

Mr. William Clemens

Oral History

Kennedy Space Center

Interviewed August 3, 2004

Interviewer:

Gregg Buckingham

Transcriptionist: Mandi Falconer
All Points Logistics

1 [Chatter at beginning]

2 Buckingham: ...August 3rd, 2004 with Mr. Clemens this morning. For the record please
3 state your full name, where you were born and the date you were born.

4

5 Clemens: Yeah. My name is Bill Clemens. I was born in the mountains of southern
6 West Virginia in a little town, a coal mining community called Loredo. And born on 17
7 September 1928.

8

9 Buckingham: Ok. Very good.

10

11 Clemens: And I went to school at West Virginia University/Tech and I graduated in 1955
12 with a Bachelor's in Science and Electrical Engineering. Prior to that I was, I had been in
13 the Air Force on the Berlin Air Lift, in 1948 on the, I went during a Soviet Union, when
14 the Soviet Union blockaded Berlin. And so the allies, British and French, Americans
15 decided that they would fly all the supplies needed by Berlin, since no other means of
16 entry into Berlin was available due to the blockade and by Joseph Stalin at that time.
17 They went on. I was there for about a year in West Germany, they didn't call it West
18 Germany before the Soviet Union broke up. And we were successful. We broke the
19 blockade and then I left there and after I got out of the Air Force, that's when I decided I
20 needed a lot more education than I had.

21

22 Buckingham: Ok.

23

24 Clemens: Coming from southern West Virginia mountains, coalvilles.

25

26 Buckingham: So you grew up in West Virginia and then moved into the Air Force and
27 from there went to college at...

28

29 Clemens: Yes. Right.

30

31 Buckingham: Very good. And graduated in 1955?

32

33 Clemens: 1955. Later on, when I came into the Space Program I went to Florida's
34 School of Technology Graduate School and took seven or eight courses, but wasn't able
35 to finish too much because of the demands of the Space Program at that time were pretty
36 heavy.

37

38 Buckingham: So, when you got your degree in electrical engineering did you plan on
39 working, did you want to work in the Space Program?

40

41 Clemens: In 1955, when I graduated, there was absolutely no discussion of the, to my
42 recollection, of any Space Program. It was, it may have been in the thinking process of
43 some of the NASA management or, NASA wasn't even formed then. It was another
44 group that I can't remember, but anyway, the Space Program wasn't even its infancy at
45 that time, as far as I can remember. Chuck Yaeger broke the sound barrier and they had a
46 few other things, but I don't know, I don't recall any other events much about space.

47

48 Buckingham: Ok.

49

50 Clemens: So, I went to the coal industry after I, and the electric utility industry and
51 worked there for the period of 1955 to 1962 and then the Space Program was just starting
52 to blossom with the launch of one of the first satellites. I think it was called Echo and
53 Alan Shepard's launch, first man in space, first American in space. And that was when
54 my interest was generated in the Space Program. I was living in Pennsylvania and I saw
55 it on the black and white TV. We didn't even have color TV then. And then the
56 Pittsburgh Press and I saw an ad there by one of the contractors here at KSC, Cape
57 Canaveral at that time, Pan American for engineers. So, went to Pittsburgh and we were
58 living near there and I interviewed with them for a job here at KSC and that's where I
59 ended up. And they assigned me, as electrical engineer from the coal industry, to the
60 Mercury Program on Complex 14.

61

62 Buckingham: Ok.

63

64 Clemens: And I felt very much felt very much like a (??? 093) out of wood. It was a
65 completely new world. I was overwhelmed by the Space Program at that point on the
66 Mercury Program. It seemed that the eyes of the world were on that program at that time.
67 John Glenn had just made his first flight prior to my coming to Complex 14. My first
68 launch involvement was with Scott Carpenter. And I was assigned the liquid oxygen and

69 the RP1 fuel propellants, the ground systems that were used to transfer those propellants
70 to the Atlas boosters that were used on the Complex 14 orbital launches for Mercury.

71

72 Buckingham: Ok.

73

74 Clemens: And we successfully, as you know, went through that program with a few
75 glitches on the ground, but only delays on launch, but Complex 14 and the Mercury
76 Program from that point was very successful.

77

78 Buckingham: So, did you participate, as well, in the launch activities?

79

80 Clemens: Yes. Yes. I was in, I was... During the countdown, much to my amazement
81 on my first launch, only three of us were down there at the launch pad during the LOX,
82 the fueling and the LOX transfer into the Atlas. And everybody else was in the 10 foot
83 wall of the blockhouse back behind us. So, I realized that this wasn't one of the safest
84 positions to be in. So, one of my first events was when they started LOX chill down on
85 the Atlas, the vapors from the liquid nitrogen chill down unit completely enshrouded me.
86 I couldn't believe it. This was supposed to be happening. Well, I (??? 131) by my much
87 more experienced engineer from General Dynamics Astronautics that everything was
88 normal and we were just sailing right along. And then, shortly after that the LOX came,
89 that started to chill down, came down behind the blast wall, which was where we were
90 standing, and in our vicinity. And made a tremendous noise and got gaseous oxygen was
91 flowing all around the outside of this area down there. Obviously, everything had to be

92 completely secured, including any vehicle or whatever, not for (??? 143)... No spark
93 because oxygen, liquid oxygen was in heavy in the area. So there could have been an
94 ignition of that from any source that any of us might have.

95

96 Buckingham: You all are right in the middle of that.

97

98 Clemens: We were right in the middle of that during the countdown on a Mercury. That
99 was a little bit nerve wracking in the beginning, but I got used to it.

100

101 Buckingham: Did you actually physically stay there at launch or did they evac you out of
102 that?

103

104 Buckingham: No, when we got the Atlas filled, put the fuel in first, RP1 as they called it,
105 and then we got liquid oxygen up to what they called 90 percent fill and it started gushing
106 out of the top of the Atlas. We knew then and the blockhouse had readings they were
107 transmitting to us, we knew they were about 90 percent filled as I recall, and then safety
108 would advise us that we had to leave then and get back to the blockhouse. And then we
109 stayed there and we monitored through telescopes our system from the blockhouse during
110 launch countdown to see if we had any leaks, anything going up to the launch pad from
111 the transfer units we were using on the ground to launch.

112

113 Buckingham: Ok. And so that first launch, what is that like being in the blockhouse to
114 see that first launch?

115

116 Clemens: First launch was, I look back on that as just awe inspiring. I was just absolutely
117 caught up in that thing. I was, I was... I had great admiration for everybody that was
118 involved in the preparation and the countdown of that Atlas launch vehicle and the
119 Mercury capsule because it was very serious. Everything was done right by the book and
120 I'm sure everyone had a great deal of apprehension and had a great deal of glee when it
121 finally launched and lifted off the pad and then you heard the words BICO, which was
122 booster engine cut off. You could see the total relief on everybody. It was just
123 absolutely, you know, up until that point you almost wanted to collapse with relief. And
124 then, of course, people had to leave there, even though they had worked all night, and go
125 down to the beach and celebrate for a few hours.

126

127 Buckingham: Yes sir. That was a lot of work up to that point.

128

129 Clemens: Yeah. It was a great relief when it lifted off and they got into orbit. Everybody
130 felt good about that.

131

132 Buckingham: Was there anything else about the Mercury Program that you would like to
133 say or were involved with? Because you went from there and then that lead into Gemini
134 Program.

135

136 Clemens: Well, we had a few glitches on our systems on the ground that I can address.
137 One in particular was we had a relief valve, a liquid oxygen relief valve, that kept

138 popping and relieving on its own right outside the LOX transfer unit. As they opened the
139 outlet valve from out transfer unit, and the pump were running, and this relief valve
140 popped. And so, some of the mechanical experts decided that, "They call that water
141 hammer," then said. So the relief valve popped. So they decided in there wisdom to put
142 that relief valve on top of the blast wall and then they would thin it down to the ground
143 towards in front of the LOX transfer unit. So, then they did that and then we went into
144 countdown again and I was standing in front of the LOX transfer unit, checking
145 everything out, and we started the pump. Making sure that nothing was leaking in there
146 before we got to 90 percent fill. And lo and behold the relief valve let go, again, and
147 dumped LOX all over me. All over my back, down the whole... oh yes. And I left
148 everything out at that point including my headset strung out on the ground running from
149 this thing. But anyway...

150

151 Buckingham: You had a protective suit on, though, right?

152

153 Clemens: Yeah. Yeah. By the time it would hit me and it would vaporize real quick, but
154 my concern was the potential fire hazard, you know, and this LOX all over me was not a
155 good thing to have. So, anyway, we shut down the operations then and later on they did
156 another modification to that. Whatever it was that solved the problem. But that was on
157 of the most significant events on that particular operation.

158

159 Buckingham: Very good. Ok.

160

161 Clemens: From there, when the Mercury Program concluded, I transferred... I got
162 involved in one other program over on Complex 12, which is two complexes down on the
163 Cape, and that was the first interplanetary launch to Venus in the free world and that was
164 called Mariner. And that launch was an Atlas-Angena. Angena was built by Lockheed
165 and the Atlas was built by General Dynamics. So the Angena was a second stage rocket
166 that put the Mariner spacecraft on the proper trajectory towards Venus. And that was a
167 very successful launch.

168

169 Buckingham: Which Mariner was that?

170

171 Clemens: That was Mariner 1 and 2, I believe. Yeah, they had two of them. But that
172 was a very successful program, too.

173

174 Buckingham: And so you were supporting the launch facilities...

175

176 Clemens: Yeah. I did the same thing there that I had on the Mercury Program. The
177 launch facilities, fuel, and LOX, and also gaseous nitrogen were all included in part of the
178 systems. And when the Mercury Program ended I went with Lockheed Missile and
179 Space Company which was, which had built, designed and built the Angena second stage
180 rocket on Complex 14. I stayed on the same Complex. And this project with the Angena
181 was to rendezvous with the Gemini and that was to be our first rendezvous in space. So,
182 my function there was to, after going to California, to (??? 260) for about two months and
183 getting some background and training on it, we had a vehicle function generator which

184 simulated all the functions on the Angena and I somehow got the responsibility for that.
185 So, I was switched from LOX/RP1, to now I'm coming back into my own profession.
186 But anyway, it was only one vehicle function generator in the world for that particular
187 project, that Angena, and we... I had the responsibility for getting that up on the tower. It
188 was a pretty sizable console. Probably about 8 feet long and maybe 7 or 8 feet high. We
189 got it up on the tower first try. We couldn't get it to fit the platforms so I had to bring it
190 down. I was very nervous because this was the only one of its kind in the world. So,
191 well I made, or had them design me an i-beam platform, I mean a channel platform, so
192 that we could roll it in when we got it up high enough, roll it in on the platform and that
193 worked. That allowed us to get it up there and to get into place and I was totally relieved.
194 Three or four weeks later we got a hurricane coming and they said, "You're going to
195 have to bring down that vehicle function generator. We can't leave it up there during this
196 hurricane." So, we had to bring it down, again. And then, eventually, when the hurricane
197 passed we had to put it back up again. So, I got the nickname yo-yo.

198

199 Buckingham: Ok. That's where it came from.

200

201 Clemens: Anyway, when we wrote the procedures, most of them for check out of this
202 vehicle function generator, which was to check out all the instrumentation associated
203 with Angena in the blockhouse, all the cabling that led from the launch pad to the
204 blockhouse and so forth, we had to validate that procedure to the Air Force. And we
205 finally successfully did it. It took a lot of work. We had a lot of changes to make and
206 time went by, but that worked. Well, that validated everything before we hooked up the

207 Angena and then it was finally launched and they had some difficulty during the
208 rendezvous and they did not have a successful mate on the rendezvous with the first one.
209 And so, that was the end of my involvement with that. I left and came over here when
210 Kennedy Space Center, in 1965, when this thing was building up. You could see a lot of
211 activity going on over here in 1965. So, I interviewed with a contractor as a lead
212 engineer on the crawler transporter and I got the job. At that time, in 1965, it was early,
213 very early in 1965, February 1965, the VAB, the Vertical Assembly Building I think they
214 called it then, Vehicle Assembly Building now, it was still under construction. The pad,
215 the launch pad was still under construction. Crawlers were still under construction. The
216 crawler way was still being built. The Launch Umbilical Towers, there were three of
217 those, and the Mobile Service Structure, which weighed about 10 ½ million pounds and it
218 had to be moved in around the Apollo launch vehicle after we had taken the LUT, or the
219 Launch Umbilical Tower, and the Apollo to the launch pad and we brought up the Mobile
220 Service Structure. All of these were under construction at that time. There were a lot of
221 problems. The crawler had a lot of problems, only one that I'm most familiar with, the
222 other things I just heard about. And there was a lot of pressure to get these systems
223 working. I was, I have to say, as the young ones do today, I was in total awe of NASA at
224 that point, their management, their engineering, for the concept that they were developing
225 here. They had already developed the concept, but I mean, the construction and the
226 magnitude of this program - putting this all together and making it work. This is
227 absolutely one of the most unique, innovative, and enormous undertakings of its kind. I
228 think, and maybe in the history of mankind. I just can't think of anything that would
229 surpass that, at that point, you know, we're talking now about putting a man on the moon.

230 John F. Kennedy had made his commitment in early 1960's, who I met by the way on
231 Complex 14 when he came over on the Mercury Program, and he made this commitment
232 that we would put a man on the moon by the end of that decade. That was a hard pressed
233 statement to make because they had an enormous way to go to get one up there by 1968
234 and 1969. It looked like... I look back on it and I thought this was almost an impossible
235 task: mission impossible.

236

237 Buckingham: So, where you were here with Debus and von Braun?

238

239 Clemens: Debus and von Braun and all those people were here, and Michael Patrone,
240 they were all here. They were all magnificent, I thought. Absolutely had control, had
241 vision, they knew everything that was going on even down to the minor details on the
242 crawler, which amazed me. And we had troubles with the crawler in the beginning that
243 some of the local papers were saying the concept of using a crawler for roll out to the pad
244 Apollo was very tenuous. It may not perform the function that it needed to be. Need to
245 perform, getting the Apollo, we're talking about lifting 12.3 million pounds, a four
246 hundred and thirty-some foot structure, and lifting it up and carrying out the 3 ½ miles to
247 Launch Pad A and that's a 5 percent grade. We maintain level on all this period of time.
248 So, when they had the crawler under construction, we're running into some very difficult
249 problems.

250

251 Buckingham: What are some of the problems that you had with the crawler itself? The
252 design or

253

254 Clemens: One of the most significant problems we ran into, which had the papers, the
255 local papers that this thing may not work, may not perform the function, we had 176
256 bearings, tapered roller bearing, on what they call the truck assembly, it's where the belts,
257 and there were a total of 8 belts, with each shoe, they're 456 shoes, weigh 2,000 pounds
258 each, that were going around and had to be turned and, of course, those bearings had to
259 support the load that was being transferred down through the belts to as we icked up the
260 Shuttle, and they were tapered roller bearings. And when we picked that Launch
261 Umbilical Tower up, which by itself, well in the early testing day it weighed over 12
262 million pounds, and when we got up away form the park site for the Launch Umbilical
263 Towers some of those bearing cracked/crushed when we were in the turning mode and
264 putting some side forces on these bearings that somebody during design, I guess, did not
265 visualize. So, that became a very, very major concern. Replacing 176 bearings, there
266 were probably 14, I don't know exact size, diameter of 14 to 18 inches in diameter inside
267 and the outside of these trucks was a very large concern. Well, again there were people
268 in NASA design and in the industry, Marion Power Shuttle from Ohio built them,
269 contracted to build a crawler, they got together and they decided that we would eliminate
270 those bearings, the thing can roll on, I don't want to mention the name, the roller bearings
271 and we'll put in sleeve bearings, Ron's Alloy, and they had to be fitted in there so that
272 they wouldn't rotate. So, they had, the terminology escapes me now, but they had to chill
273 these bearings down, the Ron's Alloy sleeve bearings down enough so that they could
274 slip them in there and then they would expand and they would stay in position. And that
275 took a lot of effort to get those bearings, to pull all those bearings out of there and replace

276 them with those sleeve bearings, Ron's Alloy sleeve bearings. And then, the temperature
277 of those bearing had to be measured. We had to put thermal couples in some of the
278 bearings. Then those had to be read out when we were going down the road, because if
279 we got a hot bearing we could have a seize up. So, we had instrumentation on all the
280 bearings and they had to be automatically greased. We had a lubricator that greased all
281 these bearings on the way to the launch pad and we monitored there temperatures. So,
282 that was, I thought that was big engineering problem that was very successfully solved,
283 again, by some of the outstanding engineering and thinking here by NASA management
284 and contractor personnel getting together and discussing this. I still have great
285 admiration for some of these people. We had a lot of problems with out electronics – a
286 terrible problem with electronics. It was built, I don't think they're in business now, I
287 don't know, American machine and Foundry and the elctronics was in control of
288 steering and leveling, which was absolutely necessary for the successful operation of this
289 machine.

290

291 Buckingham: Now the way the crawler works, how's the electronic circuits actually
292 used?

293

294 Clemens: They are used for two functions. One for steering and one is to maintain level.

295

296 Buckingham: So, there's electric motors that perform...

297

298 Clemens: The electronics then controlled the hydrolic pumps that pump, in each corner in
299 and out, in order to maintain a level within approximately minutes of one arc, much less
300 then one degree in level, and that had to be maintained while we were goin up this 5
301 percent slope, which was 1,200 feet long at the launch pad. Still had to maintain that
302 level. That was sensed, that was sensed by then by a mercury monometer. It was about a
303 3/8 inch tube, stainless steel tubes, that extended diagonally from each corner of the
304 crawler internally, by the engine room, and then across each corner, and that measured
305 the level and then another item called pressure equalization so you could maintain your
306 pressure and your level in these corners. So, we had about three to four hundred pounds
307 of mercury, liquid mercury in those, in that monometer, in those tubes. And in the
308 middle we had pressure transducers that sensed the differential pressure in the mercury
309 from one side to the other. And we used that through out the Apollo Program and a good
310 bit of the Shuttle Program.

311

312 Buckingham: Now, did you physically ride in the crawler when you do the transport?

313

314 Clemens: Yes. I was a control room engineer, and sometimes called the operations
315 director for most... I was on every Apollo rollout. I never missed a one. From 500F,
316 which was the first mock up of Apollo, all the way through the end of the Apollo
317 Program. In ever missed one. In fact, I never missed a rollout to the pad in 28 years,
318 except for one Shuttle.

319

320 Buckingham: So, you were involved when it carried over in the Shuttle Program.

321

322 Clemens: Yes. I still... When the Shuttle Program ended, I mean the Apollo Program,
323 excuse me, ended, NASA was in the process of rebidding some of the contractors for
324 ground support and other. There was a total revamping of the organization out here after
325 the Apollo Program. So, after the Apollo Program was over, Boeing took over the
326 contractual area that I was working in on the crawler. So, NASA decided, along with
327 ourselves, that we needed to totally upgrade and modify all the systems on the crawler,
328 all the electronic systems mainly to state-of-the-art, because you could no longer
329 purchase the hardware that we had. You could use spares or whatever. They couldn't
330 recognize it. It had gotten that old. And electronics was changing in leaps and bounds.
331 So we went through a process of two years between the Apollo and Shuttle of modifying
332 eight consoles on each crawler, and the cab controls for doing the steering and the speed
333 control, and that was tremendous project. We ordered 5,000 line items that we had to
334 assemble in that May. We had to make our own circuit cards and assemble all of this and
335 then check out each console and then integrate it all together in the crawler with
336 programmable controllers that we had never used and computer. We successfully got
337 that accomplished in time for the first Shuttle rollout, which was John Young and
338 Crippen, first astronauts to fly the Shuttle. That's when I got my Snoopy pin for leading
339 the effort, that two year effort on that modification. That was the most significant and
340 most difficult task that I ever had to accomplish in all the time I worked here at KSC, but
341 I was totally involved, totally in agreement that it had to be done and that it had to be
342 done in the two years that we had. And there were some people believing that we
343 couldn't do it. Now, I was actually told that, but I said, "We have no choice." We

344 haven't any choice because the whole program depends on this thing getting completed.
345 Because we had the crawlers tore apart as far as the internal workings were concerned.
346 All the old consoles were out and gone and we were in the process of building and
347 installing hundreds of new cables and all that. And anyway, it was successfully
348 accomplished.

349

350 Buckingham: And it's a yes. I just noticed that sliver snoopy on your lapel there.

351

352 Clemens: Yeah. Believe me, I had some excellent, excellent engineering help there.
353 Boeing supplied some outstanding engineers to work with. This was not a one-man
354 show. I was put in lead because I had been there a long time and obviously knew more
355 than the guys, some of the guys had been working on the Saturn V during Apollo. So,
356 the crawler was a new thing with them. But they were excellent. They know what they
357 were doing. Without them I don't know what I would've done. They were absolutely
358 tremendous. They deserve this thing as much as I do. But, it's been successfully used
359 ever since. There's been some modifications, but basically the hardware is pretty much
360 as it was during that period.

361

362 Buckingham: Was there anything else dealing with the Apollo Program like the launch to
363 the moon or anything else from the Apollo Program?

364

365 Clemens: I would, yes, I would say that one of the most significant events in my life and
366 during the Apollo Program, was just prior to Apollo 11 rollout we had dignitaries from all

367 over the world coming here to visit KSC. I don't know how generals and admirals and
368 whatever from NATO and you name them, foreign countries, and Johnny Carson and Esd
369 McMahon and his group and other that I gave tours to through the crawler. There was a
370 tremendous build up of excitement about this whole Apollo 11 launch. And I was made
371 supervisor not too long prior to that of the crawler. So, I gather the guys on the crawler
372 together and I was pretty emotional about that whole thing by then, and I expressed my
373 concern that we, that this is one of the most significant times in the history of our
374 country. We had the eyes of the world on us. It was absolutely necessary that each of us
375 perform to our best capabilities. Not let anything go unnoticed, That we will correct any
376 problem we can and we get this thing in the best shape we can and that during the
377 operation we must be very professional and I knew that we could count on everybody to
378 do their best. So, I was emotionally pretty worked up about that. I absolutely did not
379 want us to have any measure of problem on the way to that launch pad. Because Debus
380 had invited hundreds, if not thousands, of people to view that rollout that morning of
381 Apollo 11. And they were standing outside of the VAB, high bay, and when we were
382 getting ready to roll out you could see them through the doors. The fields were full of
383 people from all over and he had put a big digital clock up there so that we could see it
384 right outside of our control room. Debus, when I say he. So at 0700 exactly, and this
385 wasn't easily accomplished because you had a lot or preparations before starting well
386 before midnight to get this rollout accomplished by 0770 in the morning.

387

388 Buckingham: So you had start before midnight to get ready for a 7am rollout.

389

390 Clemens: Oh yeah.

391

392 Buckingham: So there's 7 hours of work just leading up to...

393

394 Clemens: Yeah. 7 or 8, yeah. A lot of observers up and down because that four hundred
395 and some tower and they had to get all there stuff lose from the launch vehicle and the
396 Launch Umbilical Tower. And we had preparations. Transporting, we provided power
397 to the mobile launcher. We had to transfer out power to them and that sort of thing in
398 preparation for rollout. So, anyway, we got everything ready at 0700. Michael Patrone
399 his voice came over the net quite a bit because he was equally concerned Iif not more so.
400 But at 0700, probably just prior to that, we brought our engines up, those 27 150-
401 horsepower engines, the speed 1,000 RPM, so that right at 7 o'clock we could release
402 the brakes and put the thing in motion. And then we started rolling out just as Debus had
403 asked us to do which made me fee very good. With all those people standing out there,
404 you know, we got a lot of applause and cheers and anyway. So, we got to the launch pad
405 without any events to mind and then after that we had to go back and pick up, halfway
406 between the launch pad and the Vehicle Assembly Building, we had to go back and pick
407 up the mobile service structure, which is a very awkward structure that didn't lend itself
408 to equal weight distribution on the crawler, but it weighed 10 ½ million pounds. And so,
409 we lifted it, took it up around the vehicle, and that was a very touchy operation because
410 there was a lot of platforms that had to be open and didn't really have a lot of clearance
411 around the Apollo vehicle, launch vehicle stack. So, we had to have observers up and
412 down on each of those platforms communicating with us in the crawler control room at all

413 times during our final approach at the launch pad. And on that occasion we got around
414 very well, no difficulty. That seemed to be an almost flawless operation. They all didn't
415 go that way. But that day was one very big highlight for me.

416

417 Buckingham: Wow.

418

419 Clemens: We had other occasion where we had platform, even though they had cushion
420 around them, it touched the spacecraft of something, which would bring your heart up
421 into your throat. And then we'd have to make very careful adjustments before we made
422 any moves. And we had people up on those platforms and three hundred and some feet.
423 Well, I remember, actually having some real nerve problems over this because we were
424 sweating back and forth. You couldn't avoid that. You know, whenever you try to level
425 it magnifies itself and three hundred and some feet. So, I've talked to a lot of observers
426 up there that were having some serious nerve problems over that whole...

427

428 Buckingham: That's something that people that aren't involved don't really understand.
429 That that's something critical, that that does happen, that you have such a large structure,
430 it's huge and able to sway and a critical alignment associated, to try to get that all around
431 the launch vehicle.

432

433 Clemens: When we came we had six pedestals to set that Launch Umbilical Tower on at
434 the pad. And this structure, as huge as it was had to be set down within plus or minus
435 two inches. So, we came up with a simple way of putting a piano wire across the tops of

436 the pedestals so that we could align the pin that came off of the bottom of the Luanch
437 Umbilical Tower up with this piano wire going down and they would guide us in. Later
438 on we got a little more sophisticated and we used a laser. That would give the driver of
439 the crawler who was bringing it in for final positioning, he could then see on the screen
440 his positioning relative to those mounts. (??? 575) was a lot of improvement.

441

442 Buckingham: You do what you had to do to get it done.

443

444 Clemens: What was that?

445

446 Buckingham: You had to do whatever you had to do as far as the alignment. Excellent.

447

448 Clemens: Yeah.

449

450 Buckingham: Then leading into the Shuttle Program, you supported, of course, the first
451 Shuttle mission, first Shuttle launch and subsequent Shuttle launches after that.

452

453 Clemens: Yes. In 1980, NASA asked me if I would come to work with them. That
454 sounds a little egotistical, but I don't mean it to be. There weren't many crawler people
455 in the world with a lot of experience at that time. So, anyway, I went to work with
456 NASA in 1980 as a, naturally, as a crawler systems engineer, crawler being my
457 responsibility. So, I still was on, very much involved with all our operations and had
458 some authority over, you know, their work and so forth on the crawlers, and was still on

459 all the rollouts until my time of retirement in 1994 except for one. I missed one out of all
460 those years.

461

462 Buckingham: Was there any events that, like, stick in you mind as far as any of the
463 rollout and rollbacks? I remember during the Shuttle Program when we had things would
464 happen at the pad, you'd have to roll the vehicle back, and then there was some of the
465 preps for hurricanes, where we'd maybe have to get the crawler in position. Were you
466 involved in all those kind of things?

467

468 Clemens: Yeah, We had big concerns about getting the crawler back to the VAB during
469 hurricane season, and during the first Apollo launch, I'm sorry, during the first transfer of
470 the 500F mock up of the Apollo...

471

472 Clemens: ...very difficult time. The bearing overheated, some of them weren't getting
473 their grease. The winds were very high so we had a lot of swaying of the structure and
474 then we had not developed a completely automatic leveling control. It had to be done
475 manually with the console by looking at meters and hand levers. He had to do that. So, I
476 had... that was a very, very taxing time for everybody to get that thing back to the VAB.
477 It was a lesson learned right off the bat. First of all, don't wait too long. Once you get a
478 Shuttle, I mean a hurricane warning is to bring it back, because if you wait to long you
479 get into that situation, which could be disastrous, especially for the Shuttle. Because, as I
480 recall, I don't know if I'm accurate on this, but as I recall, the maximum wind sail that
481 the Shuttle can take exposed on the crawlerway is about 45 miles wind. A 45 mile per

482 hour gust will do some damage. So, it behooves you to bring that back if there is a
483 hurricane in the vicinity, don't wait too long. The crawler, like any other vehicle of that
484 magnitude and that complex can have a problem and break down and be out exposed on
485 the crawlerway. I was so concerned about that, I'll get into a little more detail I suppose,
486 concerned about that and the possibility of a lightning stroke on the Solid Rocket
487 Boosters. What would happen if we got a lightning stroke on a Solid Rocket Booster
488 while we area exposed on the crawlerway? And I brought this up after the Columbia
489 disaster. They asked people what they were concerned about, and this has been a concern
490 of mine. I didn't know what the answer was, but I was concerned that the various
491 segments of the Solid Rocket Boosters, you know, when they are stacked together, they
492 are stacked together with an o-ring and so forth. And I was concerned what happens if a
493 lightning stroke penetrated those seems when we're out on the crawlerway. Would we
494 have an explosion? Well, I didn't think it would go as far as it did, but it turned out to be
495 a humongous question that nobody really had an answer for. I was asking about... I don't
496 know, but somebody give me warm feeling that this is not a problem. And when the
497 experts got into it, the lightning experts, the solid rocket experts, it turned out to be a big
498 problem. In their mind they weren't sure either.

499

500 Buckingham: So, you're question Is pretty much is something that nobody had thought
501 about.

502

503 Clemens: It appears that way. Because it went on for a long time. We had a lot of
504 meetings. We went to Huntsville. They hired PhD's from universities that were into

505 electromagnetic from lightning strokes and I understand that (??? 071) even built a
506 lightning test facility out at there facility out in Utah to make sure and measure the
507 electromagnetic energy that would penetrate that seal. And it took a couple of years. I
508 was shocked...

509

510 Buckingham: It was a good question.

511

512 Clemens: ...it generated into that.

513

514 Buckingham: That's a very good question.

515

516 Clemens: But anyway, they finally came to the conclusion that they could, that it was
517 going to be alright. There wasn't enough energy there to light the propellant. So, that
518 was a comfort; however, there was still this concern about bringing Shuttle back in a
519 hurricane and getting the Shuttle in the winds and so forth. So, I was asked to make a
520 presentation to the Center Director, then Center Director General McCartney, at KSC
521 headquarters. So I did. I went to his office along with several other people including
522 Bob Seek and my boss, Mr. Lloyd, who is our division chief, and expressed on him my
523 concerns that the crawler could possibly break down out there and we'd be in protracted
524 high velocity wind area and we could do major Shuttle damage. And I, my request was
525 that when they make the decision to bring the Shuttle back to the Vehicle Assmby
526 Building, to be on the cautious side – not wait until they have almost a certainty of having
527 an impending hurricane hit at high impact here. And he agreed with me. He was very

528 gracious and nice about it. He totally agreed. He said that's where he will go from now
529 on. That from that point on they would, he would be on the cautious side. Now, he may
530 have already decided that, but he indicated that he was in total agreement with what I was
531 saying and I walked out of there feeling pretty good about that because it was a deep
532 concern, really.

533

534 Buckingham: I think to this day they still basic requirements of when they roll the Shuttle
535 back it's the first thing.

536

537 Clemens: Yeah. It should always be. When you're talking about the consequences of
538 making a mistake there and waiting to long are too much to comprehend.

539

540 Buckingham: Well, very good, any other final comments or anything else that you would
541 maybe like to say...

542

543 Clemens: Well...

544

545 Buckingham: ...any of your career or just outside, some of the local things that maybe
546 you've participated in, while in the area? Anything else?

547

548 Clemens: Well, I don't have a whole lot to add to that. I think I've talked about myself a
549 lot, but I have taking on some projects that are outside my scope of training. One was, I
550 was put in charge of refurbishing the crawlerway after the Apollo Program. They had

551 large indentations, the crawlerway was compacted by the Corps of engineers. They put a
552 layer down, and then they (??? 135) and then they compacted that and it was very dense.
553 But over the years, with 12 ½ million pounds going down the same tracks, back and
554 forth, back and forth, that crawlerway started to get a track that was lower than the
555 outside edges all the way down and now water was standing in the crawlerway in those
556 low places all the way down through the crawlerway. And that made it difficult for the
557 crawler because it would wash off the lubrication on our tread belts, but it had to be
558 lubricated all the time. So, they gave me the job of leading the effort to refurbish the
559 crawlerway, made a road map. Anyway, what we did, what we finally did, we got the
560 equipment, I don't know, 60 or 70 or 80 railroad cars or a lot more. I can't remember
561 now. But we brought them in on truck on that (??? 150). We had to clean everything off
562 of the crawlerway and put new (??? 123) down in those low places all the way to the
563 launch pad at Pad A then Pad B and then recompact it, smooth it out, and that was a big
564 effort. It cost several million dollars really. And then we had to bring in this, what they
565 call Alabama River Rock, which is round smooth rock and reinstall that all over the
566 crawlerway because all of that had been crushed over the years. It was no longer usable.
567 During Apollo they'd have to find the good rock that was lying on the side and put it on
568 the tracks where we would go and move the old stuff out first. So, we had to completely
569 refurbish the crawlerway.

570

571 Buckingham: Just some of the basic figures for the crawlerway, like how deep was the
572 river rock, and then the layer underneath that.

573

574 Clemens: It varied. On the, I'm trying to remember this, I think what we had on the main
575 crawlerway was 4 inches of river rock depth and, I think, we had on a curve we had a
576 little more, maybe 6 inches. It's hard for me to recall. In the very beginning when the
577 crawlerway was built by the Corps of Engineers they were so concerned about the
578 crawlerway washout, washing out from underneath it because of all the standing water all
579 around here and the lagoon and all that, so they were afraid that the weight of the crawler
580 and the mobile launcher, which together was about 18 million pounds, was going down
581 the crawlerway and would build up enough hydrolic water pressure underneath the
582 crawlerway, that you could build up enough pressure that it would suddenly wash out and
583 it would collapse under it. So, what they did, the Corps of Engineers, they decided to
584 drill holes in the crawlerway, especially going out to Pad B which was their primary
585 concern, and put transducers down about 100 feet. And for two solid weeks, this was
586 prior to our first Apollo rollout, we rolled back and forth – about 14/15 hours a say. Back
587 and forth. Very slow. All the way from the intersection of Pad and Pad B to Pad B. Roll
588 back and forth very slow while the Corps of Engineer read the build up of hydrolic build
589 up pressure under there. Now, when they saw that we had apparently squeezed out
590 whatever liquid water was underneath there or enough that they got down to where there
591 pressure readings were at a safe and ok they had to call away and say we were ok. But, it
592 took two solid weeks of that to make sure that they felt we were safe enough to transverse
593 over that.

594

595 Buckingham: Wow. That is always one of thigns that I get questions about: the crawler
596 because it, the crawlerway and the crawler because they are so unique.

597

598 Clemens: Yeah, they really are.

599

600 Buckingham: Like nothing else on the planet.

601

602 Clemens: That's absolutely another concept. I have people in mind, you know, that I
603 have a great admiration for, even today, and one of them is, we were very much involved
604 in all these facilities here at KSC for the Apollo program and one of the guys I admire
605 probably as much as anybody I've ever worked with, one of my heroes almost, is D. B.
606 Buchanaan. Have you ever heard of him as a former director at Kennedy Space Center?

607

608 Buckingham: Yes sir.

609

610 Lemens: He was very instrumental at putting all of that stuff together out there. He was
611 very instrumental in crawler. He had his hands in about everything. And as I say at the
612 beginning, those directors that we had here at Kennedy, my hat's still off to them. Debus,
613 when we had a crawler, a small crawler problem, such as a pin coming out, the
614 connecting pin on the shoes, we had a little T-pin there, and we were a little leery about
615 changing anything in those days because we are at the very beginning of the program, so
616 we went to a meeting and we presented some of the problems that we had. You'd think it
617 was just a minor problem, but we didn't know what the solution was right off the bat.
618 We got a carter key in there. Dr. Debus was sitting on the meeting, because he listened to
619 all of these problems back in those days, and he says, "Hold it right there." And in his

620 German accent, he say, "I want you to build a key for the end of that cross pin so that you
621 don't ever have to worry about it coming off again." So, that's what we did and we never
622 worried about it again. But, there's a man of his intellect that's down at the smallest
623 problem but he had the solution. He'd been around enough of that kind of stuff that he
624 had a solution and when he said to do it then that meant do it. I mean, what else would
625 you say.

626

627 Buckingham: Excellent.

628

629 Clemens: And that was the way with some of the KSC management during that period,
630 Apollo, they were totally involved. I'm trying to think, Michael Patrone had something
631 to do with something we did on the crawler, a change we made. He came up with an idea
632 and a suggestion. They just got themselves involved all the way around. Believe me,
633 when you got it from someone on that level it took the load off of you because you didn't
634 have to go around asking everyone else. Those people were tremendous.

635

636 Buckingham: The decision was made and you just carried it out.

637

638 Clemens: The decisions was made and you knew they knew what they were talking about
639 and I have a great deal of admiration for those people today.

640

641 Buckingham: Excellent. Well, is there any other final comments? anything else you
642 would like to say?

643

644 Buckingham: Well, one comment that was on your list there that I would like to, from my
645 experience and the background, I would like to say... One thing I learned, very deeply
646 ingrained in me over the years, you never want to get yourself so entrapped in a position
647 where you think that you are the expert, therefore you can make decisions that may,
648 much to your surprise, have significant consequences immediately or down the road,
649 especially during operations when time might be limited. But I am a firm believer that if
650 there is an operational problem that has some immediacy to it, before you make any
651 decision, no matter what level you are on, and I'm sure that's done now by the test
652 conductors and so forth, but you know, you get down on the lower levels that has to be
653 done. Of any mistake I have made, and I know others, people in higher position than me,
654 the mistake is made because they inadequate consultation with their peers, with their
655 management before they made a final decision thinking this was not a very significant
656 thing but then it turns out to be a lot more significant. So, if I had to do it over again I
657 would indoctrinate every new employee that came here to KSC, especially engineering,
658 technicians too, and I would impress on that until they got tired of hearing it. Don't make
659 any rash decisions because you think you are the expert. Don't be afraid be afraid to
660 consult with your peers. Don't let the ego stand in your way. Consult with management
661 because there is too much at stake. There's too much here in this program; it's not like
662 any other industry. I'm totally a believer in that because of my own experiences and
663 what I've seen with other people.

664

665 Buckingham: So, not matter how long you've been here or whatever, you could always
666 learn something new.

667

668 Clemens: Yes. Absolutely. You can learn something. And one thing is that I do believe
669 that people can be involved with something so long that they think they are the overall
670 last word on that particular system and this having constant consultation before any
671 significant change is made is vital to this program - more than anything else.

672

673 Buckingham: Good words. Good words. Ok, well. anything else? No.

674

675 Clemens: No. Accept I will say one little thing, when I look back on it earlier that I didn't
676 envision the Space Program when I got out of college. Never knew anything about it.
677 And then before I got out of it we were on the moon. We were putting Space Stations up.
678 So in my short time, which is thirty some years, 33 or 34 years in the space industry, but I
679 believe we are going to see, because of what I've seen and what the scientists and the
680 engineering and NASA and the industry, I believe, we've got a lot of surprised coming to
681 us in the future, those of you that are going to live long enough to see it. I believe space
682 travel 50 years from now is going to be common place, interplanetary, who knows?
683 When I got out of schools computers where a science fiction thing almost, who know
684 what the future brings. But there will be a lot of things only because we have some great
685 minds involved in this industry.

686

687 Buckingham: Ok, well thank you very much for your talking and taking the time this
688 morning.

689

690 Clemens: I hope I didn't bore you to death.

691

692 Buckingham: No sir. Not at all. A lot of good information. I think a lot of people have
693 never heard the story, the crawler story, the crawlerway story, those details, the things
694 that that you really never about that has to be done to accomplish the goal. Rolling out,
695 rolling back and any other activities associated with the launch.

696

697 Clemens: I can tell you at times, and during the Shuttle program there was a lot of stress,
698 a great deal of stress, and the operations were extremely long. We were sometimes 24-30
699 hour out here because when they took the Launch Umbilical Tower, got it down to the
700 pad it took us hours to get clear of the pad, even after we set it down. Then we had to go
701 back and pick up the mobile service structure.

702

703 Buckingham: Yeah, because it was all serial.

704

705 Clemens: And bring it back to the launch pad.

706

707 Buckingham: That all had to be accomplished together.

708

709 Clemens: Yeah, and then we had to bring the mobile service structure away form the pad
710 during launch countdown. We had to stay out here and sleep on cots until we had launch
711 in case we had to take the mobile service structure back.

712

713 Buckingham: That's amazing.

714

715 Clemens: Do you want to know the most frightening thing I ever experienced out here?

716

717 Buckingham: Yes sir. Yeah. I'd like to hear that.

718

719 Clemens: We brought the mobile structure, the only one the world during Apollo, 10 ½
720 million pounds approximately, we got it back to the park area between the VAB and the
721 pad and the thing was completely out of level. We didn't know how much out of level.
722 You could get out and see it leaning. Well, we didn't really have an idea what we were
723 going to do about getting that thing back level. We were actually in a state of panic about
724 getting that thing back and so was many, many other people out here because it spread all
725 over KSC. So, we had a printed circuit card that had a lead came loose, we found out
726 later, that reversed the polarity to the pumps. So instead of pumping up it was pumping
727 down, so the guy hit the panic button and shut it down, fortunately. But by then it was
728 way off scale. We didn't know where it was. All it indicated was it was off scale. So,
729 we got a lot of consultation on what to do about it then. None of them seemed to be too
730 valid. We talked and talked and talked about it and we finally decided our group, inside
731 that control room, we had to have the decision, we had to consult among ourselves, make

732 up a decision before we recommend anybody, before we touched anything. And we
733 decided that we had to level it with the pumps on the crawler, but we had to know that
734 when we started those pumps that we were going in the right direction. To pump in the
735 wrong direction again would exacerbate, make the problem worse, and could be
736 disastrous. So, anyway, with all of our consultation among each other, we decided that
737 we could test without turning the system on by looking, with the amount of experience
738 we had out there in hydraulics, we could tell whether we were pumping, that would,
739 pushing the switch would make it pump up in that corner or pump down, whatever. And
740 with all of the background that we had, all the knowledge, with all of it put together in
741 there we were able to turn the pump which way to pump in the right direction. We had to
742 repair that card, put a new card in there. So we did that and lo and behold we turned it on
743 and all of us had big knots inside of us, I'm sure, and we pumped it up and it came in the
744 right direction and we went back to level. I do believe that is one time I had my
745 intestines tied into a knot, if I ever had them tied into a knot it was that time.

746

747 Buckingham: You think, a one of a kind element that you had on there. If you lose that
748 there's nothing else like that.

749

750 Clemens: That was the only one in the world. Apollo program can't go on without that.
751 Reckon that thing would have been a total disaster.

752

753 Buckingham: Good story. Good information. Thank you again for your time.

754

755 Clemens: Thank you. Thank you. I wish you'd give me Mike's. I like Mike. You can
756 tell Mike, Mike tries to give me golf lessons and I've always told him, "Either Mike
757 you're a bad teacher, or I'm a bad pupil." But I like him. I'm sorry, he had a little
758 problem at the club. I don't know. It made me mad.

759

760 Buckingham: Yes sir.

761

762 Clemens: I was always angry over that. And I wasn't there that day

763

764 Buckingham: Can I get your phone number?

765

766 Clemens: Yeah.

767

768 Buckingham: Then I'll be able to have him either contact you or give him your phone

769 number.

770

771 Clemens: Yeah. 321.....

772

773

774