dropped away from the B-29, we had no electrical power. Now since the jettison switches worked off of solenoids, they'd open jettison valves, the X-1 was not designed to land with a full load of fuel. In fact it wasn't designed to even take off with a full load of fuel. So we discussed this, and Dick Frost sort of invented a little system. He took an H-2 bail-out bottle with some 1800 pounds of air aboard, and we hooked that through a manual valve that I could control from the cockpit. If I ever dropped and lost electrical power I could reach over and manually open that valve that let this

1800 psi of gas go directly to those jettison valves, and when we fell away and lost radio and lost all the instrument power, I realized that I had no battery. We had never used this system before, but I only had that one chance, so I reached up and opened the valve on the H-2 bailout bottle and boy, I immediately heard those valves pop in the back, and of course then felt the airplane beginning to get lighter, as the fuel and lox jettisoned, so it ~~was~~ worked out beautifully, as it was designed.

Those were simple things, the way the X-1 was designed to operate.

Q: If you hadn't had that fail safe system that you . . .

Yeager: We would have wiped out the ~~acorn~~ real ~~easy~~ easy because the touchdown gear would have collapsed and we would have probably ended up with a rather bad fire and everything else because that's the way the system was designed.

But that was the concept behind the whole X-1 program -- it was simplicity. The airplane was designed for 18 g's positive or negative because of the unknown that we were faced with. ~~That's~~ That's much greater than the pilot can take. The way we sat in the X-1 on a C-type parachute, your feet were actually about as high as your belt was; your knees were even with your

shoulders; you leaned back against this liquid oxygen tank, and so you could pull a lot of g's with the X-1 without blacking out. Although we did not wear a G-suit, we had no capability, no air valve in the airplane to wear a G-suit.

As we went along, the first aerodynamic problem that we ran into with the X-1 occurred, oh, somewhere around .87-.88 mach number. There we ran into our first buffeting. Now the No. 1 X-1 -- serial No. 6062, -- had an 8% wing, cord to thickness ratio, and a 6% tail. The No. 2 X-1 -- serial number 6063 -- had a 10% wing and an 8% tail, and obviously the thicker the wing the lower mach number at which the shock waves would form on the wing.

I flew the No. 1 X-1 because I liked the way it flew: it had a better wing, although it landed quite a bit faster than the No. 1 (2 ?). I didn't mind that because I was spending operating off the lake bed. It stalled at around 180 miles per hour, whereas the No. 2 airplane stalled at around 160 miles^{per} hour.

So I flew the No. 1 airplane throughout the whole test program, and we ran into our first buffeting at , 87 mach number, between 87 and 88 mach number, and at that point the buffeting . . . the airplane began to buffet all over as the old P-80s and P-84s did at p^{B} xx88 mach number.

So after our first big buffet we came down and it showed a shock wave ~~had~~ formed on the thickest part of the wing and the thickest part of the horizontal stabilizer and it was beginning to form in behind, we had the turbulent air and the buffeting.

At point .88 mach number, in this buffet, I pulled $2\frac{1}{2}$ to 3 g's, the buffeting increased in severity, and I got a little bit of wing wallow, as the lateral stability began to break down in the aircraft.

On the next flight I took the airplane up to .9 mach number, and the buffeting began to increase more in severity, and I got a wing drop on the airplane; it took about a quarter aileron to hold that wing up under stabilized conditions, and as I pulled a few g's the airplane buffeted more and I got a wing wallow again.

Then, sitting there at .92 mach number in this heavy buffet, the next flight I got up at .94 mach number indicated, and at .94 mach number I rolled the airplane over -- I still had some aileron control -- and pulled back on the stick, and the damn thing didn't do anything except go the way it was headed, and I pushed forward on the stick and pulled back from stop to stop, and the airplane did nothing. So I immediately raked off the rocket engine and decelerated back and jettisoned the remainder of the fuel, and glided on down, and landed on the lake bed. And I was really worried, because I had lost the elevator effectiveness on the airplane, and we were beginning to build up a little bit of a nose-up trim/ We were going through a nose-down trim. Now we were beginning to build up a nose-up trim. And I knew that if the airplane either pitched up or pitched down -- as had been anticipated by a lot of

doubting Thomases -- if it did this, man, I had no ^{way of} ~~mix~~ controlling ~~think~~ it.

So we came down and looked at the data, and what had ~~happn~~ happened, the shock wave that had formed on the thickest part of the horizontal stabilizer at around 88 mach number, at .94 had moved back on the airfoil and laid down, and was at the hinge point of the elevator. And we had completely lost the elevator effectiveness. The strain gauges on the elevator showed absolutely zero strain with foil up or foil down elevator at ~~point~~ .94 mach number.

We had ^{to} sort of fall back and regroup. We looked at the systems, and since we had built this capability of moving the horizontal stabilizer from the cockpit with these ~~air~~motors, it was a rather crude system, and I could control it with increments of about 1 degree: it was the finest that I could control it with, this trim switch on the stick, on the wheel or control column.

We looked at the system, and since it had never been used before in flight, we started practicing with it on the ground and checking out the system itself. I got so that we got a little confidence in the system, so we decided we'd go up the next flight and try it out, and see how effective that horizontal stabilizer was. So the next flight I went up to about .85 mach number and I had good elevator control, and I changed, I trimmed nose up, or lead the edge of the horizontal stabilizer down.

As I recall I moved it one degree, and the airplane pulled about three g's. So I retrimmed it back to zero, rolled out, let it accelerate on up to ~~point~~ .9 mach number, made the same blip on the thing, had a one degree change, then got three g's, just like I had down at .85 mach number. So I rolled it up, and ignited off the third chamber--I was at about 35,000 feet, as I recall-- and accelerated on up to .94 mach number, and made ~~make~~ that same change, and the airplane pulled three g's, just like that.

And this showed me -- I was sitting there flapping the elevator back and forth -- that when I retrimmed the old stabilizer back, boy, it rolled out immediately. If the airplane had a tendency to pitch up or down as I increased my mach number, I still could fly that airplane with that horizontal stabilizer, although I had lost the elevator effectiveness.

From there on out it was a piece of cake. I think it took two more flights. The next flight up to about .955. We were just increasing in mach number, and a slight nose-up trim change. I used the horizontal stabilizer to trim the fore-and-aft.

Then on the next flight I was sitting there looking at .96 mach number, 965, and the mach meter began fluctuating. Now my mach meter only went to .0. Sitting there reading .96, 965, fluctuating -- and all at once ZAP! it jumped off

the scale up to about -- if you extrapolate it -- to about 1.05 mach number. At that point the buffeting ceased, I pulled back on the stick, the airplane turned a little bit with full elevator, and I knew I had gotten the airplane up to supersonic speed. So I shut off the engine. As I came back the mach meter jumped back to .96, ~~and there was a~~ ^{as the} shock wave off the static source. Then I ran into the buffeting again, and on down, and decelerated the same way. I came on down and landed.

Actually I transmitted over the radio on that flight that I had gotten a jump in the mach meter. The guys on the ground knew exactly that we had gotten the airplane up to supersonic speed.

We came down, and everybody was quite elated about the program because it was that simple -- we had gotten the airplane up to supersonic speed, and of course it took Wright Field -- you know, we called Col. Boyd and told him we hecked the program, then Mr. Bell . . . I think Dick Frost called Mr. Bell and said everything went beautifully. And it took a couple of hours before it began to sink in back there. We were planning a big party over at Poncho Barnes that night, and in about two hours a telephone call came from Wright Field and said, THE WHOLE PROGRAM IS CLASSIFIED.

Q: (laughter, subdued)

Yeager: So that kind of killed our get together, but as it worked out that was the way the whole program went.

Now going back, getting into the type of flying that you did, really in the days of the X-1, during August and September, leading into October the 14th, which was our first supersonic flight, mentioning that we only flew the X-1 a couple of flights a week, really I don't think that a lot of people had confidence. It wasn't too ~~an~~ important a program. It wasn't documented with film. There was very little coverage on the old X-1 program during that time, and we didn't get an awful lot of attention except from Col. Boyd. He called us back to Wright Field a couple or three times, especially when we ran into this loss of elevator, and he sat us down and he said, "Now look, if you guys don't like the way this thing is going you just knock it off." And he was very adamant about the safety thing being the primary factor. We just tried to impress on him that I had a great deal of confidence in the airplane and a great deal of faith in the whole thing. It looked like we were going to hack the program. And he being the kind of pilot he was, really a great airplane driver, he sort of realized how we felt about it, and he was all for us, and I would say that he was one of the few senior officers that really knew what was going on. As for the rest of the guys in the industry and in some areas of the Air Force, there

really wasn't a great deal of confidence in the program. And that's the reason why there wasn't a great deal of documentation.

When it came to flying other types of test programs, really that was the reason we'd bust our fanny. I flew many, many test programs day and night, cross country, flying aircraft around from Wright Field back out to Edwards, trying out different systems on P-80s, P-84s, armament, performance testing, stability control. So even though I was the only pilot flying the X-1 -- I had Bob Hoover as a backup pilot who never did get to fly the airplane. Really it was just sort of a hobby that whole X-1 program.

Q: (hearty laughter)

Yeager: But it turned out to be quite successful. And we all had a lot of confidence in the airplane.

Q: Was that the same Bob Hoover that flies for North American?

Yeager: Yes. Bob and I worked together from '46-'47 on many air shows, the Civil Air Patrol air shows in the spring of 1946, the fall of '46, we'd take a P-80 out or two P-80s, we did a lot of the stuff in formation. Bob used to do it with P-38s and

51s as he does today. He is an excellent pilot. But Bob had a lot of accidents while he was in the Air Force. In fact while we were flying the X-1 program, shortly after I got the airplane to supersonic speed he ejected out of a P-84 and broke his leg, and that wiped him out of the X-1 program completely. Consequently later on he went ahead and got out of the Air Force and went to work for Allison Division of General Motors, then went to work for North American.

Q: It must have been frustrating for him to be a backup pilot all the time.

Yeager: Yes, Bob was an excellent pilot, a real leader type guy, but as Gen. Boyd said in later years Bob didn't have the stability that I had, or he didn't have the feeling for machinery. Bob abused machinery a lot because he didn't have the sense of respect or knowing its limits, and so consequently he had a lot of systems failures in aircraft all during our test programs in 1946 and early '47, leading up to the X-1.

Q: General, it sounds like your hands on experience was a pretty key factor in all this. Nowadays you know, we have all these people with these technical backgrounds and double E degree degrees and all that, but it really comes down to hands on

experience, ~~and that's what really pulled you~~ through.

Yeager: Well, to go back in remembering, Walt Williams was a brilliant aeronautical engineer -- he was really good, and I wasn't. I had a high school education. Although I had been to performers test pilot school, all that you were taught in a test pilot school is how to get the data you are after, and also how the techniques of piloting an airplane affect the end result or the reduced data. And I really didn't understand a great deal about what was going on aerodynamically in the X-1. I knew what was happening in the cockpit. Jack Ridley had a doctor's degree in aeronautical engineering. He studied under Dr. Von Karmen, and Jack Ridley was born and raised in Oklahoma. And I was born and raised in West Virginia. He came from a hillbilly area, the same as I, and many was the time after a meeting with NACA on what had happened and what probably would happen, that Jack Ridley would take me off in a corner and interpret.

Q: (laughter)

Yeager: And he could explain it the way I understood it because he was an excellent pilot and really a brilliant aerodynamicist along with Walt Williams. And that's the way this program went/

Old Jack, I would keep quiet, and Jack would talk, and after the meeting we'd go and Jack would explain what was going on. And ^{in turn} before we were going to ~~the~~^{the} meeting, I'd sit down and talk to Jack and give him my feelings, and he in turn would interpret those, (laughter) so that NACA understood.

And that's the way the team ~~worked~~ got involved.

Q: Thank you, sir.

Yeager: I am going to take this back with me. I still have a lot more work to do on the later series, but I just wanted to get this X-1 tape locked in, because it was really the important item that you guys were working on.

Q: Thank you. If you feel you'd like to scratch any parts of that, just x it out.

Yeager: I am going to let you guys pull out your duplication in here.

(cross talk, about somebody who comes in and would like an autograph of Gen. Yeager. Somebody says, "He's got a young kid who desperately wants to come here.")

(end of recording)

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