



1  
00:00:15,709 --> 00:00:13,339  
when I think about 1969 and I look back

2  
00:00:18,350 --> 00:00:15,719  
you know a hair right now in the back of

3  
00:00:21,409 --> 00:00:18,360  
my neck is arising because I remember

4  
00:00:23,029 --> 00:00:21,419  
those days was really the focus of what

5  
00:00:26,269 --> 00:00:23,039  
we have been preparing for after

6  
00:00:28,490 --> 00:00:26,279  
President Kennedy had really charted us

7  
00:00:30,220 --> 00:00:28,500  
as now so to try to send somebody to the

8  
00:00:34,280 --> 00:00:30,230  
moon and bring him back safely and

9  
00:00:36,140 --> 00:00:34,290  
really when the words were said you know

10  
00:00:38,000 --> 00:00:36,150  
they just said rang a bell with me after

11  
00:00:40,369 --> 00:00:38,010  
all those years and the hard work and

12  
00:00:43,130 --> 00:00:40,379  
the sweat the blood looking all the

13  
00:00:45,079 --> 00:00:43,140

problems that we had been through so

14

00:00:47,119 --> 00:00:45,089

there's no question if you go back and

15

00:00:49,520 --> 00:00:47,129

look in history and I'm a history buff

16

00:00:51,890 --> 00:00:49,530

by the way and I look at what we've done

17

00:00:53,810 --> 00:00:51,900

really with the lunar landing I think I

18

00:00:56,030 --> 00:00:53,820

don't know of anything that it's greater

19

00:00:58,399 --> 00:00:56,040

than that you think about wars and you

20

00:01:00,410 --> 00:00:58,409

think about back in history and a lot of

21

00:01:03,530 --> 00:01:00,420

the things that's happened but if you

22

00:01:04,670 --> 00:01:03,540

think about human endeavor I don't know

23

00:01:11,100 --> 00:01:04,680

of anything when you talk about

24

00:01:15,360 --> 00:01:14,070

well we have to go back a few years if

25

00:01:18,330 --> 00:01:15,370

you want to look at what made the

26

00:01:21,150 --> 00:01:18,340

program successful and I have to give

27

00:01:23,160 --> 00:01:21,160

the German team really the credit and I

28

00:01:24,960 --> 00:01:23,170

started with a lot of them in early 50s

29

00:01:27,600 --> 00:01:24,970

because we were with the army in those

30

00:01:30,870 --> 00:01:27,610

days and of course 1960 we went to NASA

31

00:01:32,430 --> 00:01:30,880

but a lot of work had begun von Braun

32

00:01:34,740 --> 00:01:32,440

was always interest in space travel

33

00:01:36,780 --> 00:01:34,750

he didn't care a thing about military he

34

00:01:38,970 --> 00:01:36,790

didn't care the thing about ballistic

35

00:01:41,850 --> 00:01:38,980

missiles and so forth but of course he

36

00:01:43,469 --> 00:01:41,860

came over here with the paperclip when

37

00:01:44,219 --> 00:01:43,479

we brought two people over after World

38

00:01:46,469 --> 00:01:44,229

War two

39

00:01:49,650 --> 00:01:46,479  
the German team when they came here to

40

00:01:52,110 --> 00:01:49,660  
redstone and started just extending the

41

00:01:54,150 --> 00:01:52,120  
v2 the old v2 rocket that they had built

42

00:01:56,730 --> 00:01:54,160  
in fact he was the key person in that

43

00:01:58,530 --> 00:01:56,740  
and we went to the Redstone muscle then

44

00:02:01,290 --> 00:01:58,540  
after that that was about a hundred

45

00:02:02,910 --> 00:02:01,300  
seventy-five nautical mile listing

46

00:02:04,350 --> 00:02:02,920  
missile and after that was a Jupiter

47

00:02:06,180 --> 00:02:04,360  
missile which was an intermediate-range

48

00:02:09,240 --> 00:02:06,190  
ballistic missile fifteen hundred miles

49

00:02:11,130 --> 00:02:09,250  
we all worked on that then the idea came

50

00:02:13,199 --> 00:02:11,140  
up with he really wanted to build

51  
00:02:15,990 --> 00:02:13,209  
something big that he could go into

52  
00:02:17,520 --> 00:02:16,000  
space and carry some heavy payloads so

53  
00:02:20,220 --> 00:02:17,530  
we started looking at how does one

54  
00:02:22,470 --> 00:02:20,230  
cluster we took the tanks from the

55  
00:02:24,630 --> 00:02:22,480  
Redstone 70 inches in diameter we took

56  
00:02:26,520 --> 00:02:24,640  
the Jupiter which was I in a minute

57  
00:02:29,430 --> 00:02:26,530  
range here immediate range ballistic

58  
00:02:32,100 --> 00:02:29,440  
missile it had 105 inch in diameter and

59  
00:02:34,410 --> 00:02:32,110  
then with clustered goals and we was

60  
00:02:37,320 --> 00:02:34,420  
able to cluster an engine we had eight

61  
00:02:40,020 --> 00:02:37,330  
engines nine tanks now think about how

62  
00:02:41,940 --> 00:02:40,030  
do you get the propellants and for for

63  
00:02:44,250 --> 00:02:41,950

the benefit let's say of people they may

64

00:02:46,740 --> 00:02:44,260

not know how rocket engine works but you

65

00:02:48,690 --> 00:02:46,750

have to have a fuel and oxidizer when

66

00:02:50,370 --> 00:02:48,700

you go up into space is no air up there

67

00:02:52,680 --> 00:02:50,380

like an airplane or a jet engine

68

00:02:55,140 --> 00:02:52,690

wouldn't require so we care oxidizer and

69

00:02:56,820 --> 00:02:55,150

most of time we use liquid oxygen and

70

00:02:59,490 --> 00:02:56,830

the fuel can be different things your

71

00:03:02,310 --> 00:02:59,500

automobile uses gasoline back in those

72

00:03:03,930 --> 00:03:02,320

days we use alcohol 75% alcohol

73

00:03:08,340 --> 00:03:03,940

there's a few and then we went to

74

00:03:10,800 --> 00:03:08,350

Keirsey and rp1 or jet fuel but we had

75

00:03:12,570 --> 00:03:10,810

to design the system and we clustered

76

00:03:14,370 --> 00:03:12,580

the tanks and you had to manifold all

77

00:03:16,320 --> 00:03:14,380

these system you get both the oxidizing

78

00:03:18,090 --> 00:03:16,330

the fuel to the individual engine but if

79

00:03:20,280 --> 00:03:18,100

you got eight engines you can imagine

80

00:03:21,930 --> 00:03:20,290

what a plumber's nightmare you had and

81

00:03:23,910 --> 00:03:21,940

you had cross feed you're worried about

82

00:03:24,809 --> 00:03:23,920

one engine would do something to the

83

00:03:26,550 --> 00:03:24,819

engine adjacent

84

00:03:29,970 --> 00:03:26,560

to it whether it was the feed system or

85

00:03:31,979 --> 00:03:29,980

was vibrations or whatever so we went

86

00:03:33,959 --> 00:03:31,989

through a lot of testing to do that in

87

00:03:36,270 --> 00:03:33,969

addition to clustering engines then you

88

00:03:37,949 --> 00:03:36,280

had to pressurize the tanks once you

89

00:03:39,420 --> 00:03:37,959

start taking the propellants out if you

90

00:03:41,550 --> 00:03:39,430

don't continue to put the pressure in

91

00:03:43,170 --> 00:03:41,560

there the tank will collapse so we had

92

00:03:45,509 --> 00:03:43,180

pressurization system we had to design

93

00:03:47,670 --> 00:03:45,519

and we went through a lot of tests here

94

00:03:49,349 --> 00:03:47,680

at our Center to develop these systems

95

00:03:50,759 --> 00:03:49,359

we did a lot of the analysis and

96

00:03:52,890 --> 00:03:50,769

everything in fact I had worked in

97

00:03:54,449 --> 00:03:52,900

propulsion and that's why I keep

98

00:03:56,069 --> 00:03:54,459

referring to the engines and a

99

00:03:58,530 --> 00:03:56,079

propulsion system because that that's

100

00:03:59,520 --> 00:03:58,540

the experience I had acquired back

101

00:04:02,789 --> 00:03:59,530

during those years

102

00:04:05,970 --> 00:04:02,799

well after we flew we flew some 10 of

103

00:04:07,649 --> 00:04:05,980

those the old Saturn 1 Saturn 1b after

104

00:04:10,679 --> 00:04:07,659

we clustered them and we went to a

105

00:04:12,839 --> 00:04:10,689

second stage and we went to a high

106

00:04:15,629 --> 00:04:12,849

energy system so far as the engine

107

00:04:18,509 --> 00:04:15,639

performance and used liquid hydrogen as

108

00:04:19,680 --> 00:04:18,519

a few still liquid oxygen is oxidized

109

00:04:21,479 --> 00:04:19,690

now you say why do you use liquid

110

00:04:23,879 --> 00:04:21,489

hydrogen if you remember your chemistry

111

00:04:26,430 --> 00:04:23,889

will it has a molecular weight of two in

112

00:04:29,399 --> 00:04:26,440

terms of performance it gives you the

113

00:04:31,080 --> 00:04:29,409

highest performance and we that was new

114

00:04:33,420 --> 00:04:31,090

to us in those days no one had used

115

00:04:35,339 --> 00:04:33,430

liquid hydrogen as a fuel you got to

116

00:04:38,430 --> 00:04:35,349

recognize the liquid oxygen is at minus

117

00:04:40,740 --> 00:04:38,440

297 degrees Fahrenheit cried genie the

118

00:04:42,360 --> 00:04:40,750

liquid hydrogen is minus 421 degrees

119

00:04:44,370 --> 00:04:42,370

well that brings in a lot of problems

120

00:04:46,020 --> 00:04:44,380

how do you maintain that you don't have

121

00:04:48,180 --> 00:04:46,030

a vacuum bottle or something you have

122

00:04:50,969 --> 00:04:48,190

insulation you have to be concerned with

123

00:04:53,070 --> 00:04:50,979

in addition you have problems of getting

124

00:04:55,529 --> 00:04:53,080

the propellant at the right conditions

125

00:04:57,629 --> 00:04:55,539

for the engine in your car your car does

126

00:04:59,399 --> 00:04:57,639

what use gasoline you have a carburetor

127

00:05:02,279 --> 00:04:59,409

and you take air from the atmosphere you

128

00:05:04,409 --> 00:05:02,289

atomized the gasoline and you force it

129

00:05:06,629 --> 00:05:04,419

into your combustion chamber you have a

130

00:05:09,480 --> 00:05:06,639

spark plug too United with very similar

131

00:05:11,760 --> 00:05:09,490

and a rocket engine okay we have pumps

132

00:05:13,680 --> 00:05:11,770

to do them the same thing where we take

133

00:05:15,870 --> 00:05:13,690

the oxidizer from a few we ignite a lot

134

00:05:18,149 --> 00:05:15,880

of times with the spark spark igniter we

135

00:05:20,850 --> 00:05:18,159

call it then we have what we call an

136

00:05:23,399 --> 00:05:20,860

injector face plate that atomizer

137

00:05:25,290 --> 00:05:23,409

instead of a carburetor in fact it's a

138

00:05:27,270 --> 00:05:25,300

lot simpler we don't have Pistons like

139

00:05:30,120 --> 00:05:27,280

you have in a in an automobile or

140

00:05:31,860 --> 00:05:30,130

internal combustion engine so but you

141

00:05:33,330 --> 00:05:31,870

get into problems if you're familiar

142

00:05:34,890 --> 00:05:33,340

with some of the problems you have your

143

00:05:36,779 --> 00:05:34,900

car some time you turn the switch off

144

00:05:38,400 --> 00:05:36,789

when you hear a pin and it won't stop

145

00:05:40,610 --> 00:05:38,410

it's sort of decently

146

00:05:45,300 --> 00:05:40,620

well we call it combustion instability

147

00:05:47,310 --> 00:05:45,310

in the case of a lot of the hydrocarbon

148

00:05:48,870 --> 00:05:47,320

engines you can get involved with that

149

00:05:51,180 --> 00:05:48,880

where you don't get complete combustion

150

00:05:54,810 --> 00:05:51,190

and alas you sit there and destroy

151  
00:05:56,280 --> 00:05:54,820  
itself it goes into the various modes of

152  
00:05:58,680 --> 00:05:56,290  
vibration modes and I'll sit there and

153  
00:06:00,660 --> 00:05:58,690  
destroy itself and as we move from the

154  
00:06:02,370 --> 00:06:00,670  
Saturn one I want to make the point as

155  
00:06:05,280 --> 00:06:02,380  
we go to the Saturn five which is what

156  
00:06:08,220 --> 00:06:05,290  
we use for the Apollo this one see the

157  
00:06:09,600 --> 00:06:08,230  
first stage use five f1 engine each

158  
00:06:12,150 --> 00:06:09,610  
engine had a thrust of something like

159  
00:06:14,070 --> 00:06:12,160  
1/2 million pounds so we had five of

160  
00:06:16,170 --> 00:06:14,080  
those which gave you seven million

161  
00:06:19,080 --> 00:06:16,180  
pounds thrust well you needed that to

162  
00:06:21,240 --> 00:06:19,090  
get all this mass off and it uses liquid

163  
00:06:23,880 --> 00:06:21,250

oxygen and that was a new engine now is

164

00:06:25,980 --> 00:06:23,890

a huge engine but we had all kind of

165

00:06:28,380 --> 00:06:25,990

problems in early days name of this

166

00:06:30,570 --> 00:06:28,390

combustion instability and now if you

167

00:06:32,760 --> 00:06:30,580

can envision an injector plate some

168

00:06:35,790 --> 00:06:32,770

three feet in diameter with all these

169

00:06:37,350 --> 00:06:35,800

holes at it we had problems with the

170

00:06:38,760 --> 00:06:37,360

thing in fact we spent over thirty

171

00:06:40,590 --> 00:06:38,770

million dollars has some of the best

172

00:06:43,770 --> 00:06:40,600

brains in the country helped us on this

173

00:06:46,380 --> 00:06:43,780

same had teams working it some people in

174

00:06:47,940 --> 00:06:46,390

fact with the presidential scientific

175

00:06:50,130 --> 00:06:47,950

committee said you'd never get an engine

176  
00:06:52,440 --> 00:06:50,140  
that large to run the Russians nobody

177  
00:06:54,150 --> 00:06:52,450  
ever built an engine at large and

178  
00:06:56,160 --> 00:06:54,160  
therefore we were kind of the first one

179  
00:06:57,870 --> 00:06:56,170  
but combustion instability almost

180  
00:07:01,290 --> 00:06:57,880  
brought us to our knees we set up

181  
00:07:03,090 --> 00:07:01,300  
special teams and with our contractor

182  
00:07:05,700 --> 00:07:03,100  
Rocketdyne which is the vision north

183  
00:07:08,100 --> 00:07:05,710  
american back then and we had people

184  
00:07:10,590 --> 00:07:08,110  
from nasa and i participated and a lot

185  
00:07:12,150 --> 00:07:10,600  
of that myself personally but a lot of

186  
00:07:14,730 --> 00:07:12,160  
work was done and make a long story

187  
00:07:17,220 --> 00:07:14,740  
short if you visualize them and a flat

188  
00:07:19,560 --> 00:07:17,230

placement a flat plate injector and we

189

00:07:22,920 --> 00:07:19,570

put baffles in there and you wanted to

190

00:07:24,840 --> 00:07:22,930

be sure that they could attenuate or

191

00:07:26,100 --> 00:07:24,850

dampen any kind of oscillations well

192

00:07:28,620 --> 00:07:26,110

then what we would do it put a little

193

00:07:30,960 --> 00:07:28,630

bomb we would put a little bomb and then

194

00:07:32,760 --> 00:07:30,970

set that bomb off during the firing and

195

00:07:35,010 --> 00:07:32,770

we do this on a test stand but we should

196

00:07:37,620 --> 00:07:35,020

do like tests right here in our single

197

00:07:39,480 --> 00:07:37,630

engine test stand on our test area and

198

00:07:41,730 --> 00:07:39,490

we set this bomb off and see how long it

199

00:07:43,470 --> 00:07:41,740

would take to dampen and if it would

200

00:07:45,240 --> 00:07:43,480

dampen with the various configurations

201  
00:07:47,640 --> 00:07:45,250  
that we felt like we had a dynamically

202  
00:07:49,230 --> 00:07:47,650  
stable injector and eventually we were

203  
00:07:51,690 --> 00:07:49,240  
able to do that it took months and

204  
00:07:53,460 --> 00:07:51,700  
months months to do that

205  
00:07:54,800 --> 00:07:53,470  
in addition you have problem with pumps

206  
00:07:57,030 --> 00:07:54,810  
and you think about turbomachinery

207  
00:07:59,130 --> 00:07:57,040  
because we take the propellants from the

208  
00:08:01,830 --> 00:07:59,140  
tank and we're driving them into the

209  
00:08:03,660 --> 00:08:01,840  
combustion chamber at high pressures the

210  
00:08:05,280 --> 00:08:03,670  
combustion chamber pressure on f1 is

211  
00:08:08,160 --> 00:08:05,290  
about a thousand pounds per square inch

212  
00:08:10,260 --> 00:08:08,170  
which was really unknown in those days a

213  
00:08:12,390 --> 00:08:10,270

high Swede meant something like full 500

214

00:08:15,000 --> 00:08:12,400

pounds per square inch so as you grew up

215

00:08:17,640 --> 00:08:15,010

in pressures that meanness move 40 more

216

00:08:21,000 --> 00:08:17,650

problems associated with your turbines

217

00:08:22,560 --> 00:08:21,010

we pump the impellers etc so all those

218

00:08:25,470 --> 00:08:22,570

problems had to be worked had to be

219

00:08:27,840 --> 00:08:25,480

looked at and we we blew up a lot of

220

00:08:29,760 --> 00:08:27,850

lakhs of liquid oxygen pumps a lot of

221

00:08:32,010 --> 00:08:29,770

pumps we blow up and there's nothing

222

00:08:33,750 --> 00:08:32,020

like if you can visualize when you have

223

00:08:35,700 --> 00:08:33,760

liquid oxygen and you know about welding

224

00:08:37,469 --> 00:08:35,710

and they use the settling you know when

225

00:08:38,969 --> 00:08:37,479

he's cutting a piece of steel there was

226

00:08:41,160 --> 00:08:38,979

he do he presses the button for more

227

00:08:43,230 --> 00:08:41,170

oxygen there and that's the thing it

228

00:08:45,180 --> 00:08:43,240

gives you the high heat of course we've

229

00:08:46,590 --> 00:08:45,190

got oxygen there if you get a fire going

230

00:08:48,690 --> 00:08:46,600

look out because it's gone

231

00:08:50,640 --> 00:08:48,700

everything around it's gone there's

232

00:08:52,680 --> 00:08:50,650

nothing as serious as a liquid oxygen

233

00:08:55,320 --> 00:08:52,690

pump explosion and we had many of those

234

00:08:57,000 --> 00:08:55,330

in those days but we had barring problem

235

00:08:59,250 --> 00:08:57,010

and turbine blade problems that we had

236

00:09:02,280 --> 00:08:59,260

to overcome and there was many years

237

00:09:04,620 --> 00:09:02,290

that we we worked and I when I say we

238

00:09:06,680 --> 00:09:04,630

work we NASA with our contractors and in

239

00:09:08,850 --> 00:09:06,690

braining consultants we had academia

240

00:09:09,360 --> 00:09:08,860

assisting us and helping us in all these

241

00:09:12,420 --> 00:09:09,370

areas

242

00:09:15,150 --> 00:09:12,430

it was long hours I mean blood and sweat

243

00:09:17,520 --> 00:09:15,160

on the road a lot traveling we had a

244

00:09:19,050 --> 00:09:17,530

test dance for the f1 and it was Air

245

00:09:23,160 --> 00:09:19,060

Force Base where we land Space Shuttle

246

00:09:24,780 --> 00:09:23,170

now at big test stands out there we had

247

00:09:27,270 --> 00:09:24,790

explosions there in request and

248

00:09:30,030 --> 00:09:27,280

sometimes and eventually was able to do

249

00:09:31,680 --> 00:09:30,040

testing here at Marshall and then one

250

00:09:34,140 --> 00:09:31,690

with cluster the engine we actually did

251  
00:09:36,120 --> 00:09:34,150  
the cluster tests out here what we call

252  
00:09:38,430 --> 00:09:36,130  
the s1 see that was the first stage of

253  
00:09:40,410 --> 00:09:38,440  
Saturn and with cluster the engines and

254  
00:09:41,760 --> 00:09:40,420  
did all static fire in fact built the

255  
00:09:43,890 --> 00:09:41,770  
first stages they brought all the

256  
00:09:46,140 --> 00:09:43,900  
hardware here brought the engines and we

257  
00:09:49,410 --> 00:09:46,150  
did all the cluster tests here initially

258  
00:09:51,660 --> 00:09:49,420  
and eventually once we froze the design

259  
00:09:54,210 --> 00:09:51,670  
and then we brought Boeing in as a prime

260  
00:09:56,310 --> 00:09:54,220  
contractor to actually pick up and do

261  
00:09:57,690 --> 00:09:56,320  
the design in New Orleans and build the

262  
00:10:00,300 --> 00:09:57,700  
hardware down there and now we would

263  
00:10:02,520 --> 00:10:00,310

barge all the hardware you imagine 33

264

00:10:09,300 --> 00:10:02,530

foot in diameter the tank was 33 feet in

265

00:10:15,749 --> 00:10:13,290

the second stage again used a new engine

266

00:10:18,990 --> 00:10:15,759

what we call the j2 engine it was a

267

00:10:21,329 --> 00:10:19,000

liquid oxygen liquid hydrogen engine the

268

00:10:22,559 --> 00:10:21,339

one I'd mentioned earlier was 15,000

269

00:10:25,530 --> 00:10:22,569

pounds thrust this one had around

270

00:10:27,269 --> 00:10:25,540

200,000 pounds now we had five of them

271

00:10:29,910 --> 00:10:27,279

which gave us a million pounds in the

272

00:10:31,980 --> 00:10:29,920

second stage and what you do you'd burn

273

00:10:33,960 --> 00:10:31,990

the first stage for about 130 seconds

274

00:10:35,249 --> 00:10:33,970

first stage was separating dropping

275

00:10:38,040 --> 00:10:35,259

ocean the second stage would have

276

00:10:40,499 --> 00:10:38,050

ignited igniting and it would burn for

277

00:10:42,809 --> 00:10:40,509

some five or six minutes and then all

278

00:10:44,490 --> 00:10:42,819

you're doing is adding impulse or energy

279

00:10:45,689 --> 00:10:44,500

to the whole system and of course the

280

00:10:48,059 --> 00:10:45,699

payload up there is what you're

281

00:10:51,030 --> 00:10:48,069

interested in and we had problems with

282

00:10:52,920 --> 00:10:51,040

the second stage a lot of problems in

283

00:10:55,079 --> 00:10:52,930

terms of propellant conditioning as I

284

00:10:56,730 --> 00:10:55,089

mentioned earlier you have to have the

285

00:10:59,309 --> 00:10:56,740

propellants at the right temperature and

286

00:11:07,350 --> 00:10:59,319

pressure for the pumps and again we're

287

00:11:09,150 --> 00:11:07,360

at cryogenic temperature at night a

288

00:11:12,300 --> 00:11:09,160

Mississippi test facility which is

289

00:11:14,639 --> 00:11:12,310

Stennis Space Center today I spent a lot

290

00:11:17,220 --> 00:11:14,649

of time I said personally in Downey

291

00:11:19,949 --> 00:11:17,230

California with the first what we call

292

00:11:22,319 --> 00:11:19,959

the t-bird that was a second stage test

293

00:11:25,889 --> 00:11:22,329

bird call it the bird because it's going

294

00:11:27,629 --> 00:11:25,899

to fly but we did a lot of testing down

295

00:11:29,790 --> 00:11:27,639

here but what they did after they built

296

00:11:31,679 --> 00:11:29,800

it we had a milestone we've committed

297

00:11:33,960 --> 00:11:31,689

with Congress and with everybody to get

298

00:11:35,699 --> 00:11:33,970

ready for them the lunar mission so we

299

00:11:37,769 --> 00:11:35,709

actually shipped this hardware

300

00:11:41,519 --> 00:11:37,779

well von Braun is one of the funny

301  
00:11:43,410 --> 00:11:41,529  
stores with von Braun he invites all the

302  
00:11:46,049 --> 00:11:43,420  
big shots from Washington Administrator

303  
00:11:48,090 --> 00:11:46,059  
and all of them and they all fly into

304  
00:11:52,410 --> 00:11:48,100  
Gulfport Mississippi and our test site

305  
00:11:54,629 --> 00:11:52,420  
is near Picayune Mississippi and the

306  
00:11:56,309 --> 00:11:54,639  
base manager there was Jack bolt he was

307  
00:11:58,079 --> 00:11:56,319  
our base manager so what does he do he

308  
00:12:00,059 --> 00:11:58,089  
gets the Highway Patrol and state of

309  
00:12:02,129 --> 00:12:00,069  
Mississippi and also in state Louisiana

310  
00:12:04,799 --> 00:12:02,139  
and they set a world record drive from

311  
00:12:07,019 --> 00:12:04,809  
Airport up to the stent up to the the

312  
00:12:08,460 --> 00:12:07,029  
site there for the test course everybody

313  
00:12:10,740 --> 00:12:08,470

was all uptight because that was gonna

314

00:12:12,689 --> 00:12:10,750

be the first test on the second stage

315

00:12:15,660 --> 00:12:12,699

where we we finally got a good test off

316

00:12:18,509 --> 00:12:15,670

that night made many tips down there but

317

00:12:20,069 --> 00:12:18,519

eventually what happened well they over

318

00:12:22,930 --> 00:12:20,079

pressurized the tank and the tank was

319

00:12:24,490 --> 00:12:22,940

destroyed we had investigation

320

00:12:29,380 --> 00:12:24,500

knew what was the problem when we fixed

321

00:12:34,150 --> 00:12:31,660

third stage was built by McDonnell

322

00:12:37,270 --> 00:12:34,160

Douglas Huntington Beach and their

323

00:12:39,010 --> 00:12:37,280

testing was up in Sacramento they had a

324

00:12:40,750 --> 00:12:39,020

test facility up there and had a single

325

00:12:42,970 --> 00:12:40,760

engine the one engine

326

00:12:46,360 --> 00:12:42,980

like I mentioned on the second stage the

327

00:12:48,160 --> 00:12:46,370

j2 in they had one and eventually they

328

00:12:51,490 --> 00:12:48,170

had a problem up there was on the engine

329

00:12:53,170 --> 00:12:51,500

so von Braun he bars Casey's airplane

330

00:12:56,470 --> 00:12:53,180

and it was a dose to go out on that

331

00:12:58,090 --> 00:12:56,480

thing it was a a Lockheed Jetstar well

332

00:12:59,590 --> 00:12:58,100

here's a young engineer and ever been on

333

00:13:02,920 --> 00:12:59,600

that little jet engine and all jet

334

00:13:05,860 --> 00:13:02,930

airplane and everything and we went from

335

00:13:08,890 --> 00:13:05,870

Huntsville Redstone out here to Van Nuys

336

00:13:12,700 --> 00:13:08,900

to our contractor and you owned up to

337

00:13:15,250 --> 00:13:12,710

Sacramento went out to test and we set

338

00:13:19,000 --> 00:13:15,260

up investigation see what we need to do

339

00:13:20,470 --> 00:13:19,010

and so we got ready to come by and they

340

00:13:23,080 --> 00:13:20,480

had a Stewart on there and they were

341

00:13:25,120 --> 00:13:23,090

lucky contractors but I asked young

342

00:13:26,980 --> 00:13:25,130

fellow I said can you tell me something

343

00:13:28,510 --> 00:13:26,990

about the jet engine what the thrust is

344

00:13:30,760 --> 00:13:28,520

or something I said I got a son I like

345

00:13:32,470 --> 00:13:30,770

to tell him about this and I was just

346

00:13:34,600 --> 00:13:32,480

like a kid with a new toy being on this

347

00:13:36,310 --> 00:13:34,610

airplane so he went off about ten

348

00:13:39,960 --> 00:13:36,320

minutes he came back and he gave me this

349

00:13:42,100 --> 00:13:39,970

little brochure and it had all the

350

00:13:44,530 --> 00:13:42,110

description of what the airplane would

351

00:13:47,770 --> 00:13:44,540

do cetera except well the last page in

352

00:13:50,200 --> 00:13:47,780

there was a certificate and it says this

353

00:13:52,810 --> 00:13:50,210

is this is to certify that Alexei McCool

354

00:13:54,490 --> 00:13:52,820

jr. blah blah blah date so-and-so did

355

00:13:56,800 --> 00:13:54,500

fly in Sacramento altitude so-and-so

356

00:13:58,840 --> 00:13:56,810

ground speed of so-and-so and the pilot

357

00:14:00,700 --> 00:13:58,850

signed it well I looked down and who was

358

00:14:02,650 --> 00:14:00,710

the pilot Wernher von Braun and I looked

359

00:14:04,330 --> 00:14:02,660

up him here what's coming from the

360

00:14:06,940 --> 00:14:04,340

cockpit up there and he had a big old

361

00:14:14,160 --> 00:14:06,950

grin on his face and he wasn't checked

362

00:14:19,350 --> 00:14:17,100

that was really you know they will do

363

00:14:21,840 --> 00:14:19,360

all this and us work with all the

364

00:14:22,440 --> 00:14:21,850

counterparts let's theater at JSC at

365

00:14:24,629 --> 00:14:22,450

Houston

366

00:14:26,879 --> 00:14:24,639

our friends down there and then

367

00:14:29,129 --> 00:14:26,889

integrate all of this including all the

368

00:14:30,990 --> 00:14:29,139

work at Kennedy Space Center because

369

00:14:32,600 --> 00:14:31,000

then you got all the launch complex to

370

00:14:34,740 --> 00:14:32,610

deal with you got all the propellant

371

00:14:37,019 --> 00:14:34,750

systems that you got to fill in drain

372

00:14:38,759 --> 00:14:37,029

the tanks etc you got all that launch

373

00:14:41,100 --> 00:14:38,769

commit criteria to deal with all

374

00:14:43,980 --> 00:14:41,110

electrical systems to deal with so it

375

00:14:47,639 --> 00:14:43,990

was a big job that went NASA we all had

376

00:14:49,230 --> 00:14:47,649

to really get involved with and it was

377

00:14:53,730 --> 00:14:49,240

very challenging a lot of meetings a lot

378

00:14:55,110 --> 00:14:53,740

of travel long hours von Braun was in

379

00:14:56,850 --> 00:14:55,120

the middle of all levels you know he's

380

00:14:59,310 --> 00:14:56,860

come around before we get down there

381

00:15:01,680 --> 00:14:59,320

like for our first flight which was what

382

00:15:04,889 --> 00:15:01,690

we call a s 501 that was our first one

383

00:15:07,829 --> 00:15:04,899

and eventually it flew we didn't have

384

00:15:10,710 --> 00:15:07,839

any problems on it second flight we did

385

00:15:13,500 --> 00:15:10,720

have some problems on the first stage we

386

00:15:16,740 --> 00:15:13,510

saw what we call pogo pogo as a as a

387

00:15:19,319 --> 00:15:16,750

vertical oscillation you can what

388

00:15:22,350 --> 00:15:19,329

happens there is the engine's natural

389

00:15:25,380 --> 00:15:22,360

frequency was around five cycles or five

390

00:15:28,259 --> 00:15:25,390

Hertz very very low frequency but it can

391

00:15:30,300 --> 00:15:28,269

couple with a structural frequency and

392

00:15:31,800 --> 00:15:30,310

it couldn't it can be bad or it could be

393

00:15:33,720 --> 00:15:31,810

uncomfortable for the astronauts were

394

00:15:36,509 --> 00:15:33,730

you actually sitting there so we had to

395

00:15:38,220 --> 00:15:36,519

come up with a design fix and to

396

00:15:39,750 --> 00:15:38,230

attenuate that and we were able to do

397

00:15:41,550 --> 00:15:39,760

that through the pre valves and all you

398

00:15:44,160 --> 00:15:41,560

had was cavities there that one

399

00:15:45,780 --> 00:15:44,170

attenuate and in fact today on Space

400

00:15:48,329 --> 00:15:45,790

Shuttle we have what we call Pogo

401  
00:15:51,380 --> 00:15:48,339  
suppressors so that was a new thing to

402  
00:15:54,210 --> 00:15:51,390  
us in addition on the second stage now

403  
00:15:56,639 --> 00:15:54,220  
we had some something neither lines that

404  
00:15:59,189 --> 00:15:56,649  
carried fuel and these were braided

405  
00:16:02,370 --> 00:15:59,199  
bellows and abraded was to allow them to

406  
00:16:04,500 --> 00:16:02,380  
articulate to move and everything and we

407  
00:16:06,449 --> 00:16:04,510  
noticed that the one of the engines shut

408  
00:16:08,850 --> 00:16:06,459  
down during flight but it's on our

409  
00:16:12,389 --> 00:16:08,860  
second Saturn 5 now this is scary you

410  
00:16:14,280 --> 00:16:12,399  
know he just started flying and pretty

411  
00:16:17,160 --> 00:16:14,290  
soon the other in just a second or so

412  
00:16:18,809 --> 00:16:17,170  
another engine shut down so there was

413  
00:16:20,490 --> 00:16:18,819

three engines left and it continued to

414

00:16:23,400 --> 00:16:20,500

burn it burned longer because the

415

00:16:24,780 --> 00:16:23,410

propellant was still there and you still

416

00:16:26,460 --> 00:16:24,790

got the velocity and of course the

417

00:16:27,340 --> 00:16:26,470

guidance system was able to correct for

418

00:16:29,980 --> 00:16:27,350

this

419

00:16:33,280 --> 00:16:29,990

and eventually they separated and in

420

00:16:37,810 --> 00:16:33,290

third stage it went into a low Earth

421

00:16:40,510 --> 00:16:37,820

orbit and it was too restarted and it

422

00:16:42,100 --> 00:16:40,520

couldn't restart well we found out it

423

00:16:44,610 --> 00:16:42,110

was the same kind of problem here's this

424

00:16:47,710 --> 00:16:44,620

fuel line so we was able to go back and

425

00:16:49,480 --> 00:16:47,720

ascertain what had happened and when

426  
00:16:50,770 --> 00:16:49,490  
we've been testing you know test stance

427  
00:16:53,710 --> 00:16:50,780  
with this engine and here's this

428  
00:16:55,930 --> 00:16:53,720  
articulated line and it could get air

429  
00:16:58,360 --> 00:16:55,940  
that would liquefy and actually build up

430  
00:17:00,610 --> 00:16:58,370  
to ice and what you have if y'all

431  
00:17:03,130 --> 00:17:00,620  
familiar of what we call vortex shedding

432  
00:17:05,050 --> 00:17:03,140  
when you have bellows or something flow

433  
00:17:06,490 --> 00:17:05,060  
there and it actually would set up an

434  
00:17:08,819 --> 00:17:06,500  
oscillation it's a little bit like

435  
00:17:11,949 --> 00:17:08,829  
though familiar like a a chimney or uh

436  
00:17:13,660 --> 00:17:11,959  
smokestack the wind going around that

437  
00:17:16,000 --> 00:17:13,670  
will set up vortices and get it moving

438  
00:17:18,460 --> 00:17:16,010

or bridges will do that so you try to

439

00:17:20,260 --> 00:17:18,470

design to stay away from that but that's

440

00:17:22,270 --> 00:17:20,270

that's exactly what happened we didn't

441

00:17:23,920 --> 00:17:22,280

know that we were able to test in a

442

00:17:26,260 --> 00:17:23,930

vacuum and prove that you didn't get the

443

00:17:29,350 --> 00:17:26,270

liquefaction to attenuate it so we

444

00:17:31,510 --> 00:17:29,360

actually got really the braids but on

445

00:17:34,920 --> 00:17:31,520

the next flight now which was kind of

446

00:17:37,960 --> 00:17:34,930

interesting he decided to go ahead and

447

00:17:40,270 --> 00:17:37,970

in fly you know man these were not man

448

00:17:42,400 --> 00:17:40,280

flights and that was a big one I

449

00:17:44,440 --> 00:17:42,410

remember we set the whole had all the

450

00:17:46,150 --> 00:17:44,450

corporate presidents here and all we

451  
00:17:48,430 --> 00:17:46,160  
keep people it was a meeting here at our

452  
00:17:51,130 --> 00:17:48,440  
Center all the people in Washington came

453  
00:17:53,140 --> 00:17:51,140  
down do we fly man on a next mission

454  
00:17:55,870 --> 00:17:53,150  
and he decided to go ahead and do that

455  
00:17:58,870 --> 00:17:55,880  
and then after that and they of course

456  
00:18:01,390 --> 00:17:58,880  
went around the moon and and of course

457  
00:18:03,760 --> 00:18:01,400  
Frank borman's thing that he did before

458  
00:18:06,220 --> 00:18:03,770  
Christmas and the one it really sticks

459  
00:18:07,840 --> 00:18:06,230  
with me is the guys on Christmas Eve

460  
00:18:09,730 --> 00:18:07,850  
when they went back to I'm getting goose

461  
00:18:12,820 --> 00:18:09,740  
bumps now thinking about they went to

462  
00:18:14,470 --> 00:18:12,830  
the book of Genesis and Frank starts out

463  
00:18:16,210 --> 00:18:14,480

in the beginning you know God created

464

00:18:18,160 --> 00:18:16,220

heavens and earth and the guys actually

465

00:18:20,770 --> 00:18:18,170

they each one of the crew members they

466

00:18:22,810 --> 00:18:20,780

read parts of the creation account from

467

00:18:25,300 --> 00:18:22,820

the Bible on out today maybe that's a

468

00:18:27,610 --> 00:18:25,310

no-no I don't know but it really sticks

469

00:18:29,560 --> 00:18:27,620

for me to this day because it was

470

00:18:32,490 --> 00:18:29,570

Christmas Eve and here they've gone

471

00:18:34,930 --> 00:18:32,500

around the moon first time now anybody

472

00:18:36,730 --> 00:18:34,940

and of course that was a precursor for

473

00:18:38,440 --> 00:18:36,740

us being able to go to the moon you know

474

00:18:43,810 --> 00:18:38,450

we weren't sure what was involved in

475

00:18:49,180 --> 00:18:47,409

and he just let me use the words walk to

476

00:18:51,190 --> 00:18:49,190

talk okay you know what I mean by that

477

00:18:52,930 --> 00:18:51,200

he would come around you know you he

478

00:18:55,359 --> 00:18:52,940

would call or how the secretary called

479

00:18:57,099 --> 00:18:55,369

say he's coming over he just show up he

480

00:18:58,659 --> 00:18:57,109

come looking all the drawing board so

481

00:19:00,849 --> 00:18:58,669

what he got going on won't you design it

482

00:19:03,249 --> 00:19:00,859

this way that way but he was a people

483

00:19:05,169 --> 00:19:03,259

person he was really interested and I

484

00:19:06,700 --> 00:19:05,179

and I try to do that today myself I

485

00:19:07,960 --> 00:19:06,710

learned that from him you got to get

486

00:19:10,419 --> 00:19:07,970

around where the people are doing the

487

00:19:12,580 --> 00:19:10,429

work I mean sitting in your office or

488

00:19:14,080 --> 00:19:12,590

sitting in meetings well he did allow

489

00:19:16,119 --> 00:19:14,090

that don't misunderstand but he always

490

00:19:18,279 --> 00:19:16,129

used opportunity to get out and talk to

491

00:19:20,560 --> 00:19:18,289

the people people on the floor owned the

492

00:19:23,259 --> 00:19:20,570

shops how you doing it once you do it

493

00:19:26,499 --> 00:19:23,269

this way brilliant person very brain had

494

00:19:28,989 --> 00:19:26,509

all kinds of ideas you know good

495

00:19:30,700 --> 00:19:28,999

technical mind but if you go back to his

496

00:19:31,899 --> 00:19:30,710

early experience and I think that's

497

00:19:34,629 --> 00:19:31,909

that's the key here

498

00:19:37,269 --> 00:19:34,639

is keeping his hands dirty in other

499

00:19:39,249 --> 00:19:37,279

words when he was young you know he was

500

00:19:41,889 --> 00:19:39,259

involved in testing himself he was

501  
00:19:43,690 --> 00:19:41,899  
involved in design he had learned it the

502  
00:19:45,219 --> 00:19:43,700  
hard way just like you know working on

503  
00:19:46,599 --> 00:19:45,229  
your car you gonna learn yourself when

504  
00:19:48,489 --> 00:19:46,609  
you skinned your knuckles and everything

505  
00:19:50,889 --> 00:19:48,499  
he had done that he learned the hard way

506  
00:19:53,680 --> 00:19:50,899  
himself and he sort of preached that to

507  
00:19:55,389 --> 00:19:53,690  
us it's hands-on do you things hands-on

508  
00:19:58,269 --> 00:19:55,399  
and I think that's what made our center

509  
00:20:01,049 --> 00:19:58,279  
so great over the years is the hands-on

510  
00:20:03,039 --> 00:20:01,059  
work that we would do in-house

511  
00:20:03,519 --> 00:20:03,049  
capabilities that we have developed over

512  
00:20:06,609 --> 00:20:03,529  
the years

513  
00:20:09,549 --> 00:20:06,619

blonde brawn always you know he exude

514

00:20:11,499 --> 00:20:09,559

this idea of teamwork now he had you

515

00:20:14,349 --> 00:20:11,509

know la to keep people of the Germans

516

00:20:16,239 --> 00:20:14,359

and they were our bosses and but they

517

00:20:17,950 --> 00:20:16,249

worked very well with us they just they

518

00:20:20,649 --> 00:20:17,960

were glad to have us was all part of the

519

00:20:22,810 --> 00:20:20,659

team there wasn't any partitions between

520

00:20:24,729 --> 00:20:22,820

us you could say what you want they

521

00:20:26,529 --> 00:20:24,739

wouldn't take it personal he's always

522

00:20:28,479 --> 00:20:26,539

building up the team building up for

523

00:20:30,070 --> 00:20:28,489

people but von Braun was able to do

524

00:20:33,310 --> 00:20:30,080

things like that he was able to go to

525

00:20:36,039 --> 00:20:33,320

Congress you know and articulate you

526

00:20:38,589 --> 00:20:36,049

know NASA's needs probably the charisma

527

00:20:41,080 --> 00:20:38,599

he had you know he knew this you really

528

00:20:42,580 --> 00:20:41,090

knew everything he was just so good and

529

00:20:44,409 --> 00:20:42,590

you got to think now here's this guy

530

00:20:47,049 --> 00:20:44,419

when he was in Germany in his days in

531

00:20:48,820 --> 00:20:47,059

his early 20s he was the technical

532

00:20:50,649 --> 00:20:48,830

director so there's no question you go

533

00:20:53,320 --> 00:20:50,659

read the history and everything well

534

00:20:55,389 --> 00:20:53,330

this this country I think if you go back

535

00:20:57,330 --> 00:20:55,399

and look we were so fortunate and

536

00:20:59,549 --> 00:20:57,340

getting him plus all his team

537

00:21:01,470 --> 00:20:59,559

that's not to say that the Russians

538

00:21:03,180 --> 00:21:01,480

didn't get quite a few they got a lot of

539

00:21:05,129 --> 00:21:03,190

production manufacturing but I believe

540

00:21:07,739 --> 00:21:05,139

that this country did well by getting

541

00:21:10,710 --> 00:21:07,749

him here and his team and I he was able

542

00:21:11,730 --> 00:21:10,720

to help all of us and he always had in

543

00:21:13,710 --> 00:21:11,740

his mind you know

544

00:21:16,440 --> 00:21:13,720

going to the moon who went out into

545

00:21:18,930 --> 00:21:16,450

space space exploration he always he

546

00:21:21,119 --> 00:21:18,940

would talk about their over and over and

547

00:21:23,489 --> 00:21:21,129

over and history is proving that if you

548

00:21:25,470 --> 00:21:23,499

look back now you look at Skylab I mean

549

00:21:27,119 --> 00:21:25,480

he was heavily involved in that which is

550

00:21:29,489 --> 00:21:27,129

really our first space station in this

551  
00:21:31,529 --> 00:21:29,499  
country but he was somebody I'll tell

552  
00:21:34,379 --> 00:21:31,539  
you that you just enjoy being around he

553  
00:21:37,889 --> 00:21:34,389  
just seemed like he's just a good coach

554  
00:21:39,779 --> 00:21:37,899  
good team leader excellent you know in

555  
00:21:40,889 --> 00:21:39,789  
terms of working with people they bring

556  
00:21:42,749 --> 00:21:40,899  
congressmen you know we've had

557  
00:21:49,769 --> 00:21:42,759  
presidents come here and he'd always be

558  
00:21:55,259 --> 00:21:53,820  
I think to me that the lunar landing has

559  
00:21:57,810 --> 00:21:55,269  
probably been one of the greatest things

560  
00:21:59,869 --> 00:21:57,820  
that man has ever done no question in

561  
00:22:02,519 --> 00:21:59,879  
terms of exploration it is the greatest

562  
00:22:04,169 --> 00:22:02,529  
but it took thousands and thousands and

563  
00:22:06,029 --> 00:22:04,179

thousands people took a lot of money

564

00:22:07,379 --> 00:22:06,039

took a lot of blood and sweat people

565

00:22:09,419 --> 00:22:07,389

prepared to do that

566

00:22:11,700 --> 00:22:09,429

there was a lot of safety issues had to

567

00:22:13,919 --> 00:22:11,710

be addressed a lot of unknowns a lot of

568

00:22:14,690 --> 00:22:13,929

things that we did that we knew it was

569

00:22:18,479 --> 00:22:14,700

different

570

00:22:20,099 --> 00:22:18,489

so there's no question culmination of

571

00:22:22,649 --> 00:22:20,109

actually landing in and bringing them

572

00:22:25,079 --> 00:22:22,659

back was getting the bike safely and

573

00:22:26,700 --> 00:22:25,089

once we had splashdown and recovering

574

00:22:28,950 --> 00:22:26,710

all that and that was the time to time