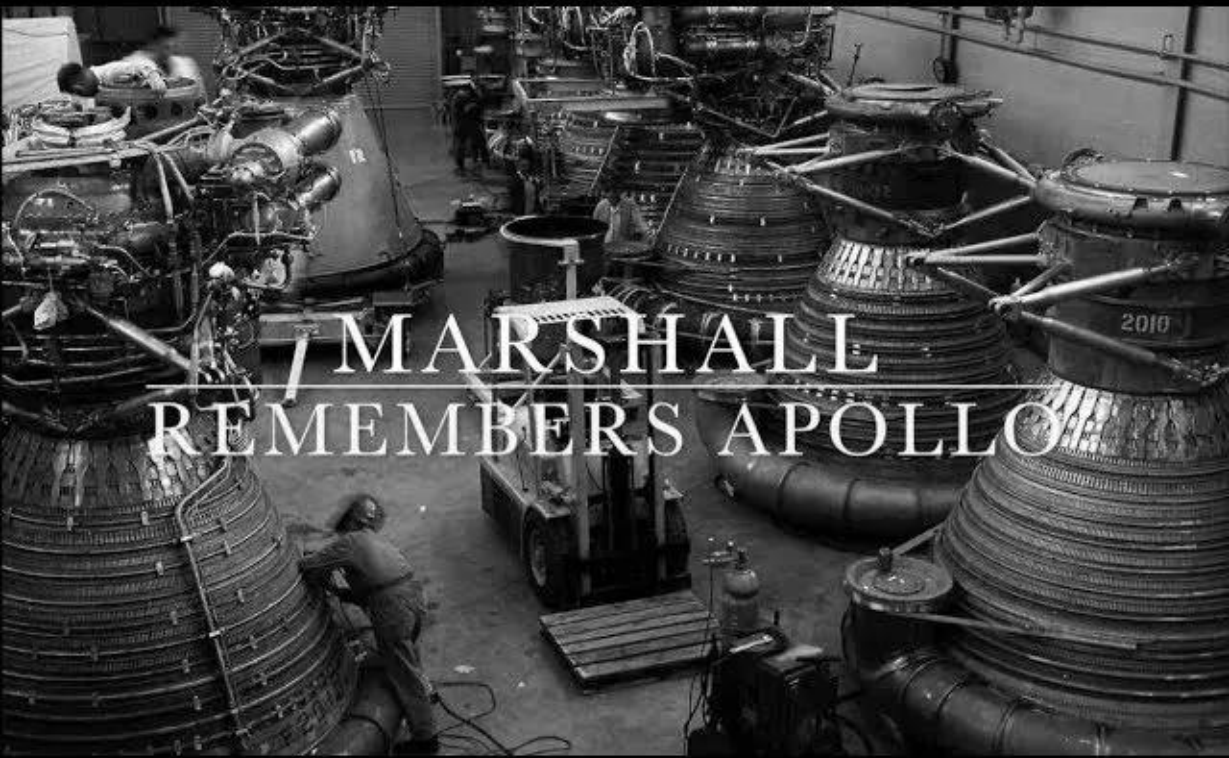
MARSHALL
REMEMBERS APOLLO

1
00:00:01,130 --> 00:00:14,410
[Music]

2
00:00:25,240 --> 00:00:22,710
I joined the Apollo Saturn program in

3
00:00:29,320 --> 00:00:25,250
1962 right after I graduated from

4
00:00:30,580 --> 00:00:29,330
Georgia Tech I later got a master's

5
00:00:32,620 --> 00:00:30,590
degree at the University of Southern

6
00:00:35,350 --> 00:00:32,630
California PhD from the University of

7
00:00:38,950 --> 00:00:35,360
Texas a little later in my in my career

8
00:00:40,960 --> 00:00:38,960
but you know the everybody was really

9
00:00:43,690 --> 00:00:40,970
enthused about the space program in

10
00:00:47,560 --> 00:00:43,700
those days of course and I'd heard a lot

11
00:00:50,110 --> 00:00:47,570
about it while I was in school Kennedy's

12
00:00:53,500 --> 00:00:50,120
speech and it was obvious that there was

13
00:00:56,410 --> 00:00:53,510

a lot of enthusiasm there and I decided

14
00:00:59,319 --> 00:00:56,420
I would join Rocketdyne and work on the

15
00:01:01,029 --> 00:00:59,329
program I was actually hired into the h1

16
00:01:05,620 --> 00:01:01,039
engine program h1 engines were the

17
00:01:11,050 --> 00:01:05,630
engines for the Saturn one 1b and when I

18
00:01:15,040 --> 00:01:11,060
got there in mid 62 June 6 do you think

19
00:01:18,250 --> 00:01:15,050
was the engine was undergoing an upgrade

20
00:01:21,550 --> 00:01:18,260
it had been qualified for 188 thousand

21
00:01:23,200 --> 00:01:21,560
pounds of thrust and they decided it

22
00:01:24,880 --> 00:01:23,210
needed more capability into boosters so

23
00:01:28,510 --> 00:01:24,890
they had upgraded it to two hundred and

24
00:01:30,359 --> 00:01:28,520
eight thousand pounds when they did that

25
00:01:32,679 --> 00:01:30,369
they had to redesign a lot of components

26
00:01:35,889 --> 00:01:32,689
so essentially we had to completely

27
00:01:38,350 --> 00:01:35,899
recoil fire the engine and that was just

28
00:01:41,800 --> 00:01:38,360
beginning to be started when when I got

29
00:01:44,020 --> 00:01:41,810
there and after being in the program

30
00:01:47,380 --> 00:01:44,030
office for I think it was three or four

31
00:01:50,230 --> 00:01:47,390
or five months I went to work on a test

32
00:01:52,450 --> 00:01:50,240
stand in Santa Susana I was responsible

33
00:01:55,450 --> 00:01:52,460
development engineer on a test and that

34
00:02:00,069 --> 00:01:55,460
was doing the testing to requalified the

35
00:02:03,060 --> 00:02:00,079
h1 and it was a fantastic experience I

36
00:02:05,889 --> 00:02:03,070
had never been around anything like that

37
00:02:08,020 --> 00:02:05,899
but we were trying to get a lot of tests

38
00:02:10,210 --> 00:02:08,030

though because you had requirements some

39
00:02:12,550 --> 00:02:10,220
time on hardware and number of firings

40
00:02:13,930 --> 00:02:12,560
and those kind of things we actually had

41
00:02:17,140 --> 00:02:13,940
two test stands there running at the

42
00:02:19,410 --> 00:02:17,150
same time and so we were getting just as

43
00:02:23,770 --> 00:02:19,420
many tests as we could off and typically

44
00:02:25,839 --> 00:02:23,780
two a day was about all you could do we

45
00:02:26,630 --> 00:02:25,849
would run in the morning I'd go back to

46
00:02:31,280 --> 00:02:26,640
the

47
00:02:34,100 --> 00:02:31,290
course everything was on strip charts

48
00:02:36,470 --> 00:02:34,110
and asila graphs in those days and I had

49
00:02:37,970 --> 00:02:36,480
two ladies who would reduce the data and

50
00:02:41,000 --> 00:02:37,980
while they were reducing data I was

51
00:02:43,520 --> 00:02:41,010
reviewing Isetta graphs and and also the

52
00:02:46,699 --> 00:02:43,530
strip charts he usually took me about

53
00:02:47,930 --> 00:02:46,709
maybe two hours to do that and then we'd

54
00:02:50,949 --> 00:02:47,940
start getting ready for the afternoon

55
00:02:56,090 --> 00:02:50,959
test and same thing over and over again

56
00:02:59,020 --> 00:02:56,100
I was on that test stand for a little

57
00:03:02,750 --> 00:02:59,030
over a year I guess and went back to the

58
00:03:05,570 --> 00:03:02,760
program office and worked there for for

59
00:03:07,580 --> 00:03:05,580
a while and I did was involved in one

60
00:03:10,040 --> 00:03:07,590
more thing there in the qualification we

61
00:03:13,000 --> 00:03:10,050
it was difficult to get the number of

62
00:03:16,250 --> 00:03:13,010
tests off that you needed to qualify

63
00:03:19,310 --> 00:03:16,260

particularly the main fuel valve which

64
00:03:23,060 --> 00:03:19,320
had been redesigned and had to be

65
00:03:26,390 --> 00:03:23,070
requalified so I came up with the idea

66
00:03:28,960 --> 00:03:26,400
of designing a flow bench where we could

67
00:03:32,120 --> 00:03:28,970
put two of the valves in parallel and

68
00:03:34,699 --> 00:03:32,130
cycle them and never turn the system off

69
00:03:38,300 --> 00:03:34,709
and we were able to get the right kind

70
00:03:40,310 --> 00:03:38,310
of loads on the on the valves and did

71
00:03:44,900 --> 00:03:40,320
that to finish the number of tests we

72
00:03:48,170 --> 00:03:44,910
had to have to to to qualify one of the

73
00:03:53,080 --> 00:03:48,180
most critical issues in the program was

74
00:03:57,860 --> 00:03:53,090
the instability of the f1 engine the f1

75
00:04:00,610 --> 00:03:57,870
injector and that problem was eventually

76
00:04:03,289 --> 00:04:00,620
solved frankly by trial and error

77
00:04:05,990 --> 00:04:03,299
you know the analytical capability in

78
00:04:08,210 --> 00:04:06,000
those days was not good enough to really

79
00:04:09,949 --> 00:04:08,220
investigate what the flow field was like

80
00:04:11,479 --> 00:04:09,959
or what was going on and as a matter of

81
00:04:14,960 --> 00:04:11,489
fact it's still not good enough to do

82
00:04:18,920 --> 00:04:14,970
that with any fidelity so the plan was

83
00:04:21,860 --> 00:04:18,930
to just design and test injectors until

84
00:04:24,830 --> 00:04:21,870
they found one that that was stable and

85
00:04:26,719 --> 00:04:24,840
they did that but one of the things that

86
00:04:30,140 --> 00:04:26,729
I did while I was working on the test

87
00:04:36,920 --> 00:04:30,150
and was the f1 was basically a scaled up

88
00:04:38,200 --> 00:04:36,930

h1 was a the f1 was 105 one point five

89
00:04:41,200 --> 00:04:38,210
million then

90
00:04:42,940 --> 00:04:41,210
the h1 was around 200,000 but

91
00:04:45,880 --> 00:04:42,950
essentially it was scaled up in a lot of

92
00:04:48,760 --> 00:04:45,890
respects so the thought was and and the

93
00:04:51,310 --> 00:04:48,770
h1 engine was stable as rock you

94
00:04:53,620 --> 00:04:51,320
couldn't move it but they decided they

95
00:04:55,150 --> 00:04:53,630
wanted to try to drive it unstable so

96
00:04:58,840 --> 00:04:55,160
they could look at what was happening in

97
00:05:01,770 --> 00:04:58,850
the combustion chamber so we put charges

98
00:05:05,620 --> 00:05:01,780
screwed charges into the injector and we

99
00:05:08,350 --> 00:05:05,630
start the engine ignited and and ignite

100
00:05:10,630 --> 00:05:08,360
the charge and you'd see a pulse in

101
00:05:13,090 --> 00:05:10,640
there but we were never able to get in

102
00:05:16,210 --> 00:05:13,100
any instability in the h1 but you know

103
00:05:18,190 --> 00:05:16,220
it wasn't hectic it was Ortoli and you

104
00:05:21,220 --> 00:05:18,200
know the process was there and and

105
00:05:23,680 --> 00:05:21,230
people were working hard every day but

106
00:05:25,570 --> 00:05:23,690
there was no I never had a feeling of

107
00:05:27,700 --> 00:05:25,580
pressure pressure of course I was done

108
00:05:28,690 --> 00:05:27,710
in the organization I'm sure that some

109
00:05:29,920 --> 00:05:28,700
of the people higher up in the

110
00:05:31,480 --> 00:05:29,930
organization had some pressure

111
00:05:38,290 --> 00:05:31,490
particularly with the instability

112
00:05:41,650 --> 00:05:38,300
problem but when I went to work there I

113
00:05:44,080 --> 00:05:41,660

had never done anything like that I you

114
00:05:46,710 --> 00:05:44,090
know I was a mechanical engineer but I

115
00:05:49,360 --> 00:05:46,720
didn't even think of a cars very much

116
00:05:51,610 --> 00:05:49,370
and one of the interesting things I did

117
00:05:54,520 --> 00:05:51,620
was that I went through a training

118
00:05:56,050 --> 00:05:54,530
program and they had an ideal training

119
00:05:58,440 --> 00:05:56,060
program to learn this engine because

120
00:06:04,210 --> 00:05:58,450
what I did was went out in the shop and

121
00:06:06,940 --> 00:06:04,220
I stood beside a mechanic's side by his

122
00:06:10,120 --> 00:06:06,950
elbow as he was completely assembling a

123
00:06:11,830 --> 00:06:10,130
liquid oxygen pump and then followed on

124
00:06:15,280 --> 00:06:11,840
through the rest of the engine so I I

125
00:06:17,710 --> 00:06:15,290
learned the engine from inside out with

126
00:06:19,870 --> 00:06:17,720
that with that kind of training I gave

127
00:06:23,680 --> 00:06:19,880
my first ever presentation to a group

128
00:06:26,920 --> 00:06:23,690
from Marshall that came out and I was

129
00:06:30,160 --> 00:06:26,930
saying I was in the working in the

130
00:06:32,980 --> 00:06:30,170
training program in the turbopump area

131
00:06:36,910 --> 00:06:32,990
and I can't remember the details of what

132
00:06:38,610 --> 00:06:36,920
it was that we had going on but and I we

133
00:06:42,190 --> 00:06:38,620
had done some work and I'd written a

134
00:06:44,230 --> 00:06:42,200
memo on it and the NASA folks came out

135
00:06:45,710 --> 00:06:44,240
to hear about the details of the

136
00:06:50,200 --> 00:06:45,720
investigation this kind

137
00:06:53,030 --> 00:06:50,210
and so I gave my first presentation ever

138
00:06:55,070 --> 00:06:53,040

to that group and we had in those days

139
00:06:57,770 --> 00:06:55,080
you use flip charts you know they were

140
00:07:00,860 --> 00:06:57,780
about 30 inches wide and 20 inches tall

141
00:07:02,270 --> 00:07:00,870
and you'd flip them over and I had a set

142
00:07:04,790 --> 00:07:02,280
of flip charts that I went through with

143
00:07:06,470 --> 00:07:04,800
that tour as a matter of fact I didn't

144
00:07:10,490 --> 00:07:06,480
even have a suit I went out and bought a

145
00:07:13,100 --> 00:07:10,500
suit for the first presentation when I

146
00:07:16,250 --> 00:07:13,110
was at Rocketdyne working on the engines

147
00:07:19,510 --> 00:07:16,260
you know every day working on something

148
00:07:21,950 --> 00:07:19,520
that Marshall had an intense interest in

149
00:07:24,830 --> 00:07:21,960
so everything we were doing was been

150
00:07:27,830 --> 00:07:24,840
transmitted back back to the customer

151
00:07:29,390 --> 00:07:27,840
and then in presentations as well and in

152
00:07:31,880 --> 00:07:29,400
providing information to him and that

153
00:07:34,070 --> 00:07:31,890
came out when I was working at Teledyne

154
00:07:36,800 --> 00:07:34,080
Brown I was in a research department you

155
00:07:38,840 --> 00:07:36,810
know we were given problems to solve

156
00:07:40,640 --> 00:07:38,850
like the one I mentioned to you that

157
00:07:44,870 --> 00:07:40,650
developing the computer program for

158
00:07:46,250 --> 00:07:44,880
their use I also did a they had a nozzle

159
00:07:49,250 --> 00:07:46,260
flow program that had been developed

160
00:07:51,140 --> 00:07:49,260
earlier but it didn't include the

161
00:07:54,800 --> 00:07:51,150
rotational flow component in the flow

162
00:07:58,190 --> 00:07:54,810
and I redid all that but it was you know

163
00:08:00,370 --> 00:07:58,200

his arms length we as a matter of fact

164
00:08:03,650 --> 00:08:00,380
they're worse than even any in progress

165
00:08:05,270 --> 00:08:03,660
reviews you do the whole program and

166
00:08:07,550 --> 00:08:05,280
then you'd go sit down with them and

167
00:08:13,019 --> 00:08:07,560
with NASA and tell them what you had and

168
00:08:18,749 --> 00:08:15,949
when I finished my master's degree I

169
00:08:23,039 --> 00:08:18,759
wanted to move into the research area at

170
00:08:24,899 --> 00:08:23,049
at Rocketdyne and they weren't inclined

171
00:08:26,369 --> 00:08:24,909
to do that they wanted me stay where I

172
00:08:28,229 --> 00:08:26,379
was

173
00:08:32,300 --> 00:08:28,239
so I started looking around for

174
00:08:35,610 --> 00:08:32,310
something else and I got in contact with

175
00:08:37,019 --> 00:08:35,620
Brown engineering which wasn't Teledyne

176
00:08:40,800 --> 00:08:37,029
Brown in those days it was just brown

177
00:08:43,949 --> 00:08:40,810
engineering and they had an opening in

178
00:08:46,590 --> 00:08:43,959
their research department and so over a

179
00:08:51,300 --> 00:08:46,600
period of a few weeks took the job and

180
00:08:55,470 --> 00:08:51,310
and and we plan to come back when my my

181
00:08:58,230 --> 00:08:55,480
organization found out that that I was

182
00:08:59,300 --> 00:08:58,240
leaving they all of a sudden offered me

183
00:09:02,670 --> 00:08:59,310
a promotion

184
00:09:05,970 --> 00:09:02,680
increase salary and moved to the

185
00:09:07,499 --> 00:09:05,980
research department but by that time I

186
00:09:12,090 --> 00:09:07,509
had told my wife that we were moving

187
00:09:13,559 --> 00:09:12,100
back south I said I throw my the boss

188
00:09:17,040 --> 00:09:13,569

has to look you can go talk to my wife

189
00:09:19,769 --> 00:09:17,050
as you want to but I'm not gonna do that

190
00:09:24,059 --> 00:09:19,779
so we came back to Brown engineering and

191
00:09:25,949 --> 00:09:24,069
I was there for about three years and

192
00:09:29,699 --> 00:09:25,959
most of the work that I did there was

193
00:09:33,210 --> 00:09:29,709
for NASA almost all of it and one part

194
00:09:36,030 --> 00:09:33,220
of it related to the to the Apollo

195
00:09:38,910 --> 00:09:36,040
program the organization was looking out

196
00:09:41,819 --> 00:09:38,920
beyond the first flights to the moon and

197
00:09:44,780 --> 00:09:41,829
and to what they were going to do to

198
00:09:47,790 --> 00:09:44,790
have habitats there for for the crews

199
00:09:50,639 --> 00:09:47,800
further out in the future and they

200
00:09:53,280 --> 00:09:50,649
needed a computer program that would do

201
00:09:55,769 --> 00:09:53,290
a thermal analysis on bodies that were

202
00:09:59,850 --> 00:09:55,779
placed on the moon and it was you had to

203
00:10:01,499 --> 00:09:59,860
be completely generic it had to be you

204
00:10:03,269 --> 00:10:01,509
had to have been define it inside the

205
00:10:05,400 --> 00:10:03,279
computer program and it had to be

206
00:10:07,290 --> 00:10:05,410
variable and it also had to have the

207
00:10:10,379 --> 00:10:07,300
capability of having shades in any

208
00:10:12,420 --> 00:10:10,389
location and so I spent quite some time

209
00:10:14,369 --> 00:10:12,430
probably about a year putting that

210
00:10:17,429 --> 00:10:14,379
program together and delivering it to

211
00:10:20,040 --> 00:10:17,439
NASA lovely work we were doing was for

212
00:10:22,810 --> 00:10:20,050
program development and Charles Darwin

213
00:10:25,139 --> 00:10:22,820

Charlie Darwin was head of program fella

214
00:10:28,840 --> 00:10:25,149
as a matter of fact I gave my first

215
00:10:32,019 --> 00:10:28,850
presentation on site that March took the

216
00:10:36,430 --> 00:10:32,029
Charter Darwin they had had it was a

217
00:10:38,889 --> 00:10:36,440
Lockheed Martin analysis of some kind of

218
00:10:41,079 --> 00:10:38,899
vehicle they had and when they got the

219
00:10:45,190 --> 00:10:41,089
results they couldn't didn't believe it

220
00:10:47,710 --> 00:10:45,200
so they they asked us to go do an

221
00:10:51,070 --> 00:10:47,720
analysis to to check what they had from

222
00:10:52,780 --> 00:10:51,080
from Lockheed Martin and I did the

223
00:10:54,639 --> 00:10:52,790
analysis but together computer program

224
00:10:57,190 --> 00:10:54,649
and did the analysis and got drastically

225
00:10:59,590 --> 00:10:57,200
different results and I also found out

226
00:11:02,560 --> 00:10:59,600
why what had caused their problem with

227
00:11:05,710 --> 00:11:02,570
it they had they had didn't have any

228
00:11:08,590 --> 00:11:05,720
conduction around the circumferentially

229
00:11:11,170 --> 00:11:08,600
around the vehicle and so that gave

230
00:11:12,970 --> 00:11:11,180
grossly different thermals us so I came

231
00:11:15,240 --> 00:11:12,980
out and presented all that to Charlie

232
00:11:22,130 --> 00:11:15,250
Darwin that was my first on-site

233
00:11:27,470 --> 00:11:24,370
to Huntsville for that interview trip I

234
00:11:32,170 --> 00:11:27,480
came a flew over from Atlanta in a dc-3

235
00:11:36,260 --> 00:11:32,180
and never been in this area at all and

236
00:11:39,500 --> 00:11:36,270
the plane landed and I got up and

237
00:11:40,880 --> 00:11:39,510
started to get out and somebody told me

238
00:11:45,110 --> 00:11:40,890

that I hadn't gotten to Huntsville yeah

239
00:11:46,640 --> 00:11:45,120
this is muscle shows so I thought the

240
00:11:49,010 --> 00:11:46,650
plane would land at Huntsville first I

241
00:11:51,200 --> 00:11:49,020
knew it was going to motion show but you

242
00:11:53,630 --> 00:11:51,210
know flew in over the rock quarry to the

243
00:11:57,170 --> 00:11:53,640
old airport

244
00:12:02,920 --> 00:11:57,180
the town was relatively small in those

245
00:12:05,360 --> 00:12:02,930
days and growth has been been fantastic

246
00:12:09,290 --> 00:12:05,370
most of it due to the space program and

247
00:12:11,120 --> 00:12:09,300
to the Redstone Arsenal of course there

248
00:12:13,850 --> 00:12:11,130
were there were a few companies here

249
00:12:21,360 --> 00:12:13,860
then but now you know anybody and

250
00:12:27,660 --> 00:12:24,150
I had a friend who had actually been at

251
00:12:31,259 --> 00:12:27,670
Rocketdyne Terre Greenwood who had come

252
00:12:33,090 --> 00:12:31,269
to NASA directly from Rocketdyne he came

253
00:12:34,920 --> 00:12:33,100
over to our place when one day and he

254
00:12:38,090 --> 00:12:34,930
said hey look he said Marshall has

255
00:12:40,650 --> 00:12:38,100
started a new graduate co-op program I

256
00:12:43,139 --> 00:12:40,660
said the deal is they'll give you half

257
00:12:45,499 --> 00:12:43,149
salary while you're at school and let

258
00:12:50,639 --> 00:12:45,509
you go work on your PhD and by that time

259
00:12:52,259 --> 00:12:50,649
I had accumulated in addition to what I

260
00:12:55,530 --> 00:12:52,269
had on my Master's I'd accumulated

261
00:12:57,929 --> 00:12:55,540
another 27 semester hours working at UAH

262
00:13:01,889 --> 00:12:57,939
so I was ready to try to finish it off

263
00:13:05,280 --> 00:13:01,899

so I came out to talk to the coop

264
00:13:07,410 --> 00:13:05,290
department about that and told them you

265
00:13:09,480 --> 00:13:07,420
know who it was and what I was and what

266
00:13:11,249 --> 00:13:09,490
I wanted to do and they said you don't

267
00:13:13,860 --> 00:13:11,259
really understand he said this is for

268
00:13:15,960 --> 00:13:13,870
people who work at NASA so I said well

269
00:13:17,879 --> 00:13:15,970
if you hire me I'll be a nicer employee

270
00:13:21,150 --> 00:13:17,889
and then I they said oh no we can't do

271
00:13:25,259 --> 00:13:21,160
that so I had about three visits with

272
00:13:27,929 --> 00:13:25,269
him and finally they hired me so I came

273
00:13:31,019 --> 00:13:27,939
out here in May

274
00:13:33,480 --> 00:13:31,029
and what University of Texas that fall

275
00:13:36,210 --> 00:13:33,490
and finished up all the coursework and

276
00:13:37,470 --> 00:13:36,220
qualifying exams and all that then came

277
00:13:40,259 --> 00:13:37,480
back to Marshall and did my dissertation

278
00:13:43,019 --> 00:13:40,269
here using the drop tower what I was

279
00:13:47,100 --> 00:13:43,029
looking at was reduced gravity nucleate

280
00:13:49,980 --> 00:13:47,110
boiling and I used freon 113 a test

281
00:13:53,549 --> 00:13:49,990
really put together a test rig and the

282
00:13:55,199 --> 00:13:53,559
dock drop tower was not frankly even

283
00:13:57,119 --> 00:13:55,209
being used at that time but they had

284
00:13:58,530 --> 00:13:57,129
some equipment that they'd used for

285
00:14:01,139 --> 00:13:58,540
earlier experiments so I used that

286
00:14:04,439 --> 00:14:01,149
equipment set it up in the drop tower

287
00:14:06,929 --> 00:14:04,449
and studied I would start the nucleate

288
00:14:08,790 --> 00:14:06,939

boiling then get out of the shield and

289
00:14:12,119 --> 00:14:08,800
they'd drop it and I had it you know

290
00:14:14,150 --> 00:14:12,129
data and in pictures all the way down so

291
00:14:18,179 --> 00:14:14,160
I that's the way I got the data for my

292
00:14:22,439 --> 00:14:18,189
dissertation while I was here working on

293
00:14:25,290 --> 00:14:22,449
my dissertation there getting involved

294
00:14:28,350 --> 00:14:25,300
already in the Skylab broker that was

295
00:14:37,170 --> 00:14:28,360
getting cranked up and defined

296
00:14:39,090 --> 00:14:37,180
so I I as soon as I finished the PhD my

297
00:14:40,769 --> 00:14:39,100
boss Charlie would at the time called me

298
00:14:43,439 --> 00:14:40,779
in and asked me what I wanted to do and

299
00:14:47,460 --> 00:14:43,449
I told everyone to stay and they had a

300
00:14:49,499 --> 00:14:47,470
section chief job that was open so he

301
00:14:55,309 --> 00:14:49,509
offered that to me and I and I took it

302
00:14:59,189 --> 00:14:55,319
and so I worked from that time until

303
00:15:02,179 --> 00:14:59,199
after launch of Skylab I was 100% on the

304
00:15:05,489 --> 00:15:02,189
Skylab program we had I had

305
00:15:08,610 --> 00:15:05,499
environmental control branch we also did

306
00:15:12,059 --> 00:15:08,620
thermal work so I was responsible for

307
00:15:13,920 --> 00:15:12,069
the environmental control system the

308
00:15:16,980 --> 00:15:13,930
interesting thing about that was it was

309
00:15:20,429 --> 00:15:16,990
the first time we'd had an active

310
00:15:24,900 --> 00:15:20,439
control system for carbon dioxide on

311
00:15:27,110 --> 00:15:24,910
Apollo and all the capsules they used

312
00:15:30,239 --> 00:15:27,120
lifting the Drakh side canisters and

313
00:15:32,549 --> 00:15:30,249

they would use they would be used up you

314
00:15:34,980 --> 00:15:32,559
know after a while and yet to replace

315
00:15:37,980 --> 00:15:34,990
them a couple of days I think so there's

316
00:15:40,040 --> 00:15:37,990
a lot of mass involved in that and we

317
00:15:43,079 --> 00:15:40,050
were gonna be on orbit you know for

318
00:15:47,340 --> 00:15:43,089
months and months so we couldn't afford

319
00:15:50,790 --> 00:15:47,350
the weight to do that so we developed it

320
00:15:54,720 --> 00:15:50,800
was actually developed by McDonnell

321
00:15:56,669 --> 00:15:54,730
Douglas East and in st. Louis molecular

322
00:15:59,460 --> 00:15:56,679
cell system which was regenerative you

323
00:16:01,259 --> 00:15:59,470
it would absorb the carbon dioxide and a

324
00:16:03,030 --> 00:16:01,269
material and then you would switch it

325
00:16:05,910 --> 00:16:03,040
over and put that to vacuum and the

326
00:16:07,319 --> 00:16:05,920
vacuum would put it out to space so it

327
00:16:09,540 --> 00:16:07,329
was a regenerative system worked

328
00:16:13,880 --> 00:16:09,550
beautifully never had any problems with

329
00:16:18,170 --> 00:16:15,860
yeah one of one of the interesting

330
00:16:22,460 --> 00:16:18,180
things of course during this period of

331
00:16:24,139 --> 00:16:22,470
time we had we talked about being in a

332
00:16:27,710 --> 00:16:24,149
race with the Russians to get to the

333
00:16:29,569 --> 00:16:27,720
moon and and we were in a race with them

334
00:16:31,490 --> 00:16:29,579
you know we knew that they had fantastic

335
00:16:35,449 --> 00:16:31,500
capability they put the first satellite

336
00:16:38,230 --> 00:16:35,459
up they put the first man in orbit but

337
00:16:40,579 --> 00:16:38,240
we never knew what they were doing they

338
00:16:42,970 --> 00:16:40,589

they knew everything we were doing and

339
00:16:46,699 --> 00:16:42,980
we knew nothing that they were doing and

340
00:16:50,690 --> 00:16:46,709
frankly didn't find out a lot about it

341
00:16:52,310 --> 00:16:50,700
until after the wall came down and we

342
00:16:53,870 --> 00:16:52,320
started having interactions with the

343
00:16:57,170 --> 00:16:53,880
Russians

344
00:17:00,530 --> 00:16:57,180
I had an visited Russia a number of

345
00:17:04,069 --> 00:17:00,540
times several times when I was deputy

346
00:17:06,140 --> 00:17:04,079
director marshal when I was chief

347
00:17:08,840 --> 00:17:06,150
engineer and NASA chief engineer and and

348
00:17:09,829 --> 00:17:08,850
when I was administrator I also visited

349
00:17:12,260 --> 00:17:09,839
several times

350
00:17:17,569 --> 00:17:12,270
some of them looking at engines other

351
00:17:20,270 --> 00:17:17,579
with Space Station things but the

352
00:17:24,500 --> 00:17:20,280
interesting thing relative to that race

353
00:17:25,880 --> 00:17:24,510
was that I think was about it must have

354
00:17:27,860 --> 00:17:25,890
been the SEC it wasn't the first it must

355
00:17:30,289 --> 00:17:27,870
have been the second or the third trip I

356
00:17:31,820 --> 00:17:30,299
took to Russia mostly I was dealing with

357
00:17:33,710 --> 00:17:31,830
the engine companies looking at their

358
00:17:36,049 --> 00:17:33,720
engines and how they developed and

359
00:17:38,960 --> 00:17:36,059
building of what they could do at NP

360
00:17:42,830 --> 00:17:38,970
under Gamache at kemp key right outside

361
00:17:44,360 --> 00:17:42,840
of Russia and cdb and veronik but when

362
00:17:47,840 --> 00:17:44,370
one of those visits second of the third

363
00:17:49,880 --> 00:17:47,850

one I went to visit an ERG yeah and they

364
00:17:53,539 --> 00:17:49,890
were responsible for the design

365
00:17:55,669 --> 00:17:53,549
development of launch vehicles and they

366
00:17:57,740 --> 00:17:55,679
had been responsible back in the days

367
00:18:01,520 --> 00:17:57,750
when we had the moon race going on for

368
00:18:06,440 --> 00:18:01,530
the their designation was the n1 launch

369
00:18:09,380 --> 00:18:06,450
vehicle and we had a nice visit with

370
00:18:12,200 --> 00:18:09,390
them and all of a sudden something

371
00:18:15,530 --> 00:18:12,210
totally unexpected they started showing

372
00:18:20,030 --> 00:18:15,540
me movies of their launch failures of

373
00:18:24,230 --> 00:18:20,040
the n1 and they discussed it very openly

374
00:18:25,580 --> 00:18:24,240
and they told me how they had come up

375
00:18:30,650 --> 00:18:25,590
short but

376
00:18:33,140 --> 00:18:30,660
and had not beat us to the moon they we

377
00:18:37,670 --> 00:18:33,150
had the f1 engine which is in you know

378
00:18:41,080 --> 00:18:37,680
million half pounds of thrust and they

379
00:18:43,970 --> 00:18:41,090
at that time did not have a large engine

380
00:18:46,460 --> 00:18:43,980
their engines it was in fifteen I think

381
00:18:49,940 --> 00:18:46,470
was their designation for it was a much

382
00:18:53,300 --> 00:18:49,950
much smaller engine they had and because

383
00:18:57,020 --> 00:18:53,310
of that they had in the mid 30 or 35

384
00:19:00,140 --> 00:18:57,030
engines in their first stage and you can

385
00:19:03,440 --> 00:19:00,150
imagine a plumbing nightmare with all

386
00:19:08,840 --> 00:19:03,450
the plumbing that feeds propellant 235

387
00:19:12,440 --> 00:19:08,850
engines and what we did was when we

388
00:19:14,720 --> 00:19:12,450

developed our booster we did a total

389
00:19:18,950 --> 00:19:14,730
system test we tested the whole stage

390
00:19:20,480 --> 00:19:18,960
many many times so that we we knew the

391
00:19:23,150 --> 00:19:20,490
plumbing the flow was going to be right

392
00:19:26,720 --> 00:19:23,160
nope no excess vibrations or anything in

393
00:19:29,390 --> 00:19:26,730
there but they didn't do that they they

394
00:19:32,600 --> 00:19:29,400
never ever tested that first stage

395
00:19:34,160 --> 00:19:32,610
completely assembled they launched it

396
00:19:37,550 --> 00:19:34,170
without ever doing that test and they

397
00:19:40,190 --> 00:19:37,560
did it they did it to save time to try

398
00:19:42,680 --> 00:19:40,200
to beat us to the moon if they had if

399
00:19:43,970 --> 00:19:42,690
they had done those tests they they

400
00:19:47,990 --> 00:19:43,980
probably wouldn't have beaten us because

401
00:19:53,150 --> 00:19:48,000
they didn't try a launch until it was in

402
00:19:54,800 --> 00:19:53,160
69 I think but you know they were lower

403
00:19:56,210 --> 00:19:54,810
there would have been later than that if

404
00:19:59,210 --> 00:19:56,220
they had taken the time to go do that

405
00:20:01,280 --> 00:19:59,220
and and even if even if they're taking

406
00:20:03,380 --> 00:20:01,290
the time with a complex situation they

407
00:20:07,150 --> 00:20:03,390
had they they might or might not have

408
00:20:09,860 --> 00:20:07,160
made it work but not doing the testing

409
00:20:13,250 --> 00:20:09,870
doomed them to failure and and they knew

410
00:20:15,170 --> 00:20:13,260
that and the the people I were talking

411
00:20:17,360 --> 00:20:15,180
to some of them were people who had been

412
00:20:20,360 --> 00:20:17,370
there in that time and they weren't just

413
00:20:21,500 --> 00:20:20,370

telling stories from from what they had

414
00:20:24,770 --> 00:20:21,510
heard they were telling you what

415
00:20:31,580 --> 00:20:24,780
happened they also had their chief

416
00:20:33,650 --> 00:20:31,590
designer had died in 1965 and that hurt

417
00:20:35,600 --> 00:20:33,660
the program a lot and another thing that

418
00:20:36,630 --> 00:20:35,610
hurt them and this is another story they

419
00:20:39,130 --> 00:20:36,640
told

420
00:20:42,279 --> 00:20:39,140
they and they were getting a lot of

421
00:20:45,100 --> 00:20:42,289
pressure having these failures from from

422
00:20:49,480 --> 00:20:45,110
higher-ups and they were getting ready

423
00:20:52,299 --> 00:20:49,490
to to do another launch and they were

424
00:20:54,659 --> 00:20:52,309
getting again with this pressure and in

425
00:20:57,039 --> 00:20:54,669
order to show confidence his confidence

426
00:21:00,279 --> 00:20:57,049
that they were going to do this and it's

427
00:21:03,340 --> 00:21:00,289
going to be successful he took quite a

428
00:21:06,520 --> 00:21:03,350
significant number of his key people and

429
00:21:09,880 --> 00:21:06,530
went out close to the launch pad and the

430
00:21:12,430 --> 00:21:09,890
launch failed and killed all of them so

431
00:21:17,760 --> 00:21:12,440
that left a hole in their in their

432
00:21:25,230 --> 00:21:21,560
well the most memorable was Apollo 11

433
00:21:30,240 --> 00:21:25,240
because that was the first launch I'd

434
00:21:32,279 --> 00:21:30,250
ever gone to and of any kind and my wife

435
00:21:36,389 --> 00:21:32,289
and I went down and watched it from the

436
00:21:38,779 --> 00:21:36,399
causeway at the Cape and that's still

437
00:21:41,909 --> 00:21:38,789
the most fantastic launch I've ever seen

438
00:21:44,130 --> 00:21:41,919

just to see that thing you know slowly

439
00:21:47,700 --> 00:21:44,140
move up off the pad and it was just and

440
00:21:52,169 --> 00:21:47,710
knowing all that had gone into it it was

441
00:21:56,940 --> 00:21:52,179
just a fantastic experience we came back

442
00:21:59,370 --> 00:21:56,950
and I watched the landing in my den on

443
00:22:03,570 --> 00:21:59,380
TV Walter contract

444
00:22:07,500 --> 00:22:03,580
Cronkite was narrating and my wife and I

445
00:22:09,389 --> 00:22:07,510
watched that on TV so that you know that

446
00:22:12,720 --> 00:22:09,399
that's the memorable event there's

447
00:22:15,000 --> 00:22:12,730
nothing more memorable than that

448
00:22:17,070 --> 00:22:15,010
well you know in the moment watching

449
00:22:19,169 --> 00:22:17,080
that there was nothing on my mind except

450
00:22:21,990 --> 00:22:19,179
what I was watching and you know I had

451
00:22:24,299 --> 00:22:22,000
done this other work but you know to see

452
00:22:28,769 --> 00:22:24,309
what we were seeing is was beyond belief

453
00:22:31,409 --> 00:22:28,779
you know that that program and you know

454
00:22:34,919 --> 00:22:31,419
the way it was started and you know nine

455
00:22:39,630 --> 00:22:34,929
years plus we were actually landing on

456
00:22:40,919 --> 00:22:39,640
the moon was hard to believe even though

457
00:22:43,110 --> 00:22:40,929
I'd worked on it and you what they were

458
00:22:45,990 --> 00:22:43,120
doing I'm watching it it's still hard to

459
00:22:47,940 --> 00:22:46,000
believe and you know I didn't really

460
00:22:53,639 --> 00:22:47,950
relate it to anything else at that time

461
00:22:55,710 --> 00:22:53,649
and I after that we went I think maybe

462
00:22:56,460 --> 00:22:55,720
and I went to one more launch and I came

463
00:22:59,010 --> 00:22:56,470

from which one it was

464
00:23:02,130 --> 00:22:59,020
there's probably 14 or 15 something like

465
00:23:06,269 --> 00:23:02,140
that and took our children to that one

466
00:23:10,169 --> 00:23:06,279
same same thing on the causeway our our

467
00:23:12,960 --> 00:23:10,179
sonim was about two years old and our

468
00:23:15,750 --> 00:23:12,970
daughter was about five I think and

469
00:23:18,269 --> 00:23:15,760
Beebe had made outfits for them red

470
00:23:19,590 --> 00:23:18,279
white and blue outfits and we have a

471
00:23:23,940 --> 00:23:19,600
picture of them sitting on the hood of

472
00:23:30,280 --> 00:23:23,950
our car at that launch so and that was

473
00:23:40,140 --> 00:23:35,650
there was some uncertainty because what

474
00:23:41,740 --> 00:23:40,150
we what we had in staffing levels was

475
00:23:44,940 --> 00:23:41,750
more than we needed

476
00:23:48,790 --> 00:23:44,950
in cases as a matter of fact we had one

477
00:23:52,570 --> 00:23:48,800
reduction in force they might have been

478
00:23:54,040 --> 00:23:52,580
two but no there was one so even though

479
00:23:56,950 --> 00:23:54,050
makes purple nervous when you start

480
00:24:01,120 --> 00:23:56,960
doing that the workload wasn't going to

481
00:24:03,760 --> 00:24:01,130
be as heavy as we had and we had you

482
00:24:04,900 --> 00:24:03,770
know I think in Apollo probably 6,000

483
00:24:08,770 --> 00:24:04,910
people here

484
00:24:11,260 --> 00:24:08,780
we had a large Kadri of technicians and

485
00:24:13,930 --> 00:24:11,270
people who did work in the work on the

486
00:24:16,210 --> 00:24:13,940
hardware and in the machine shops and

487
00:24:19,450 --> 00:24:16,220
those kind of things and that was phased

488
00:24:24,100 --> 00:24:19,460

down almost completely out after Apollo

489
00:24:25,690 --> 00:24:24,110
so a lot of that went away the size of

490
00:24:28,650 --> 00:24:25,700
the you know the engineering

491
00:24:31,240 --> 00:24:28,660
organization didn't change significantly

492
00:24:34,900 --> 00:24:31,250
but a lot of the peripheral stuff was

493
00:24:37,630 --> 00:24:34,910
was changed but you know it to me it

494
00:24:39,520 --> 00:24:37,640
wasn't so much a trans transition

495
00:24:43,660 --> 00:24:39,530
between Apollo and something else

496
00:24:45,400 --> 00:24:43,670
because when I came here again I started

497
00:24:47,860 --> 00:24:45,410
working right away on Skylab so I was

498
00:24:52,210 --> 00:24:47,870
working on the next thing already

499
00:24:57,520 --> 00:24:52,220
and then that flowed and to shuttle

500
00:24:59,500 --> 00:24:57,530
pretty quickly we were also involved

501
00:25:02,110 --> 00:24:59,510
with the Europeans and developing Space

502
00:25:04,210 --> 00:25:02,120
Lab and I was a part of the head I spent

503
00:25:05,560 --> 00:25:04,220
some time working I had a branch by that

504
00:25:09,160 --> 00:25:05,570
time and we had several people in the

505
00:25:10,930 --> 00:25:09,170
branch you were working on that we did

506
00:25:13,960 --> 00:25:10,940
some end but a lot of independent work

507
00:25:17,050 --> 00:25:13,970
analysis on our own to check what they

508
00:25:20,760 --> 00:25:17,060
were doing so it was you know it's kind

509
00:25:23,260 --> 00:25:20,770
of a from my viewpoint it was it was a

510
00:25:25,060 --> 00:25:23,270
transfer in the engineering and the work

511
00:25:26,860 --> 00:25:25,070
I was doing and it didn't change very

512
00:25:29,470 --> 00:25:26,870
much I mean you know it's still it was

513
00:25:30,730 --> 00:25:29,480

still there the Sutton and I said like I

514
00:25:32,460 --> 00:25:30,740
said the size of the engineering

515
00:25:34,570 --> 00:25:32,470
organization didn't change significantly

516
00:25:36,250 --> 00:25:34,580
when I was director of science and

517
00:25:39,560 --> 00:25:36,260
engineering I think we had still had

518
00:25:41,600 --> 00:25:39,570
2,300 people in science and engineering

519
00:25:44,600 --> 00:25:41,610
and the sounds part of that was probably

520
00:25:50,070 --> 00:25:44,610
a hundred and fifty so most of it was

521
00:26:05,700 --> 00:25:57,870
they very quickly moved into areas that

522
00:26:11,730 --> 00:26:05,710
we did not in the kerosene locks engines

523
00:26:14,549 --> 00:26:11,740
which is what the F 1 and H 1 were we

524
00:26:16,740 --> 00:26:14,559
had we knew there were better ways to do

525
00:26:20,490 --> 00:26:16,750
this to get more efficiencies to get

526
00:26:23,639 --> 00:26:20,500
more thrust but we were afraid to do it

527
00:26:26,669 --> 00:26:23,649
because that they and they stepped into

528
00:26:33,269 --> 00:26:26,679
it that they had they developed very

529
00:26:37,320 --> 00:26:33,279
early high pressure combined-cycle locks

530
00:26:39,539 --> 00:26:37,330
rich engine blocks rich fuel what that

531
00:26:44,430 --> 00:26:39,549
is is there are sections in the engines

532
00:26:46,169 --> 00:26:44,440
where you have free oxygen you have more

533
00:26:47,669 --> 00:26:46,179
oxygen and fuel so it's a fuels not

534
00:26:49,830 --> 00:26:47,679
completely burned you have oxygen in

535
00:26:51,870 --> 00:26:49,840
those passages and of very high

536
00:26:53,879 --> 00:26:51,880
temperatures and we were always

537
00:26:55,350 --> 00:26:53,889
concerned if you had areas like that in

538
00:26:57,570 --> 00:26:55,360

an engine and you had a particle go

539
00:27:00,710 --> 00:26:57,580
through and it vertically scratched the

540
00:27:03,480 --> 00:27:00,720
surface now it's gone

541
00:27:05,039 --> 00:27:03,490
they solved that and that was one of my

542
00:27:07,649 --> 00:27:05,049
first questions to around the world as

543
00:27:12,450 --> 00:27:07,659
you saw this problem well we developed a

544
00:27:14,850 --> 00:27:12,460
coating and to go in those those oxygen

545
00:27:16,799 --> 00:27:14,860
rich areas I said well how in the world

546
00:27:20,129 --> 00:27:16,809
did you've ever verified the coating

547
00:27:21,810 --> 00:27:20,139
worked I said oh no problem said we

548
00:27:23,970 --> 00:27:21,820
started a test and we've purposefully

549
00:27:24,930 --> 00:27:23,980
injected particles through those areas

550
00:27:28,889 --> 00:27:24,940
and it didn't blow up

551
00:27:31,200 --> 00:27:28,899
therefore it work so they you know they

552
00:27:33,960 --> 00:27:31,210
they could very quickly went to a much

553
00:27:37,639 --> 00:27:33,970
more sophisticated high performance

554
00:27:41,460 --> 00:27:37,649
engine than we did actually we we did

555
00:27:44,159 --> 00:27:41,470
nothing really beyond the technology

556
00:27:46,350 --> 00:27:44,169
that we used on Saturn for that

557
00:27:48,000 --> 00:27:46,360
particular engine that we had the oxygen

558
00:27:49,830 --> 00:27:48,010
hydrogen engines were the same kind of

559
00:27:53,730 --> 00:27:49,840
engines they but they didn't have to

560
00:27:57,810 --> 00:27:53,740
worry about the LOX rich in

561
00:27:58,860 --> 00:27:57,820
but they they were very very good at

562
00:28:01,470 --> 00:27:58,870
engine developments one of the

563
00:28:03,060 --> 00:28:01,480

interesting things is when I first

564
00:28:07,019 --> 00:28:03,070
started going there they didn't want us

565
00:28:09,180 --> 00:28:07,029
to see the injectors so they would

566
00:28:12,000 --> 00:28:09,190
always have a something hanging over the

567
00:28:14,460 --> 00:28:12,010
injector but later on you know we we get

568
00:28:17,130 --> 00:28:14,470
into working below us at Pratt Whitney

569
00:28:19,169 --> 00:28:17,140
we were developing the hardly 180g

570
00:28:21,389 --> 00:28:19,179
engines they were developing it Pratt

571
00:28:23,279 --> 00:28:21,399
Whitney was paying for it but we worked

572
00:28:25,529 --> 00:28:23,289
very closely with him in that and we got

573
00:28:27,990 --> 00:28:25,539
to know everything in the engine but

574
00:28:31,889 --> 00:28:28,000
there their large engine which was the

575
00:28:35,850 --> 00:28:31,899
RT 170 the rd-180 was actually a half of

576
00:28:39,029 --> 00:28:35,860
that engine but the RT 170 rather than

577
00:28:40,980 --> 00:28:39,039
having a large combustion chamber like

578
00:28:44,639 --> 00:28:40,990
we had on the f1 it had actually had

579
00:28:47,789 --> 00:28:44,649
four nozzles for combustion chambers and

580
00:28:50,490 --> 00:28:47,799
I've always thought not never been 100%

581
00:28:52,370 --> 00:28:50,500
sure that that was one of the things

582
00:28:55,620 --> 00:28:52,380
they did to avoid the combustion

583
00:28:58,380 --> 00:28:55,630
instability problem was there was for

584
00:28:59,399 --> 00:28:58,390
having four chambers but they you know

585
00:29:02,940 --> 00:28:59,409
they were they were had very

586
00:29:04,799 --> 00:29:02,950
sophisticated engines their engineers

587
00:29:09,120 --> 00:29:04,809
were fantastic I used to work with them

588
00:29:11,880 --> 00:29:09,130

you know I just when I was going over

589
00:29:14,940 --> 00:29:11,890
there while I was with NASA they were

590
00:29:17,970 --> 00:29:14,950
telling us all about the 31 170 engine

591
00:29:21,180 --> 00:29:17,980
and all have was designed except for

592
00:29:22,830 --> 00:29:21,190
coding kind of things and I kept

593
00:29:25,200 --> 00:29:22,840
pressing and I was trying to find out

594
00:29:28,320 --> 00:29:25,210
what requirements they had used to

595
00:29:30,000 --> 00:29:28,330
develop this engine I had asked him

596
00:29:33,600 --> 00:29:30,010
numerous times what kind of safety

597
00:29:36,750 --> 00:29:33,610
factor did use and finally after two

598
00:29:40,320 --> 00:29:36,760
three days of this the guy found one of

599
00:29:42,330 --> 00:29:40,330
the guy who spoke English real well said

600
00:29:45,090 --> 00:29:42,340
look we can't tell you that said these

601
00:29:47,340 --> 00:29:45,100
are military specs that we used to

602
00:29:50,549 --> 00:29:47,350
develop this thing he said we cannot

603
00:29:51,840 --> 00:29:50,559
tell you what the safety factor is he

604
00:29:54,779 --> 00:29:51,850
said but I'm gonna come in here tomorrow

605
00:29:57,600 --> 00:29:54,789
and show you something and let you

606
00:29:59,970 --> 00:29:57,610
decide he came in the next day and

607
00:30:04,169 --> 00:29:59,980
rolled out of drawing all the way eight

608
00:30:06,299 --> 00:30:04,179
feet long that had in each lot of the

609
00:30:07,710 --> 00:30:06,309
areas of the engine they had calculated

610
00:30:11,160 --> 00:30:07,720
the safety factor

611
00:30:12,660 --> 00:30:11,170
he had written it down and you can look

612
00:30:14,190 --> 00:30:12,670
at all the safety factors she's written

613
00:30:18,570 --> 00:30:14,200

down there and I said aha

614
00:30:22,200 --> 00:30:18,580
one point for just like ours when I was

615
00:30:25,140 --> 00:30:22,210
there we had a meetings in a big

616
00:30:26,370 --> 00:30:25,150
conference room long table you know

617
00:30:28,440 --> 00:30:26,380
which sit around there and meetings with

618
00:30:31,680 --> 00:30:28,450
but it was a very big room and all the

619
00:30:33,570 --> 00:30:31,690
rest of that room was engines and the

620
00:30:37,980 --> 00:30:33,580
first thing they did the first meeting I

621
00:30:39,390 --> 00:30:37,990
had with them walked in sat down and

622
00:30:42,570 --> 00:30:39,400
they said okay we're gonna give you a

623
00:30:45,180 --> 00:30:42,580
tour of our engines and in the back

624
00:30:48,480 --> 00:30:45,190
corner the back corner where they

625
00:30:50,040 --> 00:30:48,490
started they had a v2 which is the same

626
00:30:52,800 --> 00:30:50,050
thing we started with that's what they

627
00:30:57,960 --> 00:30:52,810
started with and then they must have had

628
00:31:01,050 --> 00:30:57,970
in that room 20 or 25 different engines

629
00:31:02,580 --> 00:31:01,060
and they walked through and told them

630
00:31:04,980 --> 00:31:02,590
how the totus how the technology had

631
00:31:06,480 --> 00:31:04,990
changed as they and you know fairly

632
00:31:10,110 --> 00:31:06,490
early on they were into this

633
00:31:14,010 --> 00:31:10,120
high-pressure locks rich stage

634
00:31:17,460 --> 00:31:14,020
combustion but they had at that time

635
00:31:19,260 --> 00:31:17,470
they said they had developed I don't

636
00:31:22,050 --> 00:31:19,270
remember the exact number it was high

637
00:31:25,320 --> 00:31:22,060
50s designed and developed that many

638
00:31:27,960 --> 00:31:25,330

engines and they had put about 20

639
00:31:30,390 --> 00:31:27,970
something in serial production when I

640
00:31:33,630 --> 00:31:30,400
went to Verona SH with the LOX hydrogen

641
00:31:36,390 --> 00:31:33,640
engines found the same thing they had

642
00:31:39,810 --> 00:31:36,400
designed and developed 60 of those type

643
00:31:43,280 --> 00:31:39,820
engines and put some large number in

644
00:31:46,740 --> 00:31:43,290
serial production so you know we we were

645
00:31:49,410 --> 00:31:46,750
constrained financially we we couldn't

646
00:31:50,910 --> 00:31:49,420
just go off and and do these things they

647
00:31:53,160 --> 00:31:50,920
had all the money they needed they had

648
00:31:56,700 --> 00:31:53,170
all the people they needed you know and

649
00:31:57,920 --> 00:31:56,710
and they just did whatever came next we

650
00:32:01,020 --> 00:31:57,930
were never able to do that unfortunately

651
00:32:03,180 --> 00:32:01,030
the open checkbook allowed them to do

652
00:32:06,840 --> 00:32:03,190
what any of us would have liked to do

653
00:32:09,180 --> 00:32:06,850
which is you know you you have a v2 and

654
00:32:11,190 --> 00:32:09,190
you envision the next version of that it

655
00:32:12,660 --> 00:32:11,200
has more capability and does has

656
00:32:14,880 --> 00:32:12,670
different things and you go do that and

657
00:32:17,100 --> 00:32:14,890
you say well I could also do it this way

658
00:32:18,650 --> 00:32:17,110
I can make it improve it by that way so

659
00:32:21,180 --> 00:32:18,660
you know they were making an increment

660
00:32:24,600 --> 00:32:21,190
improvements in their technology and and

661
00:32:26,490 --> 00:32:24,610
in in their engines it's what it looked

662
00:32:28,080 --> 00:32:26,500
like to me am that you you saw that when

663
00:32:30,060 --> 00:32:28,090

they stepped around the engine and told

664
00:32:31,530 --> 00:32:30,070
you you know we did this one and then we

665
00:32:33,360 --> 00:32:31,540
did this one over here and this does

666
00:32:38,810 --> 00:32:33,370
this and this does it you could see an

667
00:32:48,440 --> 00:32:43,779
one of the legacies that that was left

668
00:32:52,999 --> 00:32:48,450
by the Apollo program - in my view one

669
00:32:55,430 --> 00:32:53,009
of them was the tremendous success that

670
00:32:59,149 --> 00:32:55,440
Marshall and NASA had with the Apollo

671
00:33:02,749 --> 00:32:59,159
program left us really in good stead

672
00:33:06,049 --> 00:33:02,759
with Congress you know if it was we had

673
00:33:10,700 --> 00:33:06,059
a NASA was looked at as a can-do

674
00:33:13,700 --> 00:33:10,710
organization we can do things and so we

675
00:33:16,580 --> 00:33:13,710
begin to get other branded Marshall and

676
00:33:17,479 --> 00:33:16,590
we branched out significantly we you

677
00:33:21,680 --> 00:33:17,489
know there were four Great observatories

678
00:33:24,710 --> 00:33:21,690
and Marshall did two of them the Hubble

679
00:33:28,190 --> 00:33:24,720
and the Chandra and as a matter of fact

680
00:33:30,169 --> 00:33:28,200
we also developed one of the primary

681
00:33:32,570 --> 00:33:30,179
experiments for the gamma ray

682
00:33:34,970 --> 00:33:32,580
Observatory the burst and transient

683
00:33:36,859 --> 00:33:34,980
source experiment which was wildly

684
00:33:39,139 --> 00:33:36,869
successful thank you I was talking to

685
00:33:41,629 --> 00:33:39,149
Jerry Fishman about that just a couple

686
00:33:44,239 --> 00:33:41,639
of weeks ago we were involved in a lot

687
00:33:47,210 --> 00:33:44,249
of things other than just launch

688
00:33:49,549 --> 00:33:47,220

vehicles and propulsion at the center

689
00:33:53,509 --> 00:33:49,559
and then of course flowed into into

690
00:33:56,899 --> 00:33:53,519
space station so what had been

691
00:34:01,149 --> 00:33:56,909
established by the Saturn program at

692
00:34:03,979 --> 00:34:01,159
Marshall not only left a legacy with

693
00:34:06,279 --> 00:34:03,989
with Congress in the outside world and

694
00:34:10,010 --> 00:34:06,289
helped us to get a lot of other things

695
00:34:13,430 --> 00:34:10,020
but the thing frankly that was most

696
00:34:17,119 --> 00:34:13,440
important to me was the legacy that was

697
00:34:20,329 --> 00:34:17,129
left in the organization their

698
00:34:24,889 --> 00:34:20,339
organizational structure the way

699
00:34:27,289 --> 00:34:24,899
engineering related to the projects and

700
00:34:31,159 --> 00:34:27,299
von Braun of course set that all up he

701
00:34:32,869 --> 00:34:31,169
set up a an organization here which was

702
00:34:34,849 --> 00:34:32,879
technically focused

703
00:34:36,919 --> 00:34:34,859
we had laboratories that were

704
00:34:38,599 --> 00:34:36,929
technically folks in avionics laboratory

705
00:34:42,169 --> 00:34:38,609
tests laboratory materials laboratory

706
00:34:45,500 --> 00:34:42,179
and propulsion vehicle engineering had a

707
00:34:48,319 --> 00:34:45,510
lot of the analytical work in it so

708
00:34:50,540 --> 00:34:48,329
there were laboratories for each and

709
00:34:52,640 --> 00:34:50,550
every major discipline and

710
00:34:55,700 --> 00:34:52,650
in laboratories and the people who

711
00:34:59,120 --> 00:34:55,710
headed those laboratories were von

712
00:35:00,830 --> 00:34:59,130
Braun's board of directors and other

713
00:35:04,130 --> 00:35:00,840

center directors all the way up through

714
00:35:05,810 --> 00:35:04,140
me it was that way I looked to the

715
00:35:08,510 --> 00:35:05,820
laboratories for their technical

716
00:35:11,060 --> 00:35:08,520
expertise we have a design review or a

717
00:35:14,000 --> 00:35:11,070
Flight Readiness review whatever it was

718
00:35:15,560 --> 00:35:14,010
those lab directors and their technical

719
00:35:17,930 --> 00:35:15,570
expertise sitting around the table

720
00:35:20,030 --> 00:35:17,940
making sure the projects were doing what

721
00:35:22,940 --> 00:35:20,040
they were supposed to do and engineering

722
00:35:25,460 --> 00:35:22,950
was independent from the projects we we

723
00:35:27,050 --> 00:35:25,470
we had loyalty to the projects we were

724
00:35:29,240 --> 00:35:27,060
the conscience of the projects but the

725
00:35:30,500 --> 00:35:29,250
projects and the projects told us a lot

726
00:35:33,920 --> 00:35:30,510
of things they wanted us to do and we

727
00:35:35,450 --> 00:35:33,930
did them but we also made independent

728
00:35:38,060 --> 00:35:35,460
decisions on what we needed to do in

729
00:35:39,980 --> 00:35:38,070
programs and there there were a lot of

730
00:35:41,870 --> 00:35:39,990
places that I saw where we made those

731
00:35:45,200 --> 00:35:41,880
independent decisions to go off and do

732
00:35:47,780 --> 00:35:45,210
something which had major impacts on the

733
00:35:50,030 --> 00:35:47,790
projects and programs so it was a

734
00:35:53,660 --> 00:35:50,040
completely different different mindset

735
00:35:56,480 --> 00:35:53,670
and and it didn't change while I was

736
00:36:01,900 --> 00:35:56,490
here and I grew up in that you know I

737
00:36:06,200 --> 00:36:04,450
associate director of engineering direct

738
00:36:09,290 --> 00:36:06,210

director of engineering and science

739
00:36:11,720 --> 00:36:09,300
deputy and center director and then

740
00:36:14,630 --> 00:36:11,730
later on director so I grew up in that

741
00:36:16,250 --> 00:36:14,640
system so it was always very comfortable

742
00:36:20,720 --> 00:36:16,260
- everybody knew what everybody was

743
00:36:23,450 --> 00:36:20,730
responsible for and and having the

744
00:36:26,660 --> 00:36:23,460
organization set up that way had one

745
00:36:29,270 --> 00:36:26,670
benefit and I think this was probably in

746
00:36:30,800 --> 00:36:29,280
von Braun's mind when he did it but all

747
00:36:33,650 --> 00:36:30,810
the technical people of a certain age

748
00:36:35,660 --> 00:36:33,660
ilk were together so they fed on each

749
00:36:37,370 --> 00:36:35,670
other they did training in ER training

750
00:36:40,670 --> 00:36:37,380
among each other and they made sure that

751
00:36:44,060 --> 00:36:40,680
they had within that group all of the

752
00:36:46,850 --> 00:36:44,070
expertise that was need to do the job it

753
00:36:50,810 --> 00:36:46,860
demonstrated a capability in this

754
00:36:54,440 --> 00:36:50,820
country to do hard things and do them

755
00:36:57,560 --> 00:36:54,450
well and that I think flowed into a lot

756
00:37:00,480 --> 00:36:57,570
of things well beyond NASA it flowed

757
00:37:05,430 --> 00:37:00,490
into military everywhere

758
00:37:10,400 --> 00:37:05,440
there there's never I'll never have seen

759
00:37:12,810 --> 00:37:10,410
anything that was proposed needed

760
00:37:15,090 --> 00:37:12,820
contemplated that we didn't think we

761
00:37:17,490 --> 00:37:15,100
could do we think this country thinks he

762
00:37:19,350 --> 00:37:17,500
can do anything and it generally can and

763
00:37:21,660 --> 00:37:19,360

I think a lot of that leg and that was

764
00:37:25,230 --> 00:37:21,670
the first really big thing we did when

765
00:37:27,740 --> 00:37:25,240
you think what except for the Manhattan

766
00:37:30,780 --> 00:37:27,750
Project of course that was great but

767
00:37:34,290 --> 00:37:30,790
that was the first big really big you

768
00:37:36,060 --> 00:37:34,300
know went in 1962 stand up and say we're