

## *The Second F-104 World Altitude Record*

On 14 Dec 1959 the Lockheed F-104 established a new world altitude record of 103,395.5 feet. I was present at Edwards Air Force Base on that day as a timer/observer for the National Aeronautic Association (NAA) that was monitoring the record attempt on behalf of the Fédération Aéronautique Internationale (FAI), the governing body for aeronautical world records. I had been involved in analytic aerodynamic studies leading up to both the first and second successful F-104 altitude record events. Following is my attempt to recall that December day of 52 years ago as well as some of the post-flight analysis work I was rather freely permitted to engage in by my Lockheed employer.

Edwards was a beehive of activity that day. It was kind of a Century Series event as the Lockheed F-104, Republic F-105, and Convair F-106 were all engaged in various world record attempts. I was assigned to the F-104 prep area where I met my mentor, an older, more experienced NAA official. In an abundance of caution I disclosed to him that I was a Lockheed employee, had worked on the analytic preparation for the attempt, and I didn't want to do anything that might subsequently be challenged as a conflict of interest. He seemed kind of surprised at my concern but soon he saw to it that I was reassigned to the F-105 Thunderchief.

Upon reporting to my new mentor at the F-105 pit I was duly instructed on how to turn on the barograph. This is an atmospheric pressure measuring device carried aboard the aircraft that scratches a record on a smoked rotating cylinder. Obviously this was a relic of past epochs and was grossly inaccurate in determining precise altitudes. These barographs were supplied, calibrated, and controlled by the NAA/FAI officials. Meanwhile, the actual altitudes were to be determined from Askania photo theodolite cameras. It was explained that the barographs, by being installed and removed by NAA, assured the world that airplane was the actual one that the cameras measured. My F-104 timing activities would have been the same so I now knew my conflict of interest concerns were unwarranted.

Brig. Gen. Joseph H. Moore, the F-105 pilot, was already quite famous. At Clark Field in the Philippines he was the commanding officer of the 20th Pursuit Squadron at the age 27. On the same day as the Pearl Harbor attack he was one of three pilots to get airborne just prior to the Japanese attack. He claimed two kills in his P-40 and was awarded the Distinguished Flying Cross. He received many other awards during his 34 years of USAF service and retired as a Lt. Gen. I remember him as being very polite, probably belying his South Carolina roots.

The 100 kilometer closed course speed was circular at a constant altitude ( $\pm$  some tolerance). Airborne observers in Lockheed T-33 two-place trainer aircraft were to monitor the flight to assure that Gen. Moore didn't fly too high or too low during his



**Lieutenant General  
Joseph H. Moore  
1914-2006**



**Republic F-105B Thunderchief  
(Long flight test probe on nose not standard)**

circuit, although I suspect that radar and the Askania cameras were the ultimate determinant as to whether he strayed out of the altitude limits. Lockheed later gave me flight physicals and an altitude chamber test to qualify me for airborne observer, but I never got the opportunity.

While my mentor was away from the F-105 pit, the USAF and Republic teams came to me saying, “We’re ready to fly. Please turn on the barograph.” I hesitated as long as I dared hoping my mentor would come back to take charge. Finally I caved and turned it on. Shortly my mentor did return but by that time the team had decided for some reason they couldn’t go just then and the delay was indefinite. This meant the barograph, or at least the cylinder, had to be removed and replaced and the used one had to be re-smoked over at the NAA smoking tent—or some such place. I then got a lecture from my mentor on how to resist the team’s usual premature urging to arm the barograph until you “see the whites of their eyes” or some such homily.

We finally did get Gen. Moore off and he did set a record of 1,216 mph for which he was awarded the Bendix Trophy. He was 45 years old at the time.

Meanwhile, back at the F-104, Captain Joe B. Jordan was preparing for his fifth try at exceeding the previous record by three percent or more. Joe was 30 years old. I was 25. He was on the small side: 5 ft 9 inches — the same height as I was at the time. The top of his zoom measured out at 103,395.5 feet. It earned him the 1959 Harmon trophy. Following are some quotes attributed to Joe that appeared on page 1 of the Valley Times, a San Fernando Valley, California publication on 15 Dec 1959:



**Modified F-104C Starfighter — Edwards AFB — Dec 1959**

*It was a real thrill to set a new altitude mark, but I didn’t think I made it.  
 My altimeter fouled out at a little over 100,000 feet, so I wasn’t sure of the exact altitude.  
 Then the plane just wouldn’t go up any more.  
 The plane handled real nice. I started my altitude run at 40,000 feet, just pulled back on the stick and let her go.  
 There was no spin or anything like that.  
 Coming down it felt real good. It was sort of like an old plane handling with stick and rudder.  
 I felt tired afterwards, but it probably was from the reaction of the anxiety I felt before the test.*



**ROARS TO RECORD**—Capt. Joe B. Jordan who broke existing world record by flying to an altitude of 103,395 ft. (almost 20 miles) in Lockheed F-104C. (AP photo)

While I’m pretty sure the Convair F-106 Delta Dart was also flying on the 14th, the record it claimed was set the next day on 15 Dec. It was a new record for single engine speed over an 18 kilometer course at



**Col. Joe Rogers**

40,000 ft, of 1,525 mph at Mach 2.31. That’s the average of two passes in opposite directions. The pilot was Col. Joe Rogers (1924-2005).

It was a great couple of days for the Air Force as opposed to the US Navy that had had its chance a few weeks prior.



**F-106 Delta Dart**

**Associated Press photo of Capt. Joe B Jordan from front page of the Los Angeles Times, 16 Dec 1959, in an article by Marvin Miles**

Some factors bearing on the frenzy of USAF activity on that 14 Dec day were:

1. In 1958 the F-104 smashed a 17-day-old Navy mark by zooming to 91,243 feet.
2. The above record stood until 1 July 1959 when a Russian T431 jet fighter achieved 94,661 feet altitude.
3. In Oct 1959 the Air Force Flight Test Center (AFFTC) requested that it be given a chance to better the altitude with an F-104 based on an engineering study made at that time.
4. Around this same time the U.S. Navy was attempting to better the Russian record using their McDonnell F4H Phantom II.
5. After the F4H had made several unsuccessful attempts, the AFFTC request was granted with the stipulation that the F-104 record attempt be accomplished by 17 Dec 1959.
6. On 6 Dec 1959 the F4H beat the Russian record at Edwards on its 21st assault by reaching 98,500 feet.
7. FAI rules required that any new record exceed the old one by three percent or more. After the F4H record on 6 Dec this meant the F-104 would have to exceed 101,518 feet.
8. At this point there was apparently some consideration of scrubbing the F-104 attempt since the F4H had recaptured the record for the US from the Russians. Ultimately the F-104 effort was allowed to continue.



**F-4 Phantom II**

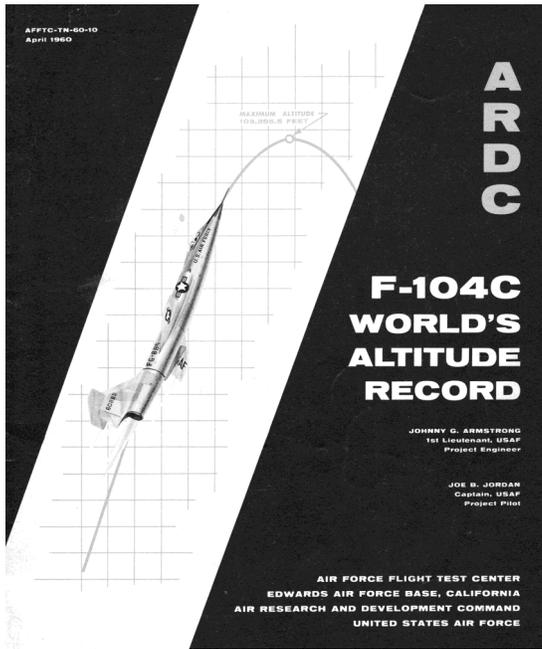
I know of no similar frenzy of record-attempt at Edwards since. It was not just USA vs. Russia but also Lockheed vs. McDonnell, and probably more importantly: USAF vs. USN. Those were heady times and I doubt we'll ever see their likes again.

————— *From here on non-technical types may become somewhat bored and wish to skim.* —————

In December of 1958 the F-104 had set a number of time-to-climb records. Hugo P. Heermann, a friend in the Mathematical Analysis Department, had become very interested in analytically optimizing such maneuvers as well as the maximum altitude problem. Though Hugo himself was not a programmer, he directed some very good ones who developed several trajectory analysis programs. I believe it was one of these that we used to provide suggested flight profiles for the 2nd F-104 altitude record. He made use of something called steepest-ascent method in the calculus of variations. This has nothing to do with the angle at which an aircraft ascends. Rather it is a technique for converging on the optimum solution. My interpretation would be like choosing the steepest side of the Matterhorn to ascend to the peak, where the peak represents the optimum. Hugo used many references. Among his favorite published authors I remember A. E. Bryson, M. R. Hestenes, and Angelo Miele.

After the 2nd F-104 altitude record Hugo made contact with 1st Lieutenant Johnny G. Armstrong at AFFTC who was the project engineer for the event and got us invited up to Edwards to chat. Hugo drove. It was about 90 miles from Lockheed in Burbank and there were no freeways to there yet. Hugo had related that his dad, a concert violinist, apparently possessed little mechanical aptitude and was apt to call in a carpenter if he needed a picture hung. Hugo lacked in that department as well, especially with regard to automobiles, which he drove as if pedaling a tricycle with the accelerator pedal acting as the pedal. It was surge forward, back off, surge again, etc.....his mileage must have been terrible. It was a long trip. I managed to avoid any further trips with Hugo as driver.

We had a very fruitful meeting with Johnny Armstrong and came back with a most excellent report (AFFTC-TM-60-10 April 1960) that he and pilot Joe Jordan had authored, a copy of which I still possess and to which I am greatly indebted for help in preparing these recollections.

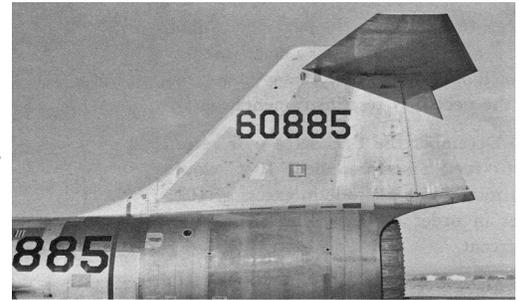


Cover of the Armstrong/Jordan report  
AFFTC-TR-60-10 dated April 1960

Lockheed made several modification to an F-104C between 24 Nov and 1 Dec 1959, some of which are discussed below, and most of which are taken from AFFTC-TR-60-10.

An F-104B (two-place trainer) empennage was substituted for the standard F-104C one. The B increased the vertical tail area by 8.3 square feet and provided increased directional stability at the higher than operational Mach numbers expected. It extended beyond the rear of the engine in what I think was called a ducktail.

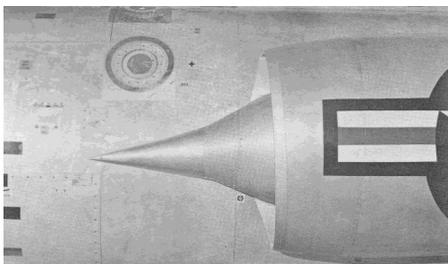
The pilot was given increased rudder authority  $\pm 20$  degrees) in flaps-up flight if he selected it from the cockpit. Otherwise authority was  $\pm 6$  degrees.



F-104B empennage with ducktail

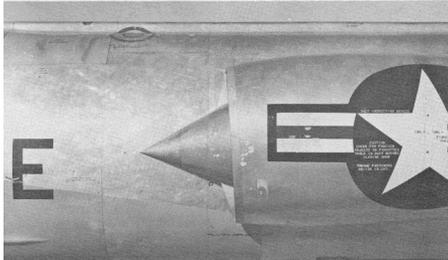


Standard F-104C empennage



Modified double-cone inlet

A double-cone inlet was installed to better position the shock wave at Mach numbers of 2.2 and above. I seem to remember our propulsion guys saying something about "shock-on-lip."



Standard F-104C inlet

Normal operation of the F-104C's J-79-GE-7 engine was restricted to Mach 2 by a maximum compressor inlet temperature (CIT) of 121 degrees C because the front frame and front compressor case are constructed of magnesium. However, the J79-GE-2 engine, two of which were used on our competition, the Nave F4H, were set to the higher limit of 153 degrees CIT for 5 minutes or less because the critical items are made of stainless steel. The F4H, being carrier-based and in a salt-spray environment needed the steel and extra thrust margin I presume. Apparently obtaining a -2 engine for the F-104 was considered but there wasn't enough time to arrange for one. General Electric, the engine maker, was persuaded to set new limits for the -7 for our flights, probably on condition that they got to tear down and inspect the engine after the mission,

which indeed happened.

AFFTC was responsible for tweaking the max engine rpm to 103.5 percent of normal and top reset rpm to 104.5 percent to increase both thrust and stall margin.

The afterburner was trimmed to provide a 10 percent higher than normal fuel flow at maximum power.

Procedural notes:

1. On all zoom flights the cabin pressure was dumped at approximately 2.0 Mach number to check for proper operation of the oxygen system and pressure suit.
2. Just before pull-up, constant ignition, minimum fuel reset, and test instrumentation switches were turned on. This provided for automatic restart capability in case the engine flamed out. With continuous ignition it was only necessary to open the throttle to obtain engine restart.

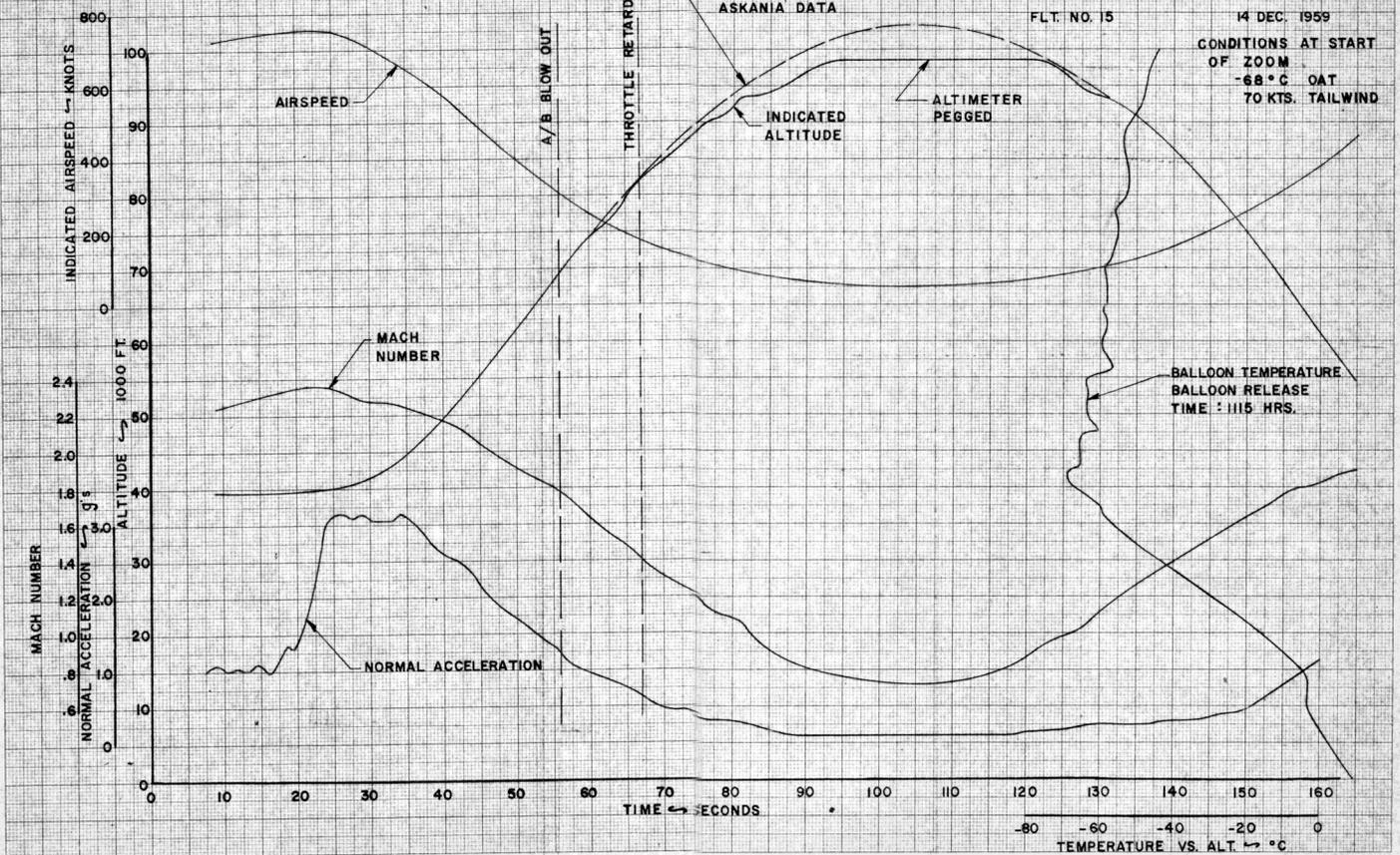
REF. AFFTC-TN-60-10

**RECORD ALTITUDE ZOOM**

FLT. NO. 15

14 DEC. 1959

CONDITIONS AT START  
 OF ZOOM  
 -68°C OAT  
 70 KTS. TAILWIND

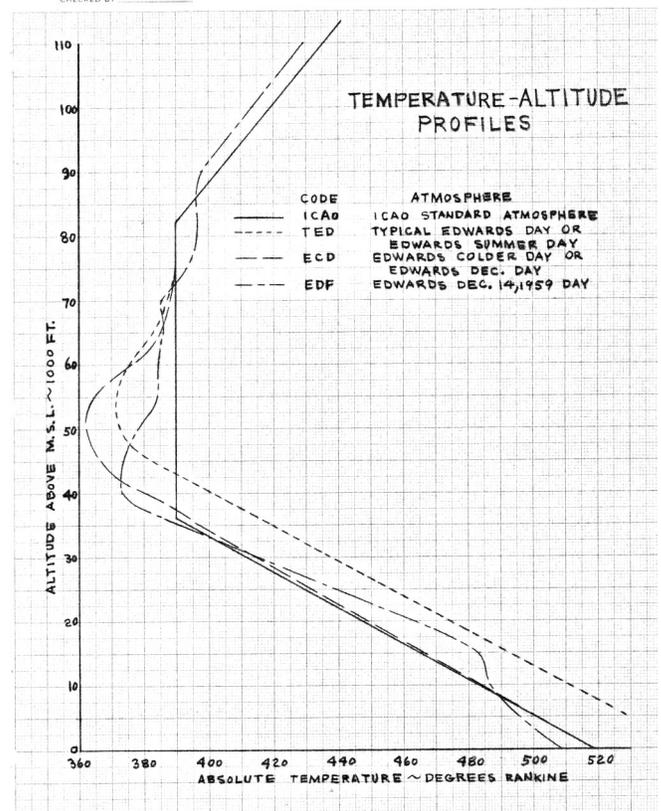


FORM 5278C

ARC F-104.2405

Now that we had a time history, Hugo Heermann and I wanted to determine how closely we could analytically duplicate the parameters of the record flight. Wonder of wonders: we had temperature versus altitude data because a weather balloon had been launched at 11:15 a.m! There existed data for a typical Edwards summer day and Edwards colder or December day. But just by plotting the balloon data we could see that 14 Dec 1959 day was too non-typical for these typical days to be useful. Therefore we needed to construct an atmosphere model for that particular day. There is a difference between pressure altitude and tapeline altitude and, to determine this, one needs to integrate the hydrostatic equation from the ground up. We had the Askania (tapeline) data and I wanted any time history we generated to show tapeline as well as pressure altitude.

Like many ancillary activities this turned out to take about ten times a long as I expected. But in the process I became sort of an minor expert on atmospheres and produced a number of tabular atmosphere tables for non-standard days that others found useful.

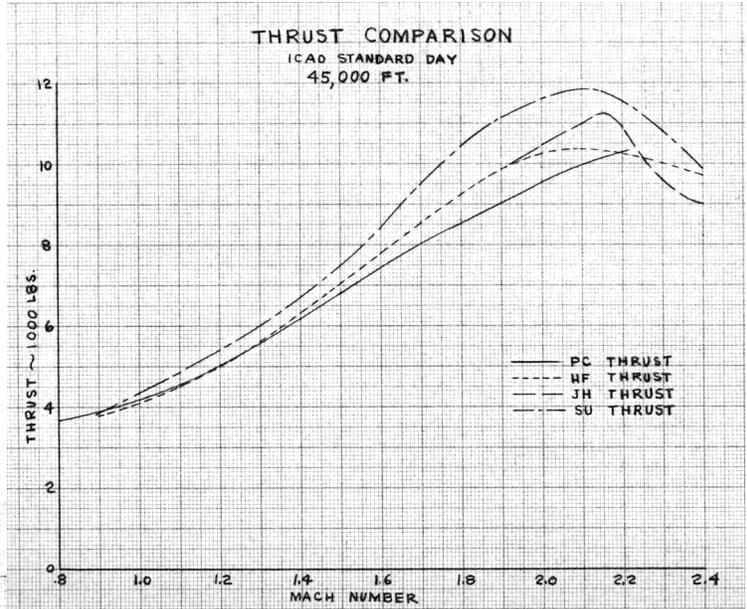


FORM 5278A

ARC F-104.2401

Various temperature vs. altitude profiles  
 Some liberties were taken to smooth the balloon data

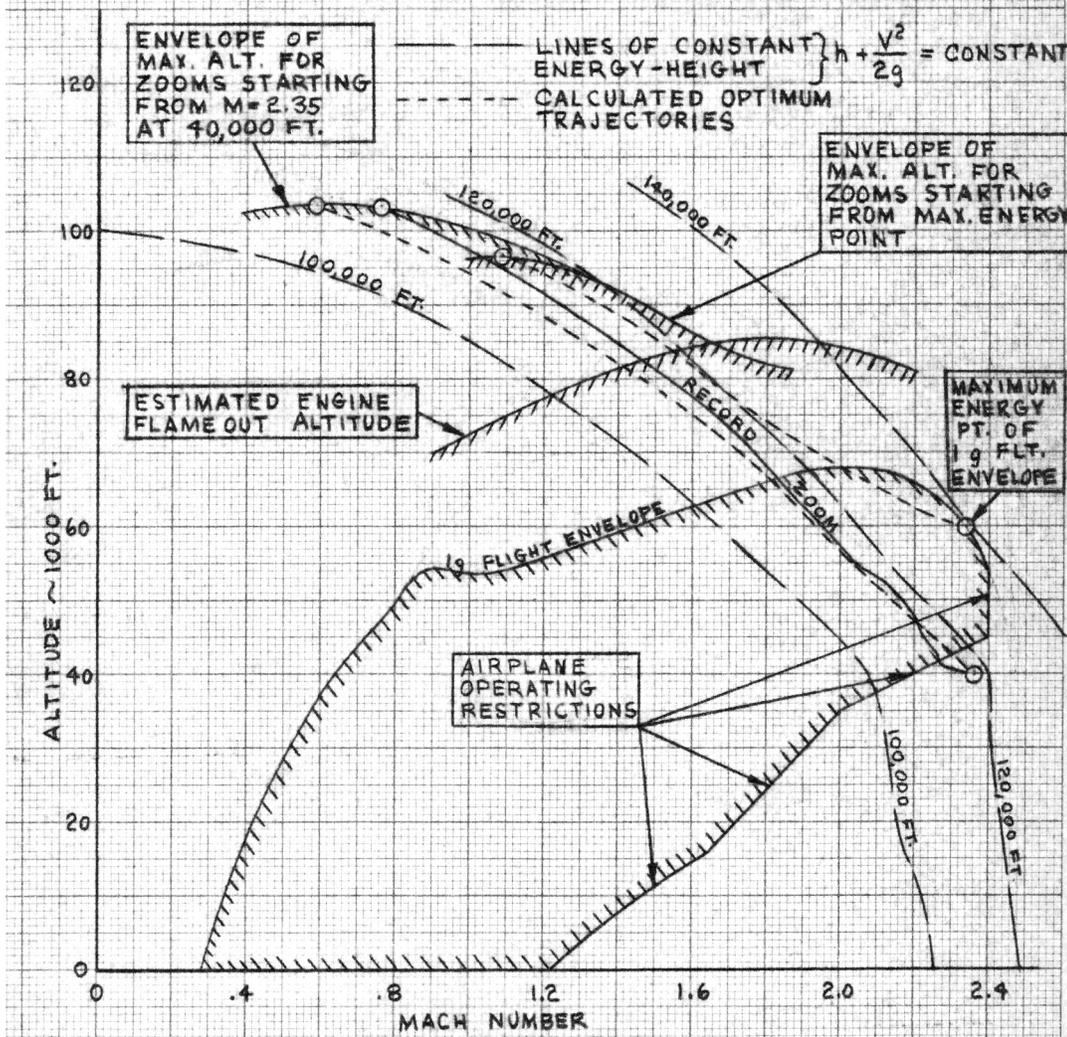
Next we obtained analytic thrust data from our propulsion people for the specific engine configuration in the record airplane. In the plot at right I labeled this SU thrust for Souped Up. I don't remember what the other thrusts are on the plot but SU is the top line and shows considerably more than the others, especially between Mach 1.6 and 2.2 where it really counted.



PREPARED BY \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_  
 LOCKHEED AIRCRAFT CORPORATION  
 CALIFORNIA DIVISION

LOCKHEED F-104C  
 SPEED - ALTITUDE ENVELOPE

CLEAN CONFIGURATION  
 WEIGHT = 15,000 LBS.  
 BASED ON ATMOSPHERE OVER EDWARDS  
 AFB ON DEC 14, 1959 11:15 HRS.  
 MODIFIED J79-7 ENGINE (SU THRUST)



The speed altitude envelope plot at the left is pretty busy but it contains a lot of good information.

The record zoom is shown as kind of a wiggly line starting at 40,000 feet and peaking at 103,395 feet at about Mach 0.75

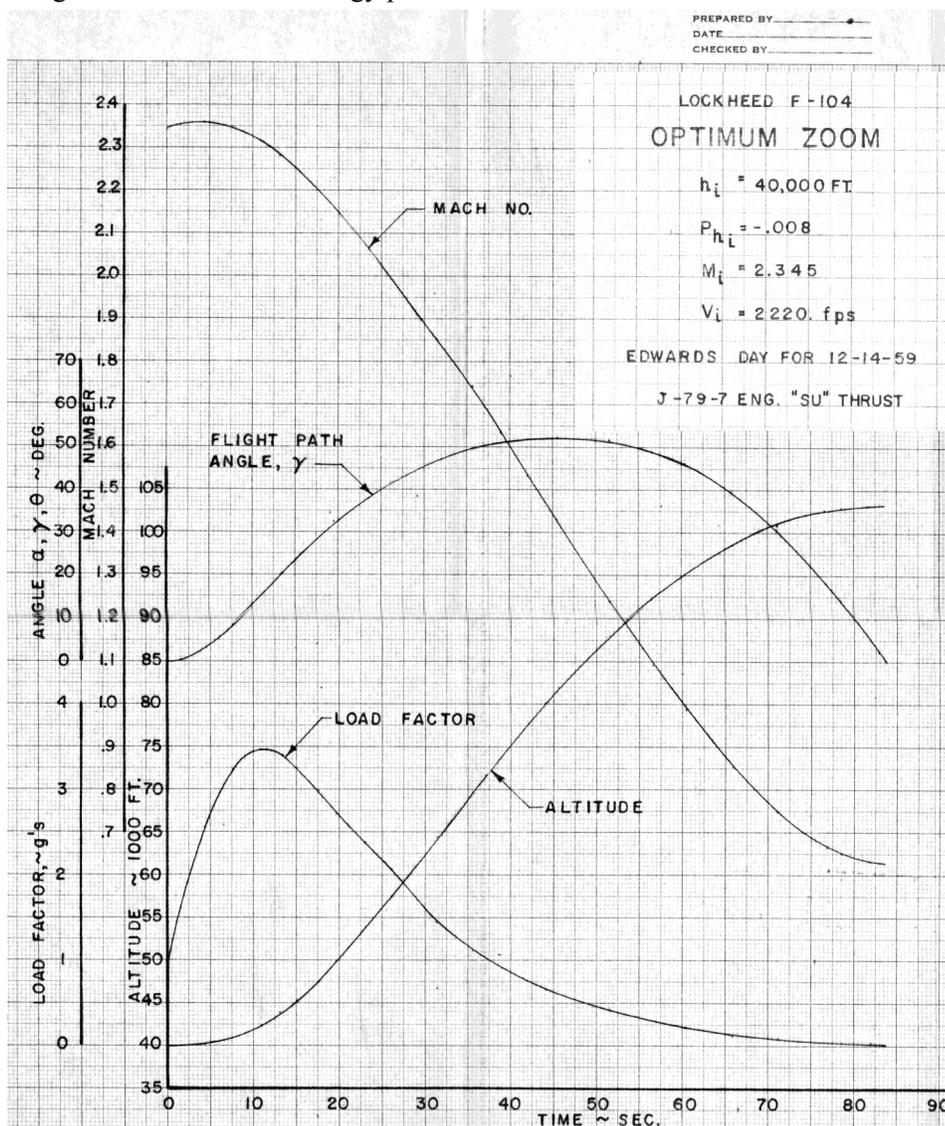
There is a dashed line starting at the same place as the record flight that ends up at about Mach 0.58 on a hatched line labeled Envelope of Max. Alt. Zooms... This is an optimum zoom calculated using Hugo's mathematical formulation. Today I can't explain why an envelope of optimums is shown. It seems to me there should be only one optimum, if the optimization was permitted to find its own load factor schedule?

You'll also notice lines of constant energy-height. At each point on a line the total of the potential energy (h or height) plus the kinetic energy (speed related and expressed as velocity squared divided by 2 times g where V is velocity in feet/second and g is the acceleration of gravity in feet per second squared). Anyhow the units end up in feet. These lines were popularized by Edward S. Rutowski in a 1953 paper titled *Energy Approach to the General Aircraft Performance Problem*. Use of these contours were often referred to as energy maneuverability studies and such were already in use at Lockheed for determining recommended climb and acceleration schedules for flight manuals when I came in 1957.

Intuitively it would seem that one should start a zoom flight where the vehicle's 1g flight envelope comes tangent to the highest value constant energy contour. That point, noted on the plot, occurs at about 60,000 feet where the 140,000 ft energy is tangent to the flight envelope. We had already learned in the 1st F104 record success that this is not the place to start. Too much time and energy is spent pulling up to a good flight path angle. Better to start lower where, with additional excess thrust there, one can rotate without losing so much speed. But just for kicks, I ran an optimum zoom trajectory from that point and you can see on the plot that it peaked out at around 97,000 feet. I don't know what starting altitudes McDonnell was suggesting for their December 1959 record F4H flight of 98,561 feet but in an informal chat with some McDonnell flight test engineers some years later I got the feeling that they leaned a bit too much toward starting near the maximum energy point.

The optimum zoom at the right shows the same peak altitude as for Joe Jordan's flight but peaking at a lower Mach number. In any case I concluded that Joe wrung all there was to wring out of the airplane's altitude capability on that fifth flight. He had "the right stuff."

I distinctly remember doing one more thing for which I have no plot to show. Notice how smooth the load factor schedule is on the optimum zoom at the right. Then look at Joe's schedule on the record flight. I ran a case using Joe's slightly lumpy g schedule and got almost the altitude he did. Then I bumped each ordinate in the load factor table by some small factor like 1.002 and ran it again. That factor was well within the tolerance with which I could read the load factors in the Armstrong/Jordan report. That trajectory was dead-on for altitude and probably close in final Mach number at the top. Maybe it was so close I didn't bother to plot it as it would have been one line on top of another?



So, if you get the idea that I had a lot of “academic freedom” in my early years at Lockheed you’d be right. It’s not that I didn’t have other assignments during this time. I was developing a mission analysis program for automatic iteration for aircraft maximum operating radius or range and I’m sure there were deadlines to produce hand/slide-rule computed missions and performance reports for the F-104. But I don’t remember any supervision specifically asking me to do this post flight simulation of the record zoom and I never published it in report form. It was what I called a bottom-drawer job that I pulled out whenever other work slowed down. I’ll admit I always looked busy because I had some initiative, was curious, and always had my bottom drawer jobs pending. I never went to the boss saying “I’m out of work. What do you want me to do next?” Perhaps the bosses assumed that, because I always appeared busy, I was working on an assigned task?

The work atmosphere was different at Lockheed in those early years. For example, we never saw a timecard. We had timekeepers who came around once or twice a week and asked what we were working on. Only they needed to know about work order numbers and what to charge our time to.

If I needed a propulsion deck of cards for a hot or cold day I’d just walk over to my counterparts in the Propulsion Dept. and they would generate it for me. There was no written request forms requiring man-hour estimates or transfer of x number of hours that required sign-off by supervision.

I had only been at Lockheed a short time when someone told me there was a group of programmers three floors down that were supposed to be working on programming reduced-weight climbs from some equations that Dick Dickinson had supplied to them earlier. Nobody had heard much from them lately but I could go down and visit with them if I wanted. I didn’t have to be told twice! What I found was a whole room-full of people happy to see an engineer, i.e. a customer. They were responsive to everything I suggested and didn’t seem concerned about budget. That’s where I first met Hugo Heermann and many others, several of whom I am still in communication with to this day. I visited the programmers once or twice a day even after they were moved to another building. They were my ticket to relief from human drudgery. Those hand-computed spreadsheets for reduced weight climbs were tedious and boring.

Hugo Heermann, however, died too early in in 1967 at age 43. Hugo was practically a chain smoker—smoking was permitted everywhere in those days. In addition there was his ever-present cup of coffee. His comments to some of his comely female programmers would be regarded as sexual harassment in today’s world. He was hospitalized for an appendectomy or gall bladder-ectomy (OK: cholecystectomy), or maybe both, and he was reported to be on the mend. I visited him in the hospital after surgery and he was upbeat and raring to get back to work. But he took a sudden turn for the worse and expired. John Clauss & I attended his funeral mass but I wasn’t much comforted. He left a wife and 5 children. As John says “He was a rare bird — fun to work with and deceptively smart.”

Joe Jordan was still living in January of 2010 when he, his family, Johnny Armstrong, and many others were present for a dedication ceremony for street named Jordan at Edwards AFB. Joe had a 22-year career in the Air Force. Among other exploits he was forced to eject from an F-111 during a gunfire test.

Random thoughts:

- The zoom maneuver had very little tactical value in a combat situations.
- 14 Dec 1959 was an especially cold day at 40,000 feet which helped achieve the starting Mach number.
- Wind speeds and directions aloft were known from weather balloon data and were effectively used by Jordan to choose where to initiate the maneuver.

- Askania data indicate Jordan’s maximum climb angle was 49.5 degrees on the record zoom. Our computed optimum zoom peaked at 54 degrees (labeled Flight Path Angle on the time history.) Once his climb angle was established, probably around 70,000 feet altitude and about Mach 1.8, Joe’s job was mostly over. From there on he was on more of a ballistic trajectory. It was like riding a cannon ball as it describes a parabolic arc when fired upward at an angle.

So, how did I become a timer for the National Aeronautic Association? I along with many others was solicited by someone at Lockheed who had received a request from an NAA person for support on that famous day. Some level of Lockheed management was obviously OK with it and it seemed like a good public service — something like jury duty. There wasn’t any worry that we wouldn’t be paid for 8 hours by Lockheed, though we were usually gone much longer than that. Other aerospace companies were also furnishing volunteers, of course. Subsequent to the Dec ‘59 event I believe I had two more trips to Edwards for the NAA.



**Piasecki H-21 Workhorse/Shawnee  
a.k.a. “Flying Banana”**

I believe it was on the last trip that a group of us boarded a C-47 at Lockheed Air Terminal early in the morning for Edwards. My first assignment was to help verify pylon placement for a low-altitude closed course record attempt. There were 12 “pylons” scattered around the desert on a circular course that apparently had been used for years. In the old days a pile of old tires were set afire at each location during the record attempt so pilots could see clearly where to avoid “clipping a pylon”.

In our new era, radar was to be used but NAA wanted a helicopter to hover over each pylon while, I suppose, some NAA official observed us on a grid on the radar scope. Our chopper was an old olive drab Piasecki H-21 “Flying Banana”, a twin tandem-rotor job that, aside from being terribly noisy, vibrated like you wouldn’t believe. We found the first pylon where I could see remnants of the old tire carcasses. We dropped down low, called radar to say “We’re here at the first pylon. Can you track us?” The answer comes back “We can’t see you on radar. You must be lost in ground clutter. Increase altitude.” So we’d rise up while trying to keep centered over the pylon until they could see us.

Same procedure repeated for about 4 pylons. Finally they called us in saying “OK. That’s enough.”

They could see that with the amount of time it was taking we’d never finish in time for the scheduled speed run. I don’t remember what other duties I had that day but some of our guys had the privilege of lying flat on their back most of the day out in the desert near Lone Pine staring up at two wires, one above the other waiting for the candidate airplane to enter the high altitude slot above them. At the moment the plane crossed the wires they mashed a button on a stop-watch or maybe a clock timer. I was denied that privilege.



**Fairchild C-123 Provider**

Timing activities were over and it was up to somebody to get us back home. There didn’t seem to be any planes free to take us. Finally they found some Air National Guard week-end warriors from South Carolina that were serving their two-weeks active duty stint. They thought their duty was done for the day until they got orders to take us back to Burbank in their C-123. By then it was sundown. Furthermore we learned that the C-123 was placarded against take off in a cross-wind of 15 knots or greater. We had to wait some more till the wind died down.

We were seated sideways along looking at a large pile of parachutes in the middle of the cargo hold. Finally we started our take-off roll. It's a good thing the runways at Edwards are very long because we seemed to accelerate for a very long time before rotation. Finally rotation, at which point something fell on me that soaked my pants in a very obvious area. It was a poorly secured pot of stale coffee that shook loose from vibration from a shelf over my head.

Eventually we arrived over the San Fernando Valley and started our approach to the Lockheed Air Terminal but it was aborted. Went around again: same thing. As we wondered if these guys were ever going to get us down we engaged in gallows humor about maybe having to use some of the parachutes. After another abort our leader unhooked his seat belt and climbed up to the cockpit and literally talked them down. He told us later that they were bedazzled by so many square miles of city lights, the likes of which they'd never seen. It seemed they every time they got low on the approach, they lost sight of the runway and panicked. Our leader gently talked them around, pointed out the Valley Steam Plant, told them when to turn and got everything lined up.

After touchdown the pilot braked to a halt in front of the terminal building, kept both engines running, and lowered the rear cargo ramp. Their next stop was Los Angeles International (LAX) where some of the timer volunteers from Douglas and North American had their cars parked. But several of them jumped out at Burbank with us. They figured if these fly-boys had so much trouble finding the runways at BUR how were they ever gonna find LAX? I guess they took a taxi from Burbank.

Later I learned that boss man Jim Hong wandered into the Aerodynamic Department while we were gone and seeing almost every desk vacant asked "Where the hell is everybody?" He was finally told "They're up at Edwards doing timing activities." After that he directed that we couldn't have that many absent at one time for such an activity.

That effectively ended my NAA career although, due to bureaucratic oversight, I continued to receive thorough flight physicals from the Lockheed doctors for a few years until somebody thought to ask "Mr. Elliott, how much flying do you do for Lockheed?" But maybe it was just as well, as the golden era of multiple record setting days at Edwards was coming to an end.



**Bob Elliott –1958**