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Transcript of Colin A. Wolden, Ph.D.

Date: July 23, 2026

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Transcript of Colin A. Wolden, Ph.D.
Conducted on July 23, 2026

1 (1 to 4)

1 UNITED STATES PATENT AND TRADEMARK OFFICE 2 BEFORE THE PATENT TRIAL AND APPEAL BOARD 3 ----- 4 TOPSOE, INC., 5 Petitioner, 6 v. 7 CASALE SA, 8 Patent Owner. 9 ----- 10 IPR2025-01454 11 U.S. Patent No. 11,286,168 12 ----- 13 Videotaped Deposition of COLIN A. WOLDEN, Ph.D. 14 Denver, Colorado 15 Thursday, July 23, 2026 16 8:59 a.m. 17 18 19 20 Job No.: 642940 21 Pages: 1 - 357 22 Reported By: Lisa A. Knight, RDR, CRR, RSA	3 1 A P P E A R A N C E S 2 ON BEHALF OF THE PETITIONER: 3 SPENCER FANE 4 BY: JEFFREY J. PHILLIPS, ESQUIRE 5 3040 Post Oak Boulevard 6 Suite 1400 7 Houston, Texas 77056 8 Phone: 713.552.1234 9 E-mail: jphillips@spencerfane.com 10 ON BEHALF OF THE PATENT OWNER: 11 DORSEY & WHITNEY LLP 12 BY: CASE COLLARD, ESQUIRE 13 1400 Wewatta Street 14 Suite 400 15 Denver, Colorado 80202 16 Phone: 303.629.3400 17 E-mail: collard.case@dorsey.com 18 ALSO PRESENT: 19 DURRELL DAWSON, Videographer 20 21 22
2 1 Videotaped Deposition of COLIN A. WOLDEN, Ph.D., 2 held at: 3 4 Dorsey & Whitney 5 1400 Wewatta Street 6 Suite 400 7 Denver, Colorado 80202 8 9 Pursuant to Notice, before Lisa A. Knight, 10 Registered Diplomate Reporter, Certified Realtime 11 Reporter, Realtime Systems Administrator, and 12 Notary Public in and for the State of Colorado. 13 14 15 16 17 18 19 20 21 22	4 1 C O N T E N T S 2 EXAMINATION OF COLIN A. WOLDEN, Ph.D.: PAGE 3 BY MR. PHILLIPS 8 4 5 E X H I B I T S 6 (Attached to transcript.) 7 DEPOSITION EXHIBIT PAGE 8 Exhibit 1 Combined Cycle Schematic 197 9 Exhibit 2 Rendering/schematic of a 197 10 combined cycle gas turbine 11 Exhibit 3 Rendering/schematic of a 197 12 combined cycle gas turbine 13 Exhibit 4 Rendering/schematic of a 197 14 combined cycle gas turbine 15 Exhibit 5 Rendering/schematic of a 198 16 furnace-fired steam 17 generator 18 19 20 21 *STENOGRAPHER'S NOTE: All quotations from exhibits 22 are reflected in the manner in which they were read into the record and do not necessarily indicate an exact quote from the document.

Transcript of Colin A. Wolden, Ph.D.
Conducted on July 23, 2026

2 (5 to 8)

5				7			
1	DEPOSITION EXHIBITS			1	PROCEEDINGS		
2	(Previously Marked)			2	THE VIDEOGRAPHER: Here begins		
3	EXHIBIT	PAGE		3	Media No. 1 in the videotaped deposition of		
4	Exhibit 1001 U.S. Patent No. 11,286,168	17		4	Colin A. Wolden, Ph.D., in the matter of		
5	(Baratto et al.)			5	Topsoe, Inc., versus Casale, in the United		
6	Exhibit 1006 PowerPoint entitled Future	246		6	States Patent and Trademark Office, IPR		
7	Energy Efficiency and CO2			7	2025-01454.		
8	Reduction Potential by Svend			8	Today's date is July 23rd,		
9	Erik Nielsen (2007 IFA			9	2026. The time on the video monitor is		
10	presentation)			10	8:59 a.m.		
11	Exhibit 1008 U.S. Patent 6,809,121 (Rytter	304		11	The videographer today is		
12	et al.)			12	Durrell Dawson, representing Planet Depos,		
13	Exhibit 1010 U.S. Patent 6,505,467	327		13	headquartered at 451 Hungerford Drive,		
14	(Fjellhaug et al.)			14	Suite 400, Rockville, Maryland. This video		
15	Exhibit 1020 Declaration of Mina Ching and	297		15	deposition is taking place at 1400 Wewatta		
16	paper entitled Energy			16	Street in Denver, Colorado.		
17	Conservation Potential of the			17	Would counsel please voice		
18	Nitrogen Fertiliser Industry			18	identify themselves and state whom they		
19	by P. Lako, March 2009			19	represent.		
20	Exhibit 2005 Curriculum Vitae of Colin A.	17		20	MR. PHILLIPS: This is Jeff		
21	Wolden			21	Phillips; and I represent the petitioner,		
22				22	Topsoe, Inc.		
6				8			
1	DEPOSITION EXHIBITS			1	MR. COLLARD: Case Collard; and		
2	(Previously Marked)			2	I represent Casale, patent owner.		
3	EXHIBIT	PAGE		3	THE VIDEOGRAPHER: The court		
4	Exhibit 2007 Declaration of Colin A.	15		4	reporter today is Lisa Knight, representing		
5	Wolden, Ph.D., in Support of			5	Planet Depos.		
6	Patent Owner's Response			6	The witness will now be sworn,		
7				7	and then we may proceed.		
8				8	COLIN A. WOLDEN, Ph.D.,		
9				9	having been first duly sworn to state the whole		
10				10	truth, testified as follows:		
11				11	EXAMINATION		
12				12	BY MR. PHILLIPS:		
13				13	Q. Dr. Wolden, good morning. My		
14				14	name is Jeff Phillips. I'm here representing		
15				15	Topsoe.		
16				16	Could you please state your		
17				17	full name for the record.		
18				18	A. Colin A. Wolden.		
19				19	Q. And do you know why you're here		
20				20	today?		
21				21	A. Yes.		
22				22	Q. Why are you here today?		

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Page 3 of 147

Conducted on July 23, 2026

9 1 A. I am here as the expert witness 2 on behalf of Casale in this case. 3 Q. Dr. Wolden, have you ever been 4 deposed before? 5 A. I have not. 6 Q. Okay. So I'm going to give you 7 a few ground rules. 8 A. Sure. 9 Q. Mr. Collard has probably 10 already told you this. So I will be asking you 11 questions. Your attorney, Mr. Collard, will be 12 making objections on the record. 13 The court reporter is typing 14 everything we say, so it's really important 15 that you don't talk over me and I don't talk 16 over you, because she has -- she can only do so 17 much. 18 If you don't understand any of 19 my questions or if I use the wrong language or 20 if it's just wrong, let me know. I'll clarify. 21 I want to make sure -- I'm not here trying to 22 trick you. I'm just trying to get a clear	11 1 A. That is correct. 2 Q. Have you ever testified at 3 trial in any cases? 4 A. No, I haven't. 5 Q. Are you being compensated for 6 your testimony -- 7 A. Yes, I am. 8 Q. -- in this case? 9 What's your hourly rate? 10 A. \$300 an hour for this case. 11 Q. Do you have any idea of how 12 much you've been paid to date on this IPR? 13 A. I can't -- probably on the 14 order of \$10,000, but I'd have to look up the 15 exact hours and do the math backwards. 16 Q. Have you been engaged by Casale 17 for any other work prior to this IPR matter? 18 A. No. 19 Q. You may or may not know, Casale 20 and Topsoe are involved in a pending patent 21 litigation in the Southern District of Texas. 22 Have you been retained by
10 1 record of your opinions today. 2 We will take a break 3 approximately every 45 minutes to an hour. 4 However, if you need a break -- a restroom 5 break, a water break -- let me know. 6 A. Okay. 7 Q. I only ask that we finish 8 whatever question is pending, and then we can 9 go off the record. 10 We'll probably take a lunch 11 break in a couple of hours or whatever seems 12 right. 13 Anyway, that's all I have. Do 14 you have any questions? 15 A. No. 16 Q. Good. 17 Are there any reasons that you 18 can't provide complete and truthful testimony 19 here today? 20 A. None. 21 Q. So you said you have not been 22 deposed in any prior cases. Is that right?	12 1 Casale as an expert in that case? 2 A. I've been retained by Dorsey & 3 Whitney on Casale's behalf, but I have no 4 direct relationship with Casale. 5 Q. So what have you done to 6 prepare for your deposition today? 7 A. I've spent a lot of time 8 reviewing the petitions; my disclosures; your 9 expert, Ritter's, disclosures; of course, the 10 '168 patent; and, you know, the 2007 IFA, and 11 all the related patents. 12 Q. So when you say "all the 13 related patents," does that include the Rytter 14 patent? 15 A. Yes, it does. 16 Q. And the Licht patent? 17 A. Licht, Terrien. Yeah. 18 Q. Fjellhaug? 19 A. Yes. 20 Q. Price? 21 A. Yep. 22 Q. I think you came in with a copy

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Page 4 of 147

Conducted on July 23, 2026

13 1 of your expert report. 2 Do you have any notes in that 3 or is that a clean copy? 4 A. No, that is clean copy provided 5 by the attorney. 6 Q. Did you review any of the other 7 exhibits accompanying Dr. Ritter's declaration? 8 A. Yes, over the course of this 9 experience. 10 Q. Did you review any of the 11 exhibits in preparation for your deposition 12 today? 13 A. I would say I focused mostly on 14 the patents and the petitions that are most 15 germane. 16 Q. You said you've been retained 17 by Dorsey & Whitney for the co-pending 18 litigation between Topsoe and Casale. 19 Have you reviewed any of the 20 prior art cited by Topsoe in that litigation? 21 A. Prior art? Could you clarify? 22 Is that different than what's	15 1 A. No. 2 Q. Approximately how long would 3 you say you prepared for today's deposition? 4 A. I mean, are you talking about 5 specifically this deposition or my time since 6 I started working on this case? 7 Q. Just this deposition. 8 A. Just this deposition? Probably 9 about 20 hours. 10 Q. I'm going to hand you a few 11 references -- 12 A. Sure. 13 Q. -- just to have in front of 14 you. 15 One of them you said you 16 already have. It's Exhibit 2007. 17 (Previously marked 18 Patent Owner Exhibit 2007 was 19 tendered to the witness.) 20 Q. Is that the one that's in front 21 of you? This is a copy your declaration? 22 A. Yep, this is -- yeah,
14 1 been disclosed in this IPR case? 2 Q. Sure. Let me take a step back. 3 So in that litigation, Topsoe 4 has provided invalidity contentions to Casale. 5 And with it, they've also provided new prior 6 art, mostly in the form of Topsoe process-flow 7 diagrams. 8 I was just wondering if you've 9 seen any of those. 10 A. I have not seen anything. I've 11 just seen the material that's with respect to 12 this IPR. 13 Q. Are there any people that you 14 talked to to prepare for this deposition? 15 A. Not really, no; outside of, of 16 course, the counsel reiterated -- you know, 17 I had several conversations with various 18 members of Dorsey & Whitney's team. 19 Q. Anybody at Casale? 20 A. No. 21 Q. Did you consult anybody about 22 the technology involved in the '168 patent?	16 1 Exhibit 2007, my declaration. Yes. 2 Q. So the Declaration of Colin A. 3 Wolden, Ph.D., in Support of Patent Owner's 4 Response? 5 A. Yep. 6 Q. So you already have that in 7 front of you. 8 I'm also going to give you -- 9 MR. COLLARD: Jeffrey, do you 10 want to mark that as Exhibit 1 or -- 11 MR. PHILLIPS: I'm going to use 12 the exhibit numbers from the IPR. I have a few 13 other exhibits. I'm going to start with 1. 14 MR. COLLARD: That's fine. 15 However you want to do it. 16 MR. PHILLIPS: Yeah, we're just 17 going to stick with these numbers, if that's 18 okay. 19 (A discussion was had off 20 the stenographic record.) 21 BY MR. PHILLIPS: 22 Q. All right. I'm going to hand

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Page 5 of 147

Conducted on July 23, 2026

17 1 you what's been marked as Exhibit 2005. This 2 is a copy of your CV. 3 A. Oh, yeah, sure. 4 (Previously marked Patent 5 Owner Exhibit 2005 was tendered 6 to the witness.) 7 Q. Do you recognize that? 8 A. Yes, I do. 9 Q. And I'm going to hand you a 10 copy -- this is Exhibit 1001. This is a copy 11 of U.S. Patent No. 11,286,168. This is the 12 Casale patent that's at issue in this case. 13 A. Yep. 14 (Previously marked Topsoe, 15 Inc. - Exhibit 1001 was tendered 16 to the witness.) 17 Q. Okay. I gave you these three 18 references because this is what we're going to 19 talk about for most of the first hour. 20 A. Sure. 21 Q. So let's start by discussing 22 your professional background.	19 1 One, I redesigned a column that 2 produced -- that refines salicylic acid, which 3 is a precursor to aspirin. 4 A little problem with it. 5 There's little dioxins, which no one wants in 6 their aspirin. So we redesigned the column to 7 eliminate the dioxins. 8 The other was a little more 9 boring. It was just they had a combustion 10 furnace that was designed to -- you know, to 11 destroy harmful pollutants from the chemical 12 plant. 13 And they had a problem that the 14 combustion furnace kept going out. And we 15 found out that was due to putting water in the 16 tank. Water puts out fires, it turns out. 17 So that was just a problem we 18 solved for them. 19 Q. Was it a furnace for treating 20 flue gases? 21 A. It was a furnace for treating a 22 lot of waste from various -- it's a huge
18 1 I see you have a Bachelor of 2 Science in Chemical Engineering from the 3 University of Minnesota. Is that right? 4 A. That is correct. 5 Q. And you have a Master's in 6 Chemical Engineering from MIT. 7 What was your research focus 8 during your master's program? 9 A. So that is a special master's 10 program at MIT called the School of Practice -- 11 School of Chemical Engineering Practice, where 12 in lieu of a conventional thesis, what we did 13 is industrial research. 14 I personally spent my time at 15 Dow Chemical and Merck Pharmaceutical doing 16 work on industrial projects. 17 Q. You said Dow and Merck? 18 A. Yep. 19 Q. So what were you doing for Dow? 20 A. They had us -- we were on 21 one-month projects. I was on two of them 22 there. This is quite a ways back.	20 1 integrated plant, and there's multiple things 2 going in at various times. 3 Q. Was this Dow down in Freeport, 4 Texas? 5 A. No. This is Midland. This is 6 in Midland. 7 Q. Midland? 8 A. Yeah. 9 Q. And then you had mentioned 10 Merck as well. 11 What did you do for Merck? 12 A. So that's their pharmaceutical 13 company. One of the projects was a fluidized 14 bed. 15 So, for example, your drugs are 16 coated with protective coatings for time 17 release. And they were drying in a fluidized 18 bed, which broke that coating. And so we had 19 to revamp that. 20 And I can't actually remember 21 what the other project was. It was something, 22 again, with the production of pharmaceuticals.

Conducted on July 23, 2026

21 1 Q. So how long -- so you said this 2 wasn't a traditional master's program? 3 A. Right. 4 Q. So were you doing these 5 projects over the course of one year? 6 A. No. This is the -- the 7 industrial projects were over a four-month 8 period, and then you'd take about a year's 9 worth of coursework at MIT is approximately how 10 the degree was done. 11 Q. Your CV also says you have a 12 Ph.D. in Chemical Engineering. 13 A. That's correct. 14 Q. From MIT? 15 A. That's correct. 16 Q. I assume you had a research 17 focus during your Ph.D. program? 18 A. Um-hmm. 19 Q. Can you talk about that a 20 little bit? 21 A. Sure. 22 I did my -- my thesis was on	23 1 on energy and materials and processes therein. 2 I work a lot with ammonia; hydrogen fusion 3 process, which is essentially hydrogen 4 processes; as well, some others. 5 Q. What do you do in the ammonia 6 space? 7 A. We work primarily on ammonia 8 utilization. At present, we've done work on 9 ammonia synthesis, ammonia purification. But 10 the current emphasis is turning ammonia into 11 basically drop-in substitutes for conventional 12 hydrocarbon fuels; and that's by creating these 13 ammonia-hydrogen mixtures. 14 Q. So you're starting with 15 ammonia, and you're working from ammonia 16 working toward fuel. Is that accurate? 17 A. That is -- for that project, 18 yes. 19 Q. And I'll ask you in a second. 20 I notice you have some patents and patent 21 applications. 22 A. Sure.
22 1 the kinetics of chemical vapor deposition of 2 diamond-thin films; and explored it using 3 various techniques such as hot filament, 4 combustion synthesis. Different ways of making 5 diamond-thin films. 6 Q. Were you working in conjunction 7 with industry on that or were you working with 8 a professor at MIT? 9 A. That was a professor -- a 10 couple of professors on it. It was an 11 NSF-sponsored project. National Science 12 Foundation. 13 Q. You are currently a professor 14 at the Colorado School of Mines; is that right? 15 A. That's correct. 16 Q. And you've been there since, it 17 looks like, 1997? 18 A. A very long time, yes. 19 Q. What is your -- what would you 20 say your research focus is today at the 21 Colorado School of Mines? 22 A. In general, it's on -- broadly,	24 1 Q. It seems like it's in that 2 area? 3 A. Sure. 4 Q. You mentioned you have some 5 involvement with hydrogen processing as well? 6 A. Yes. 7 Q. Can you describe that? 8 A. Predominantly my work is 9 developing membranes in catalytic membrane 10 reactors for hydrogen production. 11 So we do, for example, steam 12 reforming of methanol and methane as another 13 project to produce the hydrogen. 14 And then we also -- using these 15 -- membranes are a very common purification 16 technique for hydrogen, so extracting hydrogen 17 from a mixture of our gases. So we use -- we 18 develop membrane technologies for that -- for 19 those purposes. 20 Q. Is this similar to, like, 21 pressure swing absorption? 22 A. It's different.

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Page 7 of 147

Conducted on July 23, 2026

25 1 So in pressure swing 2 absorptions, an absorption-based process, 3 membranes is a separation process where the 4 membrane selectively removes one component 5 relative to the others. 6 Q. So in this case, does this 7 allow the hydrogen to pass through at pressure, 8 or is this one where the hydrogen gets lower 9 pressure and then the remaining syngas stays at 10 high pressure? 11 A. Yeah, the technologies I work 12 on, the hydrogen preferentially passes through 13 the membrane and the other species are 14 rejected. 15 Q. So you've been at the Colorado 16 School of Mines since 1997. 17 Have you had any other research 18 focus other than those? 19 A. Yeah. I mean, I'm a chemical 20 engineer, and we work on a diversity of 21 projects. 22 I've done a lot of work in	27 1 Q. Do you teach that class as 2 well? 3 A. I have. 4 Q. Is it two classes there? 5 A. We do it very uniquely. We do 6 it in a condensed summer course, like an 7 intensive six-week. That's all you do, is unit 8 operations for six weeks. And that's kind of a 9 unique feature of our curriculum, but that's 10 how we do it. 11 Q. So does your curriculum have 12 a -- and, again, I don't know what you guys 13 call it -- for lack of a better term, a plant 14 design? 15 A. Yeah. 16 Q. A class so maybe your seniors 17 that are about to graduate, it's like a 18 capstone-type class? 19 Do y'all do something like 20 that? 21 A. Yeah. We have a senior design 22 -- yeah, it's a senior-level capstone course.
26 1 plasma processing, microelectronics, solar 2 cells, solid-state batteries, electrochromics, 3 as well as the ones that I've talked about 4 there are more the current focus. 5 Q. Do you teach undergraduate 6 classes at the Colorado School of Mines? 7 A. I do. 8 Q. Which classes do you teach? 9 A. I've probably taught almost 10 everything in the curriculum. I primarily 11 teach in the area of reactor design, kinetics, 12 and transport phenomena, which are things like 13 fluid mechanics, heat transfer, mass and energy 14 balances. 15 Q. Do you teach -- okay. 16 So I went to the University of 17 Texas for chemical engineering. We had a unit 18 operations. 19 A. Sure. 20 Q. We had two of them, one and 21 two. 22 A. Yeah.	28 1 Q. So how does that work? 2 Do students work in teams? 3 A. Typically. Both in unit 4 operations and the capstone design, they work 5 in teams. 6 Q. Do y'all -- do you teach a 7 process optimization course? 8 A. We have a process control 9 course that's part of the required curriculum. 10 And we have a number of process -- yeah, 11 process optimization-type electives. They're 12 not part of the core curriculum, but they're in 13 the curriculum. 14 Q. I guess I should have asked 15 this before. 16 The plant design class, I'm 17 assuming your students are simulating plants 18 using -- I don't know what the current tools 19 are. I guess at the time it was HYSYS and 20 Aspen and PRO/II. I don't know what today's 21 modern tools are. 22 A. I mean, those are still all

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Page 8 of 147

Conducted on July 23, 2026

29 1 used. We primarily use Aspen at Colorado 2 School of Mines. 3 Q. Do the students learn how to 4 use that in a different course other than the 5 plant design course? 6 A. Yeah, they use -- it's 7 throughout the curriculum. They use 8 different -- Aspen is, of course, a very huge 9 program that you can use for lots of different 10 things. And they encounter it in multiple 11 courses. 12 Q. Do you teach an environmental 13 engineering course? 14 A. I do not. 15 There, of course, are 16 environmental engineering courses at Colorado 17 School of Mines. Those are mostly in -- we 18 have a separate civil and environmental 19 engineering department, and that's where most 20 of that coursework is housed. 21 Q. So your students in the plant 22 design class, I mean, are they expected to deal	31 1 So it really depends on what 2 projects are solicited from the community and 3 alumni and partners. 4 Q. You actually jumped to one of 5 my questions. I was going to ask if steam 6 methane reforming is a topic. 7 A. It certainly has been. 8 I've used an example in reactor 9 engineering every time I've taught the course 10 because it's a classic. It's one of ammonia 11 synthesis in steam reforming, water-gas shift. 12 Those are kind of the heartbeat of chemical 13 engineering processes. 14 Q. You mentioned ammonia 15 synthesis. 16 What about methanol synthesis? 17 A. Methanol, sure. 18 Q. Hydrogen production? 19 A. Sure. 20 Q. I mean, we're going to get into 21 this a little bit later, but, I mean, they have 22 a very similar -- many of these have similar --
30 1 with things like emissions -- 2 A. Certainly -- 3 Q. -- as part of their project? 4 A. Certainly it's -- energy 5 balances, emissions. That's all part of it, 6 typically. 7 As you know, it probably 8 depends on which project they're working on 9 what the emphasis is. 10 Q. What types of projects do you 11 guys give the students to design? 12 A. You know, that is highly 13 variable because these are -- the way it works 14 at Colorado School of Mines is we -- these are 15 industry-supplied courses, and there's -- 16 topics, if you will. 17 And a group will work with an 18 industry mentor. And these topics of -- you 19 know, they've ranged the gamut from steam 20 reforming to growing -- what was it? -- fake 21 meat -- not fake meat -- biological meat -- the 22 Impossible Burger. Sorry.	32 1 it's probably a bad term. He's going to object 2 to "similar." But they have front ends to them 3 that start with steam methane reforming. 4 Would you agree with that? 5 MR. COLLARD: Object to form. 6 A. Methanol sometimes using steam 7 reforming; sometimes it doesn't. 8 BY MR. PHILLIPS: 9 Q. Okay. You had mentioned your 10 work for Dow and Merck. 11 I believe your CV also said 12 that you did work for 3M -- 13 A. Yep. 14 Q. -- in the past? 15 A. Yep. 16 Q. What was the context of that 17 work? And what did you do for them? 18 A. I was -- as you know, they make 19 things like Post-it pads. And I ran a slack 20 coder that put the adhesive on various 21 materials to stick or to not stick to things. 22 So developing those coating --

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Page 9 of 147

Conducted on July 23, 2026

33 1 polymer-coating processes, I guess, would be 2 the best description of it. 3 Q. So where was this along your 4 professional road? 5 A. That was early. That was -- 6 I was an intern while I was an undergraduate. 7 That was in the summer between my 8 undergraduate years at the University of 9 Minnesota. 10 3M is located right in 11 St. Paul. It was at the corporate research 12 center right outside of the Twin Cities. 13 Q. Yeah, I didn't ask that 14 question. 15 When you were an undergrad, did 16 you do any -- I mean, this was obviously one 17 summer internship. Did you do any co-op 18 programs or anything like that? 19 A. No, I didn't. I did a lot of 20 undergraduate research. 21 Q. So your work for 3M, Dow, and 22 Merck, did you ever work in the operating	35 1 A. Not a commercial synthesis 2 plant, no. 3 Q. So you say "not a commercial 4 plant." 5 A. So we've designed and built 6 laboratory-scale systems in my lab to make 7 synthesis and alternative ways to -- you know, 8 that would be hopefully more cost competitive 9 of what the commercial size. But I have not 10 done work that, say, Casale would do. 11 Q. So would you say this is more 12 bench scale or lab scale? 13 A. Yes. 14 Q. Like a pilot unit or smaller 15 than that? 16 A. Smaller than that. Maybe pilot 17 at the biggest, but... 18 Q. So do you have any experience 19 in designing, commissioning, or operating a 20 commercial plant involving the steam methane -- 21 or the steam reforming of natural gas? 22 A. Again, my experience is --
34 1 facilities? 2 A. Yes; at Dow, I did. The other 3 places, I was more in the -- I would say the 4 corporate research and not the plant, if you 5 will. I was very much in the plant at Dow. 6 Q. And this was in Midland? 7 A. That's correct. 8 Q. How long would you say your 9 work -- 10 A. Sorry. Sorry to interrupt. 11 I also worked -- I can't 12 remember the company -- between San Diego, 13 I worked in a plant making xanthan gum out of 14 San Diego, between Minnesota and MIT, which was 15 also plant experience. 16 I don't know if that's on my 17 CV. 18 Q. Have you ever done any work -- 19 strike that. 20 Do you have any experience in 21 designing, commissioning, or operating a 22 commercial ammonia synthesis plant?	36 1 I have done those processes at the lab scale 2 and the bench scale, but not at a commercial 3 scale. 4 Q. Do you -- has any of your work 5 that you've done to date involve what I'm going 6 to refer to as "off sites and utilities"? 7 Do you know what I mean by that 8 term? 9 A. Could you define it, please? 10 MR. COLLARD: Object to form. 11 THE DEPONENT: I'm sorry. 12 MR. COLLARD: Go ahead. 13 MR. PHILLIPS: Sure. 14 MR. COLLARD: I think you're 15 clarifying it. 16 BY MR. PHILLIPS: 17 Q. Again, I'm not trying to trick 18 you on this. 19 So "off-sites and utilities," 20 I guess I'm referring to steam generation, 21 power generation, cooling water. Any of those 22 areas.

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Page 10 of 147

Conducted on July 23, 2026

37 1 MR. COLLARD: Hold on. 2 Can you re-ask the question, 3 now that you've defined it, just so we have a 4 clear record? 5 MR. PHILLIPS: Sure. 6 BY MR. PHILLIPS: 7 Q. I was just wondering if any of 8 your prior work to date has involved what I'm 9 going to refer to as "off sites and utilities," 10 as I've defined it. 11 MR. COLLARD: Object to form. 12 Go ahead. 13 A. Not that I would describe, no. 14 BY MR. PHILLIPS: 15 Q. Do you have any experience 16 with designing, commissioning, or operating 17 equipment for steam generation? 18 A. Again, at the lab scale. 19 So, for example, we do steam 20 reforming, methanol reforming in my lab. And 21 part of that involves -- yes, we have steam 22 generators, again, at the lab scale. That's	39 1 many -- it's typically an absorption process. 2 BY MR. PHILLIPS: 3 Q. What's your understanding of 4 precombustion CO2 removal? 5 A. Precombustion is where you 6 reform the fuels and extract the CO2 before you 7 burn them. So there's no CO2 in the emissions. 8 The CO2 is taken out prior to the combustion 9 step. 10 Q. So you're going to be burning 11 something other than natural gas, for example? 12 MR. COLLARD: Object to form. 13 A. You will burn something that 14 has been reformed from a fuel, whatever that 15 is. It's not necessarily natural gas. It 16 could be other -- it could be coal. It could 17 be other types of fuels. 18 BY MR. PHILLIPS: 19 Q. So in this case, the '168 20 patent, would you characterize the burning of 21 CO2-depleted syngas as a type of precombustion 22 CO2 removal?
38 1 part of what we designed and built. 2 Q. Do you have any experience with 3 designing, commissioning, or operating 4 equipment for the cogeneration of steam and 5 power? 6 A. I have never worked on power. 7 Power is -- yeah, is not part of what I do in 8 my lab. We just do the chemical processing, if 9 you will. 10 Q. Are you familiar with the terms 11 post-combustion CO2 removal and precombustion 12 CO2 removal? 13 A. Yes, I am. 14 Q. What is post-combustion CO2 15 removal? 16 A. Typically, post-combustion CO2 17 removal is when you extract CO2 from the flue 18 gases after the combustion process. 19 Q. So that's some sort of 20 scrubber? 21 MR. COLLARD: Object to form. 22 A. It's typically -- there can be	40 1 MR. COLLARD: Object to form. 2 A. It is not, in the conventional 3 sense; but it is just -- you're burning 4 hydrogen, so there's no CO2 emissions. 5 BY MR. PHILLIPS: 6 Q. I'm going to look at your 7 declaration, Exhibit 2007. 8 A. Sure. 9 Q. And I want to direct you to 10 paragraphs 47 through 52. 11 A. 47. Yep. I'm at 47. So, 12 yeah. 13 Q. So let's go to specifically, 14 I guess, paragraph 52, which is the last 15 paragraph in that section. 16 So this section of your 17 declaration deals with the level of ordinary 18 skill in the art. 19 Do you see that? 20 A. Yep. 21 Q. So you state in paragraph 52 22 that you've accepted Dr. Ritter's conclusions

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Page 11 of 147

Conducted on July 23, 2026

41 1 about the level of skill in the art. 2 Do you see that? 3 A. I do. 4 Q. Under Dr. Ritter's definition, 5 you agree, then, that a POSA must have industry 6 experience in syngas production, including 7 reforming, shift, and purification. 8 Correct? 9 A. Correct. 10 And I would also note that he 11 says that the definition is approximate, and 12 that more education may substitute for industry 13 experience or vice versa. 14 Q. So when he talks about 15 reforming, shift, and purification, I just want 16 to be clear: that includes steam reforming? 17 A. Yes. 18 Q. Does that include prereformers? 19 A. Yes. 20 Q. ATRs? 21 A. Sure. 22 Q. Water-gas shift conversion?	43 1 BY MR. PHILLIPS: 2 Q. So those unit operations -- 3 steam reforming, prereforming, ATR, water-gas 4 shift, and CO2 removal -- those front-end 5 operations are also common to other back-end 6 chemical production technologies. Right? 7 MR. COLLARD: Object to form. 8 BY MR. PHILLIPS: 9 Q. So, like, methanol production, 10 for example. 11 MR. COLLARD: Okay. Object to 12 form. Also now compound. 13 A. They -- so other things like 14 methanol involve reforming processes. But 15 oftentimes the exact processes and the 16 standards can be quite different between, say, 17 methanol and the requirements, say, for a 18 methanol plant versus the requirements for an 19 ammonia plant. 20 BY MR. PHILLIPS: 21 Q. What may be different for a 22 methanol plant, in terms of requirements?
42 1 A. That's correct. 2 Q. CO2 removal? 3 A. Yep. 4 Q. These are all unit operations 5 that a POSA would understand in the context of 6 the '168 patent; correct? 7 A. That is correct. 8 MR. COLLARD: Object to form, 9 on the last question. 10 BY MR. PHILLIPS: 11 Q. Do you understand if I refer to 12 those particular operations as the front end of 13 an ammonia synthesis plant? 14 A. Yes. They're typically 15 considered the hydrogen production that 16 precedes the ammonia synthesis loop. 17 Q. And then would you consider the 18 ammonia synthesis loop to be the back end of 19 the process? 20 A. Of an ammonia synthesis plant, 21 yes. 22 MR. COLLARD: Object to form.	44 1 MR. COLLARD: Object to form. 2 A. For example, in a methanol 3 plant, oftentimes they don't even employ a 4 water-gas shift reaction. What comes off the 5 reformer can go directly in the plant. 6 In the case of ammonia, you 7 require a much higher quality of hydrogen 8 coming off. It requires things like 9 methanation to remove the CO; where, of course, 10 the CO is actually a feedstock for methanol. 11 So there are significant differences. 12 And you have to have a much 13 higher quality front-end plant, if you will, 14 for hydrogen than you do for methanol. 15 BY MR. PHILLIPS: 16 Q. Isn't it true that in a 17 methanol plant, there's a target hydrogen-to-CO 18 ratio for the back end of the methanol plant? 19 MR. COLLARD: Object to form. 20 A. You know, it depends wildly on 21 what specific catalyst is used. 22 But, yes, there's -- of course,

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Page 12 of 147

Conducted on July 23, 2026

45 1 for any process, there's an optimum feed gas, 2 in terms of – in the case of methanol, it's 3 often CO, CO2, hydrogen. And depending on the 4 exact process, yeah, there's an optimal ratio 5 of those species that are desired for the 6 synthesis loop. 7 BY MR. PHILLIPS: 8 Q. So after the steam reforming, 9 you may have to include unit operations to 10 adjust that ratio in order to -- for an optimal 11 feed to the methanol back end. Is that right? 12 MR. COLLARD: Object to form. 13 A. It depends. 14 In some cases, they do; in some 15 cases, they don't. 16 In some cases, they just put 17 the -- what comes off the reformers directly 18 into the methanol plant. 19 BY MR. PHILLIPS: 20 Q. Would you say there are similar 21 considerations for Fischer-Tropsch, or gas-to- 22 liquids back-end processes?	47 1 BY MR. PHILLIPS: 2 Q. So would a POSA understand how 3 to adjust that ratio? 4 MR. COLLARD: Object to form. 5 BY MR. PHILLIPS: 6 Q. Do you understand that 7 question? 8 A. Yes. 9 So you're trying to -- would a 10 person understand how to adjust the 11 hydrogen-to-carbon ratio? 12 Q. Would a person of ordinary 13 skill in the art? 14 A. Yes, there's actually a number 15 of different pathways that could be done. 16 But, yes, there would be 17 different approaches you could use. A POSA 18 would know how to -- know what different 19 processes could be done. 20 Q. What are some of those 21 pathways? 22 A. For one --
46 1 MR. COLLARD: Object to form. 2 You can -- 3 THE DEPONENT: Sorry. 4 A. Could you clarify -- 5 MR. COLLARD: You can answer if 6 you can, yeah. 7 A. Yeah, I would just ask you to 8 clarify or restate the question. 9 BY MR. PHILLIPS: 10 Q. Well, we were talking about 11 with respect to methanol needing an optimal 12 hydrogen-to-carbon ratio. 13 Is that also applied to 14 Fischer-Tropsch processes? 15 MR. COLLARD: Object to form. 16 A. Yes, Fischer-Tropsch processes 17 require a -- you know, if we're depending on, 18 again, the catalyst and the specific process 19 and the specific products being made, there's 20 an optimal reactant ratio that you would supply 21 to a Fischer-Tropsch process. 22 ///	48 1 MR. COLLARD: Sorry. 2 Object to form. 3 Go ahead. 4 You don't have to clarify if 5 you don't want to, but I don't know if we're 6 talking specifically about this Fischer-Tropsch 7 process or something else. That's my 8 objection. 9 But go ahead and answer, if you 10 can. 11 A. Yeah, again, this would be very 12 -- the answer would be very specific if you're 13 doing Fischer-Tropsch for methanol or whatever. 14 I mean, what's very, again, 15 I think important to highlight is how different 16 ammonia is from that. Carbon is not part of 17 the synthesis loop in ammonia, where it is a 18 key -- it's obviously what's used in 19 Fischer-Tropsch, their methanol synthesis. 20 So that hydrogen-carbon ratio, 21 which is very important in those processes, is 22 not part of an ammonia synthesis process.

Conducted on July 23, 2026

49 1 With respect to how you would 2 change that hydrogen-to-carbon ratio, one 3 possible way would be how you operate your 4 reforming step. Another possible way is to use 5 water-gas shifts and further shift the mixture 6 in one case. 7 Again, you can purify a 8 hydrogen and add it in or you could add CO₂ or 9 you could add all these gases from different 10 processes. 11 Again, these are very complex 12 processes, and it would really depend on what 13 resources are available locally and what's 14 being desired to produce. 15 BY MR. PHILLIPS: 16 Q. And a person of ordinary skill 17 in the art has these tools in their toolbox; is 18 that right? 19 MR. COLLARD: Object to form. 20 A. A person of ordinary skill in 21 the art is familiar with these processes and 22 would have to do an evaluation of how best to	51 1 other direction to convert CO₂ to CO? 2 Is that correct? 3 MR. COLLARD: Object to form. 4 A. I mean, Fischer-Tropsch is a 5 synthesis process. That's where you supply a 6 hydrogen and CO to build higher hydrocarbons. 7 Water-gas shift isn't part of 8 Fischer-Tropsch. It might be an ancillary part 9 of the plant, but it's not part of the 10 Fischer-Tropsch process. 11 BY MR. PHILLIPS: 12 Q. That's exactly what I was 13 saying. And maybe I was unclear, so let me 14 back up. 15 The water-gas shift reaction is 16 an equilibrium reaction, isn't it? 17 MR. COLLARD: Object to form. 18 A. Under typical conditions, the 19 water-gas shift is equilibrium limited. 20 BY MR. PHILLIPS: 21 Q. And so for a Fischer-Tropsch 22 process, you're interested in hydrogen and CO
50 1 optimize or achieve the desired goal. 2 BY MR. PHILLIPS: 3 Q. So let me pick on water-gas 4 shift, for example. 5 A. Sure. 6 Q. I think you said earlier, in 7 the ammonia process, the water-gas shift would 8 be driven to convert CO to CO₂? 9 Is that correct? 10 MR. COLLARD: Object to form. 11 A. That is correct. 12 In the water-gas shift, 13 especially for ammonia production, they often 14 will have multiple water-gas shift reactors to 15 drive all the CO to CO₂ and consequently make 16 more hydrogen, because you need all the 17 hydrogen that you can get. And the CO is a 18 poison for ammonia synthesis. 19 BY MR. PHILLIPS: 20 Q. So isn't it true, then, in 21 Fischer-Tropsch processes, the equilibrium of 22 the water-gas shift would be directed in the	52 1 feed; correct? 2 MR. COLLARD: Object to form. 3 A. Generically, Fischer-Tropsch 4 uses CO and H₂ as an input. That's the primary 5 input to a Fischer-Tropsch process. 6 BY MR. PHILLIPS: 7 Q. So in terms of, again, the 8 front-end unit operations, you would use 9 water-gas shift reaction to convert CO₂ to CO? 10 MR. COLLARD: Object to form. 11 BY MR. PHILLIPS: 12 Q. Is that right? 13 A. Typically, you probably would 14 not use the water-gas shift. You would just do 15 the reforming, which turns methane into a 16 mixture of CO and H₂, and just use that as it 17 is. Typically. 18 BY MR. PHILLIPS: 19 Q. But after reforming, you would 20 have CO₂ as well in that syngas stream; 21 correct? 22 MR. COLLARD: Object to form.

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Page 14 of 147

Conducted on July 23, 2026

53 1 A. There would likely be a little 2 bit of CO2, but it's a minor component after 3 just the reforming step. It's primarily CO and 4 H2. 5 BY MR. PHILLIPS: 6 Q. So you'd agree with me, then, 7 that a POSA would be familiar with how to apply 8 these front-end unit operations to the various 9 back-end production processes? 10 MR. COLLARD: Object to form. 11 A. Again, these are very complex 12 and quite different processes: ammonia and 13 methanol and Fischer-Tropsch. 14 So to be an expert in one 15 doesn't necessarily mean that you would be 16 equipped to know the individual vagaries of 17 the different processes. 18 BY MR. PHILLIPS: 19 Q. So I wasn't -- 20 A. You'd have a general but not 21 necessarily a specific understanding, I would 22 say.	55 1 actually. 2 THE DEPONENT: What's that? 3 MR. COLLARD: Sorry. And 4 scope, I said. But go ahead. 5 THE DEPONENT: Sorry. I didn't 6 mean to talk over you. 7 A. Yes. They work in various 8 technologies beyond ammonia, yes. 9 BY MR. PHILLIPS: 10 Q. In paragraph 49 of your 11 declaration -- sorry. That's not the right 12 paragraph. Hang on a second. 13 (Pause.) 14 In paragraph 50 of your 15 declaration, you provide your own definition 16 for a POSA. 17 Do you see that? 18 A. Yep. 19 Q. You stated that a POSA would 20 have a Bachelor of Science in Chemical 21 Engineering plus two years' experience working 22 with ammonia production systems or an advanced
54 1 Q. And I wasn't speaking to the 2 actual ammonia or Fischer-Tropsch or methanol 3 processes. I was really focusing more on the 4 steam, methane, reforming, water-gas shift, 5 hydrogen, and CO2 removal steps. 6 Would a person of ordinary 7 skill in the art be knowledgeable as to those 8 steps in order to provide the feedstock 9 necessary for the various back-end processes? 10 MR. COLLARD: Object to form. 11 A. A POSA, working in reforming, 12 would be very familiar with the different 13 reforming technologies in water-gas shift. 14 BY MR. PHILLIPS: 15 Q. And, in fact, the engineers at 16 Casale and the engineers at Topsoe have 17 technologies in ammonia production, hydrogen 18 production, methanol production as well. 19 Right? 20 MR. COLLARD: Object to form. 21 A. Those companies -- 22 MR. COLLARD: And scope,	56 1 degree in chemical engineering. 2 Is that accurate? 3 A. Yes, that's what it says. 4 Q. And you state that "This skill 5 level reflects familiarity with ammonia 6 production systems and emissions reduction 7 processes." 8 Do you see that? 9 A. Yes. 10 Q. Here's my question: Are you 11 POSA under your own definition? 12 A. Yes. 13 Q. Why? 14 A. I'm a chemical engineer with 15 advanced degrees in chemical engineering. And 16 I've worked in these fields for 25 years or 17 more. 18 Q. So you have familiarity with 19 ammonia production systems? 20 A. Yes, I do. 21 Q. And you have familiarity with 22 emissions reduction processes?

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Page 15 of 147

Conducted on July 23, 2026

57 1 A. Yes, I do. 2 Q. So when you say you have 3 familiarity with ammonia production systems, 4 are you referring to the front end or the back 5 end of ammonia synthesis? Or both? 6 MR. COLLARD: Object to form. 7 A. I'm familiar with both. 8 I'm familiar with reforming 9 process to -- processes in water-gas shift to 10 produce the hydrogen. I'm familiar with 11 ammonia synthesis; developed catalysts for that 12 process. 13 BY MR. PHILLIPS: 14 Q. Would you agree that the 15 '168 patent does not discuss ammonia synthesis 16 in detail? 17 MR. COLLARD: Object to form. 18 A. No. I would disagree. The 19 focus of it is ammonia synthesis -- 20 BY MR. PHILLIPS: 21 Q. Is the -- 22 A. -- with reduced emissions.	59 1 Q. Bingo. 2 A. Yes, I'm familiar with it. 3 Q. And, for the record, I just 4 wanted to -- hopefully you'll agree with that, 5 GREET stands for Greenhouse Gases, Regulated 6 Emissions, and Energy Use in Technologies. 7 Does that sound accurate? 8 A. I believe so. I can't recall 9 exactly, but it's something like that. 10 Q. So can you describe the GREET 11 model for measuring carbon intensity for blue 12 ammonia? 13 A. I really cannot. I do not -- 14 I'm familiar with the GREET model in a general 15 sense, but I do not know. 16 It's a very complex model. It 17 was developed at Argonne. I don't know the 18 specifics of its definitions or how that code 19 works. 20 Q. What's your understanding of 21 it? 22 MR. COLLARD: Object to form.
58 1 Q. Is the focus ammonia synthesis 2 or is the focus preparing the feedstock for 3 ammonia synthesis? 4 MR. COLLARD: Object to form. 5 A. I think the focus is as 6 described in the title. It's about ammonia 7 synthesis with reduced emissions. 8 BY MR. PHILLIPS: 9 Q. Let's talk about emissions 10 reduction in ammonia synthesis plants for a 11 second. 12 A. Sure. 13 Q. Are you familiar with the GREET 14 model for measuring carbon intensity for blue 15 ammonia? 16 A. Could you clarify? I'm sorry. 17 Q. The GREET model, G-R-E-E-T. 18 I think it stands for green- -- 19 A. Oh, the GREET. 20 Q. GREET. 21 A. Developed by Argonne National 22 Labs? That one?	60 1 A. What I understand is it was a 2 model that was developed to try to provide a 3 resource for others to analyze the carbon 4 intensity of various processes. 5 BY MR. PHILLIPS: 6 Q. What is your understanding of 7 the term "carbon intensity"? 8 A. It's usually defined in terms 9 of greenhouse gas emissions. 10 Of course, CO2 is the 11 predominant gas that contributes to greenhouse 12 emissions. So it's typically -- when I 13 say "carbon intensity," it's usually synonymous 14 with CO2 emissions. 15 Q. Are you aware that there are 16 tier-based tax credits that companies like 17 Casale and Topsoe claim from the U.S. 18 government that's associated with the 19 production of blue ammonia? 20 MR. COLLARD: Hold on. 21 Object to scope. I mean -- 22 object to form.

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Page 16 of 147

Conducted on July 23, 2026

61 1 And, Jeff, you know, he can 2 answer if he knows. But at some point, we're 3 going to have to get closer to the scope of 4 his -- I don't know how this ties at all to any 5 of the opinions that he gave. 6 So I don't want to have a big 7 fight about scope, but we need to get back 8 towards his opinions. 9 MR. PHILLIPS: Okay. 10 MR. COLLARD: Go ahead. 11 MR. PHILLIPS: I was just 12 wondering if he understood that there's tax 13 credits associated with blue ammonia. 14 A. I am not familiar with the 15 details, but I am aware of the code 50Q or 16 whatever -- I can't remember -- yes, that 17 carbon tax credits are an issue. 18 BY MR. PHILLIPS: 19 Q. And the only reason why I'm 20 asking these questions is I was wondering if 21 you were aware that the GREET model takes into 22 account the electricity in utilities emissions	63 1 BY MR. PHILLIPS: 2 Q. Well, that's actually a good 3 question then. 4 What are the sources of CO2 5 emissions in an ammonia synthesis plant? 6 A. In a conventional ammonia 7 plant, as defined today? 8 Q. Sure. 9 A. Sure. 10 Typically, methane -- natural 11 gas is burned to power the units. And natural 12 gas is also used to create the hydrogen that 13 goes into the ammonia plant. 14 And so there are two distinct 15 sources. There's the CO2 produced in the -- as 16 a co-product, if you will, the hydrogen 17 production; and then there are CO2 emissions 18 associated with the furnaces to power that 19 process. 20 Q. What do you mean by the word 21 "power"? 22 MR. COLLARD: Object to form.
62 1 associated with the power consumed to run a 2 hydrogen or ammonia plant. 3 MR. COLLARD: Object to scope. 4 Object to form. 5 A. Again, I'm not familiar with 6 the details of the GREET model. I just know 7 the general purposes. 8 BY MR. PHILLIPS: 9 Q. So when we're talking about CO2 10 emissions relating to the ammonia synthesis 11 process, would a POSA consider the CO2 12 emissions relating to power and steam 13 production in order to operate the ammonia 14 synthesis process? 15 MR. COLLARD: Object to form. 16 A. Again, it depends on how one 17 defines the scope of the plant. There's many 18 definitions. 19 In principle, I think people 20 consider CO2 emissions from methane burning or 21 natural gas emission as the primary CO2 22 emissions associated with ammonia production.	64 1 A. What I meant specifically was 2 the combustion of natural gas to provide heat 3 to those processes. 4 BY MR. PHILLIPS: 5 Q. What about the power needed to 6 operate pumps and compressors throughout the 7 process? 8 A. That is -- I mean, again, 9 that's a little different because -- at least 10 in my view, because it depends on where the 11 plant exists and what the power sources are. 12 In some places, that power may 13 be provided by renewables, such as hydro power 14 or solar and, in that case, will not have CO2 15 emissions. Electricity may come from nuclear. 16 It may come from, you know, gas-fired power 17 plants. There's a whole source. 18 So that is -- I think that's 19 why it's excluded. There's not a clear 20 definition of where that -- those -- the 21 emissions associated with the electricity come 22 from.

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Page 17 of 147

65 1 Q. You've seen some of the prior 2 art in this case. And we're going to talk 3 about it later. 4 In the prior art, there is the 5 use of gas turbines in order to generate 6 electricity. 7 Do you agree with that? 8 MR. COLLARD: Object to form. 9 A. You'd have to -- you know, in 10 general, but you'd have to, you know, point me 11 to the specifics. 12 But, in general, yes, gas 13 turbines are used to produce electricity. 14 BY MR. PHILLIPS: 15 Q. And that was before 2017. 16 Would you agree with that? 17 A. Gas turbines have been used for 18 a long time to produce electricity. 19 Q. Again, we're sticking with 20 natural gas as a fuel, which is what we were 21 talking about earlier. 22 Does the combustion of natural	67 1 iterative process. 2 I wrote the initial draft 3 especially with regard to the technical issues; 4 and, of course, my CV and my qualifications. 5 The team from Dorsey provided a lot of the 6 wording with respect kind of to the legal 7 form -- the proper legal way to phrase things. 8 And we iterated from there. So 9 it was written collaboratively. 10 BY MR. PHILLIPS: 11 Q. How many hours did you 12 personally spend writing this declaration? 13 A. It's difficult to recall, but 14 it scores in the 20 to 40 hours, in that. And 15 when I say that, that's not just the writing, 16 but doing the research and reviewing the patent 17 material and the various materials that were 18 provided in this case. 19 Q. In paragraph 2 and in 20 paragraph 19, you say you considered certain 21 materials and documents that you've cited in 22 the declaration.
66 1 gas in a -- to fuel a reformer versus the 2 combustion of natural gas to generate power in 3 a gas turbine, does that create the same 4 emissions? 5 MR. COLLARD: Object to form. 6 A. The combustion of natural gas 7 will form the same amount of CO2 regardless of 8 the combustion process. Whether it's emitted 9 depends, of course, on the rest of the process. 10 BY MR. PHILLIPS: 11 Q. Let's take a step back. 12 Exhibit 2007, is this your 13 declaration -- 14 A. Yep. 15 Q. -- we were looking at earlier? 16 Did you write this declaration? 17 A. I did. 18 Q. How much would you say was 19 written by your attorneys representing Casale? 20 MR. COLLARD: Object to form. 21 Go ahead. 22 A. So the authorship was an	68 1 Did you read all these 2 documents cover to cover? 3 A. If we're talking about the 4 specific documents as opposed to -- 5 specifically, I read cover to cover, you know, 6 the petitions, Dr. Ritter's testimony, 7 Dr. Ritter's declaration, the 2007 IFA, and all 8 the patents cited -- the primary patents that 9 are cited in this. 10 Some of the other materials, 11 I did probably not read cover to cover, as they 12 were very extensive. 13 Q. Is there anything that you 14 reviewed for your declaration that is not 15 identified in Exhibit 2007? 16 A. Could you rephrase? 17 What exactly do you mean by 18 that? 19 Q. Sure. 20 I just was wondering if there 21 is any other documents that you considered for 22 your declaration that wasn't specifically

Conducted on July 23, 2026

69 1 identified in Exhibit 2007. 2 A. I mean, I looked at some 3 general references on gas turbines and some 4 other references on ammonia production that 5 were not listed in the things. 6 Q. So Exhibit 2007 contains all 7 the opinions you intend to offer in support of 8 Casale's response to the IPR? 9 A. That's correct. 10 Q. Nothing has been withheld? 11 A. No, not intentionally. 12 Q. In paragraph 34, you provided a 13 legal definition of "objective indicia of 14 nonobviousness." 15 Do you see that? 16 A. Yep. 17 Q. I didn't see anywhere in 18 Exhibit 2007 that you actually offered any 19 opinions concerning objective indicia of 20 nonobviousness. 21 Is that correct? 22 A. I believe that's correct.	71 1 I just want to make sure 2 I fully understand your question. 3 BY MR. PHILLIPS: 4 Q. Sure. 5 So my question for you is: 6 Would you agree that the industry was actively 7 pursuing CO2 reduction -- emissions reduction 8 via hydrogen fuel substitution by at least 9 2007, a decade before the critical date of the 10 '168 patent? 11 Is that right? 12 MR. COLLARD: Sorry. Object to 13 form. 14 You can answer, if you 15 understand the question. 16 A. I would disagree with that. 17 I think CO2 reduction was 18 certainly a target of the industry prior to the 19 dates you're talking about, around 2007. 20 I think the primary focus of 21 the industry, at least in my understanding, was 22 CO2 capture and sequestration. CCUS, or
70 1 Q. So you're presenting no 2 evidence on commercial success? 3 A. No, I'm not. 4 Q. No evidence on licensing? 5 A. No. 6 Q. No evidence on industry praise? 7 A. No. 8 Q. No evidence on copying? 9 A. No. 10 Q. No evidence of a long-felt need 11 in the industry? 12 A. No. 13 Q. So none of this analysis 14 appears in Exhibit 2007; right? 15 A. I do not believe so. 16 Q. Would you agree that the 17 industry was actively pursuing CO2 reduction 18 via hydrogen fuel substitution by at least 19 2007, a decade before the critical date of the 20 '168 patent? 21 MR. COLLARD: Object to form. 22 A. Could you restate that, please?	72 1 utilization, as it's called, would be the 2 primary, not substitution with hydrogen. 3 BY MR. PHILLIPS: 4 Q. But the industry was 5 substituting hydrogen-rich streams as fuel in 6 ammonia synthesis plants as early as 2007; 7 right? 8 MR. COLLARD: Object to form. 9 And asked and answered. 10 Go ahead. 11 A. I'm not aware, not in the 12 actual ammonia synthesis plant. 13 BY MR. PHILLIPS: 14 Q. What plant, then? 15 A. Again, not in -- hydrogen 16 wasn't used as a fuel. 17 Q. Hydrogen wasn't used as a fuel 18 in the industry in 2007? 19 A. In general, yes, for creating 20 heat. 21 Q. Was the industry pursuing that, 22 though?

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Page 19 of 147

Conducted on July 23, 2026

73 1 A. You know, I really -- 2 MR. COLLARD: Hold on. 3 THE DEPONENT: Sorry. 4 MR. COLLARD: I don't know what 5 industry we're talking about. Object to form. 6 A. Again, I can't -- when you say 7 "industry," I don't know who. 8 And, as you noted, I've been in 9 academia, so I do not have insight into what 10 was happening in industrial boardrooms in 2007. 11 BY MR. PHILLIPS: 12 Q. So it's your testimony you're 13 not aware that the industry was pursuing CO2 14 emissions reductions by using hydrogen-rich 15 streams for fuel as of 2007? 16 MR. COLLARD: Object to form. 17 A. I believe that, again, CO2 18 emissions was predominantly being pursued in 19 terms of carbon capture, sequestration, and 20 utilization. 21 BY MR. PHILLIPS: 22 Q. Are you aware that Casale has	75 1 provided to me. But that is what I'm aware of. 2 Q. So you have not formed any 3 opinions regarding the patentability or 4 validity of these new proposed claims? 5 A. Of course not, since I don't 6 know what they are. 7 Q. And just to confirm: 8 Exhibit 2007 doesn't address these substitute 9 claims; correct? 10 A. No, it doesn't, because I'm not 11 aware of them. 12 MR. PHILLIPS: I think we're at 13 a good breaking point. 14 MR. COLLARD: Sure. 15 THE VIDEOGRAPHER: All right. 16 Stand by. 17 We are going off the record. 18 The time is 9:59 a.m. 19 (Recess taken.) 20 THE VIDEOGRAPHER: We are back 21 on the record. The time is 10:20 a.m. 22 ///
74 1 proposed substitute claims 24 through 27 in 2 this IPR proceeding? 3 A. Is this with respect to the -- 4 when the Casale patent was reexamined? 5 Are we talking about that? 6 Sorry. 7 Q. No. 8 In the IPR, there's a proposed 9 substitute/additional claims that's been 10 proposed by Casale. 11 I'm just wondering if you're 12 aware that that has happened. 13 A. Are you talking about the -- 14 again, can you point specifically to what 15 you're referring to? 16 Q. They would not show up in the 17 '168 patent. This is just a proposal from 18 Casale. I just didn't know if you were aware 19 of that or not. 20 A. I am not. 21 I'm just -- I'm familiar with 22 the ex-parte reexamination and what's been	76 1 BY MR. PHILLIPS: 2 Q. Sir -- Dr. Wolden, I just 3 wanted to remind you after the break that 4 you're still under oath. 5 A. Thank you. 6 Q. We're going to switch gears. I 7 want to talk about the '168 patent for a little 8 bit. 9 A. Okay. 10 Q. That's Exhibit 1001. You 11 should have a copy in front of you. 12 A. Yes. 13 Q. You said that you reviewed the 14 '168 patent in preparation for your deposition 15 today. Is that right? 16 A. I did. 17 Q. Let's start on column 2, line 6 18 through 9. If you could turn to that. 19 It says, "The object of the 20 invention is to provide a method for conducting 21 ammonia synthesis processes with CO2 emissions 22 into the atmosphere which are greatly reduced

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Page 20 of 147

Conducted on July 23, 2026

77 1 compared to the prior art." 2 Do you see that? 3 A. I do. 4 Q. So you agree, that the focus of 5 the '168 patent is to reduce CO2 emissions from 6 flue gases? Is that accurate? 7 MR. COLLARD: Object to form. 8 A. I agree that it's to reduce CO2 9 emissions with respect to conducting ammonia 10 synthesis processes. 11 BY MR. PHILLIPS: 12 Q. But that it's also reducing CO2 13 emissions from flue gases associated with 14 ammonia synthesis processes. Would you agree 15 with that? 16 MR. COLLARD: Object to form. 17 A. It's -- the words are very 18 generic. It just says "reducing CO2 emissions 19 with respect to ammonia synthesis," not exactly 20 the way or how it should be done, at least in 21 that statement. 22 ///	79 1 ammonia enables the operator of the plant to 2 receive a tax credit in the United States. Is 3 that correct? 4 MR. COLLARD: Object to form. 5 A. I'm not aware of the exact tax 6 laws and implications. 7 BY MR. PHILLIPS: 8 Q. So is it your testimony that a 9 POSA would not be aware of that? 10 MR. COLLARD: Object to form. 11 A. Probably not. Or not 12 necessarily. 13 BY MR. PHILLIPS: 14 Q. But a POSA's boss would be 15 aware of that; right? 16 MR. COLLARD: Object to form. 17 A. Possibly. I can't speak to the 18 boss. 19 BY MR. PHILLIPS: 20 Q. So when an engineer designs an 21 ammonia synthesis plant, does carbon intensity 22 for the ammonia product become a product
78 1 BY MR. PHILLIPS: 2 Q. Okay. We had mentioned this 3 earlier. One of the purposes of reducing CO2 4 emissions is to qualify the ammonia product as 5 blue ammonia. 6 Is that right? 7 MR. COLLARD: Object to form. 8 A. You had mentioned blue ammonia 9 before and mentioned that there were tax 10 credits involved. 11 BY MR. PHILLIPS: 12 Q. Are you familiar with the term 13 "blue ammonia"? 14 A. Yes. 15 Q. What's your understanding of 16 the term "blue ammonia"? 17 A. Blue ammonia is derived from 18 blue hydrogen, which is hydrogen that is 19 typically produced conventionally, but the CO2 20 is, again, sequestered or captured or utilized 21 and not emitted to the atmosphere. 22 Q. So, in turn, qualifying as blue	80 1 specification? 2 MR. COLLARD: Object to form. 3 A. I don't exactly know what the 4 -- how the product is defined. 5 For ammonia, it's typically 6 defined by what the purity of the ammonia is. 7 There are different grades: refrigerant grade, 8 industrial grade ammonia. 9 That's the primary qualification 10 of ammonia coming out of the ammonia plant. 11 BY MR. PHILLIPS: 12 Q. But for blue ammonia, wouldn't 13 you agree that the carbon intensity of the 14 ammonia is also a product specification? 15 MR. COLLARD: Object to form. 16 A. Again, I don't know the 17 specific terminology. But blue ammonia would 18 imply that there was significant carbon capture 19 utilization involved in the process. 20 BY MR. PHILLIPS: 21 Q. And I think you agreed earlier, 22 but correct me if I'm wrong, the GREET model is

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Page 21 of 147

Conducted on July 23, 2026

81 1 how CO2 emissions are quantified with respect 2 to blue hydrogen and blue ammonia. 3 Is that accurate? 4 MR. COLLARD: Object to form. 5 A. What I understand about the 6 GREET model is that it's one of many models 7 that are available to quantify and compare CO2 8 emissions from various processes. 9 BY MR. PHILLIPS: 10 Q. So let's talk about the sources 11 of flue gas emissions in an ammonia synthesis 12 plant. 13 A. Sure. 14 Q. I'm going to list a few. 15 A. Okay. 16 Q. Is steam methane reforming a 17 source of flue gas emissions? 18 A. Yes, it is. 19 Q. Are furnaces for preheating 20 feed to an ATR a source of flue gas emissions? 21 A. Under typical operations, yes, 22 they are.	83 1 plant? 2 MR. COLLARD: Object to form. 3 A. There certainly can be. 4 There can be CO2 associated 5 with some of the other processes, such as a 6 methanation step or compressors or other 7 processes. 8 Again, it would depend on the 9 very specifics of what the plant comprised. 10 BY MR. PHILLIPS: 11 Q. Can you explain how there's CO2 12 emissions associated with the methanation step? 13 MR. COLLARD: Object to form. 14 A. Again, it's -- you know, I 15 really -- I can't, without a specific process- 16 flow diagram. Sorry. 17 BY MR. PHILLIPS: 18 Q. Can you explain how there are 19 potential CO2 emissions associated with 20 compressors? 21 MR. COLLARD: Object to form. 22 A. It would depend on how they
82 1 Q. What do you mean by "typical 2 operations"? 3 A. Conventional. 4 Conventionally, all these 5 furnaces are fired with natural gas. And under 6 that assumption, yes, they are a source of CO2. 7 Q. Are steam boilers a source of 8 flue gas emissions in an ammonia synthesis 9 plant? 10 MR. COLLARD: Object to form. 11 A. If they are powered by natural 12 gas or fossil-fuel combustion, yes, they are. 13 BY MR. PHILLIPS: 14 Q. Are steam superheaters a source 15 of flue gas emissions in an ammonia synthesis 16 plant? 17 MR. COLLARD: Object to form. 18 A. Again, if they are powered by 19 fossil-fuel combustion, yes, they are. 20 BY MR. PHILLIPS: 21 Q. Are there any other sources of 22 flue gas emissions in an ammonia synthesis	84 1 were powered. 2 BY MR. PHILLIPS: 3 Q. So you had qualified your 4 answers earlier with respect to the combustion 5 of natural gas. Is that right? 6 A. Yes. 7 I mean, for CO2 emission, I'm 8 assuming that you're either using natural gas 9 or fossil fuels to conduct that combustion, 10 which would make the CO2. 11 Q. What's the reaction for the 12 combustion of natural gas? 13 A. Again, natural gas is a -- it's 14 a diverse thing. But most people assume that 15 the primary component is methane. And methane 16 reacts with an oxygen molecule to produce 17 CO2 -- well, a couple oxygen molecules to 18 produce CO2 in water. 19 Q. Does that reaction go to 20 completion? 21 A. Typically. It's very 22 exothermic. It doesn't always go to

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Page 22 of 147

Conducted on July 23, 2026

85 1 completion. 2 Of course, that's why we -- 3 power plants worry about CO emissions. So if 4 it's only combusted to CO and not CO2, that is 5 an important environmental regulation that goes 6 to smog and things like that. 7 So it goes very closely to 8 complete combustion, but not always. There's 9 usually ethylene treatment plants. 10 Q. Can you give me a sense of what 11 the temperatures are like in the radiant 12 section of an industrial furnace? 13 MR. COLLARD: Object to form. 14 A. Again, there's many industrial 15 furnaces. So it's -- it would be very specific 16 to the conditions being employed. 17 BY MR. PHILLIPS: 18 Q. Do you have any sense for a 19 range of what the temperatures might be? 20 MR. COLLARD: Object to form. 21 A. Combustion temperatures can be 22 1000 to 2000 degrees piggyback flame	87 1 much more specific about what you're talking 2 about. 3 Q. Have you ever heard the term 4 "radiant section of a furnace" before? 5 A. Yes, I have. 6 Q. Generally, what would you 7 describe as the radiant section of a furnace? 8 A. The radiant -- in general, the 9 radiant section is where the flame is, where 10 the combustion is taking place, and where the 11 gas is at its hottest, if you will. 12 Q. Are you familiar with the term 13 "convection section of a furnace"? 14 A. Broadly. 15 Q. What would you say broadly is 16 meant by the term "convention section of a 17 furnace"? 18 A. Again, there are many different 19 furnaces and many different configurations. 20 Some work by convection, some work by induced 21 natural convection and don't have that section. 22 So it's a -- it's very
86 1 temperatures. 2 BY MR. PHILLIPS: 3 Q. When you say "1000 to 2000," is 4 that Celsius? 5 A. Celsius. 6 Q. Is that the temperature of the 7 flue gas that's emitted to the atmosphere? 8 MR. COLLARD: Object to form. 9 A. Again, it depends very much on 10 the process. 11 There's, oftentimes, post- 12 treatment processes before the emission to the 13 atmosphere which could dramatically change the 14 temperature of that gas. 15 BY MR. PHILLIPS: 16 Q. I had mentioned earlier the 17 radiant section of a furnace. 18 Do you have an understanding 19 for what the radiant section of a furnace is? 20 A. Again, that's very specific. 21 I mean, there's very -- 22 different furnaces. You'd have to be very --	88 1 nondefinitive, if you will. 2 Q. Let's pick a furnace, then. 3 Let's say the charge preheater 4 for an ATR. Are you familiar with that 5 furnace? 6 A. Not the -- I know what a charge 7 preheater is, and I know its purpose. Exactly 8 how the nozzles are configured, you know, those 9 are very specific details to the internal 10 structure of the furnace, and I can't speak to 11 that. 12 Q. What is the charge preheater of 13 an ATR? 14 A. It is a furnace that's coupled. 15 And the combustion heat is then coupled to 16 preheat the methane or natural gas that 17 typically goes into the -- an ATR. 18 Q. How does it preheat that gas 19 that's fed ultimately to the ATR? 20 MR. COLLARD: Object to form. 21 A. So, generically, a furnace has 22 two components: a combustion section, which

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Page 23 of 147

Conducted on July 23, 2026

89 1 produces very hot flue gas; and then there's a 2 heat exchanger component, where that heat is 3 transferred to another fluid, in this case, the 4 charge of the natural gas. 5 BY MR. PHILLIPS: 6 Q. Is the charge of the natural 7 gas inside tubes within the furnace? 8 MR. COLLARD: Object to form. 9 A. Again, I can't speak to the 10 specific configuration. 11 BY MR. PHILLIPS: 12 Q. I'm just trying to get a sense 13 for how a furnace operates. And I -- 14 MR. COLLARD: Then ask a 15 question about it. 16 MR. PHILLIPS: No. This isn't 17 meant to be a trick question. I'm not trying 18 to be -- a trick question. I'm just trying to 19 get on the record essentially how a furnace 20 operates. 21 BY MR. PHILLIPS: 22 Q. Can you describe how a furnace	91 1 that the temperature of the flue gas that's 2 emitted to the atmosphere? 3 MR. COLLARD: Object to -- 4 okay. Are you asking it again? 5 BY MR. PHILLIPS: 6 Q. Yeah, so my question now is: 7 Are furnaces designed to emit flue gases at 8 2000 degrees to the atmosphere? 9 MR. COLLARD: Object to form. 10 A. Of course not. 11 BY MR. PHILLIPS: 12 Q. Why do you say "of course not"? 13 A. Because the furnace's objective 14 is to use that heat and transfer it to another 15 fluid. And in doing that, the flue gas gets 16 considerably colder. 17 And, as I said, there's also 18 often other treatment processes of the flue gas 19 before it goes into the atmosphere. 20 Q. So is the goal to try to 21 extract as much of the heat as possible from 22 the combusted flue gas products?
90 1 operates, generally? 2 MR. COLLARD: Object to form. 3 A. Again, as I think I've said it, 4 there's a combustion section and then there's a 5 heat transfer section. Exactly how that heat 6 transfer section works, there's many different 7 configurations. 8 You can directly fire on a 9 tube, as you kind of were alluding to; or you 10 could run two process gases through a heat 11 exchanger. 12 That's, for example, what 13 happens in your house, where the air -- cooled 14 air from your house goes through a heat 15 exchanger with the combustion gases of your 16 furnace and comes out the other side warmer. 17 BY MR. PHILLIPS: 18 Q. So I think one of the questions 19 I asked at the beginning of this line of 20 questions is -- you had mentioned that the 21 temperatures in the radiant section can be 1000 22 to 2000 degrees C. And my question was: Is	92 1 MR. COLLARD: Object to form. 2 A. Typically, yes, that is the 3 goal, is to maximize -- for example, my house 4 has a high-efficiency furnace, which extracts 5 over 90 percent of the combustion heat from the 6 natural gas to the air. 7 BY MR. PHILLIPS: 8 Q. And that's something you'd 9 expect from your senior plant design students 10 as well -- right? -- in terms of designing 11 furnaces? 12 A. Yes. You would want -- in 13 general, you want a furnace to efficiently 14 transfer as much as the combustion heat to the 15 -- whatever the desired fluid is, or the 16 desired charge, as possible. That's just 17 efficiency. 18 Q. So you'd agree that capturing 19 the heat from furnace flue gas is a known best 20 practice for a POSA in designing a furnace 21 before 2017? 22 Is that right?

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Page 24 of 147

Conducted on July 23, 2026

93 1 MR. COLLARD: Hold on. 2 Object to the form. 3 A. Yes. In general, yeah, for a 4 furnace design, you want to capture as much of 5 the combustion heat as possible, typically. 6 BY MR. PHILLIPS: 7 Q. And you'd agree that it was 8 known to a POSA before 2017 to use natural gas 9 as fuel for industrial furnaces. Is that 10 right? 11 A. Yes. Since about -- yes. 12 At that time, natural gas was 13 the cheapest medium. Of course, it depends on 14 where you're at. They use a lot of coal in 15 China and other places, but in the U.S., 16 natural gas has been the primary heating source 17 for a long time. 18 Q. Would you also agree that it 19 was known to a POSA before 2017 to use a 20 variety of other waste streams to fuel an 21 industrial furnace? 22 MR. COLLARD: Object to form.	95 1 A. I don't recall, but I don't 2 expect they were at that time in that plant. 3 BY MR. PHILLIPS: 4 Q. Would you agree that it was 5 known to a POSA before 2017 to use 6 hydrogen-rich streams as a fuel in an 7 industrial furnace? 8 MR. COLLARD: Object to form. 9 A. Could you repeat the question? 10 I just want to make sure I get it correct. 11 BY MR. PHILLIPS: 12 Q. Sure. 13 Would you agree it was known to 14 a POSA before 2017 to use hydrogen-rich streams 15 as a fuel in an industrial furnace? 16 MR. COLLARD: Object to form. 17 A. I don't think that was 18 conventional at that time and is not today. 19 It's -- natural gas is the fuel of choice, if 20 you will, for industrial furnaces. 21 BY MR. PHILLIPS: 22 Q. My question was a little
94 1 A. Yes. Certainly. 2 I mean, In fact, you asked 3 about my project at Dow, and that's what it was 4 doing. It was using random waste streams in a 5 combustion to generate heat for other 6 processes. 7 BY MR. PHILLIPS: 8 Q. What type of random waste 9 streams were you looking at? 10 A. I do not recall. This is 1997. 11 They were, you know, industrial processes at 12 Dow. I can't speak to what they exactly were. 13 Q. Were these waste streams that 14 contained hydrocarbons? 15 MR. COLLARD: Object to form. 16 A. Again, I can't remember the 17 specifics; but, in general, yes, I would expect 18 they were hydrocarbons. 19 BY MR. PHILLIPS: 20 Q. Were these hydrogen-rich 21 streams? 22 MR. COLLARD: Object to form.	96 1 different. 2 I didn't ask if it was 3 conventional. I asked if it was known to a 4 POSA before 2017 to use hydrogen-rich streams 5 in an industrial furnace. 6 MR. COLLARD: Object to form. 7 A. I don't think that was common 8 practice. 9 BY MR. PHILLIPS: 10 Q. Okay. That wasn't exactly my 11 question either. 12 I wasn't asking about common 13 practice. I was asking if it was known to a 14 POSA before 2017. 15 MR. COLLARD: Objection. 16 He answered your question. 17 Object to the form. 18 BY MR. PHILLIPS: 19 Q. You can answer. 20 A. I don't believe a POSA would 21 have considered hydrogen as a fuel for an 22 industrial furnace.

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Page 25 of 147

Conducted on July 23, 2026

97 1 Q. Are you familiar with using 2 pressure swing absorption for hydrogen 3 purification? 4 A. Yes, I am. 5 Q. What's your understanding of 6 that process? 7 A. So it typically involves two 8 steps. You have a compressor, which compresses 9 a gas that contains hydrogen and other 10 impurities. It goes into an absorption column, 11 where the other impurities are preferentially 12 absorbed. Hydrogen passes through. 13 It's a cyclic process where you 14 have to periodically regenerate the column. 15 Q. So I think you'd agree with me 16 that PSA produces a very high-purity hydrogen 17 product? 18 MR. COLLARD: Object to form. 19 A. Yes. 20 Again, it depends on the number 21 of stages. You can make it as low or high 22 purity as you want, depending on the economics	99 1 recovered -- let's say 15 percent -- does that 2 end up in a PSA tail gas? 3 A. Yes. 4 Q. And was it common before -- 5 would a POSA understand that PSA tail gas could 6 be used in an industrial furnace as a fuel 7 prior to 2017? 8 MR. COLLARD: Object to form. 9 A. Yes, the tail gas could -- 10 probably not directly, but typically could be 11 mixed with other gases and used in a combustion 12 furnace. 13 BY MR. PHILLIPS: 14 Q. Before 2017? 15 A. Yes. 16 Q. Do you have a sense for what 17 the hydrogen composition is in a PSA tail gas? 18 A. It very much depends on what 19 process was -- the PSA was being used on. So 20 it would depend on the amount of the other 21 impurities. So it could be highly variable. 22 Q. Would you consider that a
98 1 of the situation. 2 BY MR. PHILLIPS: 3 Q. Do you have a sense for how 4 much hydrogen is recovered in a PSA unit? 5 MR. COLLARD: Object to form. 6 A. Again, I have a sense, not an 7 exact number. But typically about 15 percent 8 of the hydrogen is lost -- not in the purified 9 stream ends up in the absorption column. 10 BY MR. PHILLIPS: 11 Q. Is that a design parameter for 12 designing a PSA recovery -- hydrogen recovery 13 unit? 14 MR. COLLARD: Object to form. 15 A. I wouldn't describe it as a 16 "design parameter." It's a constraint of the 17 process. 18 I mean, you'd love to get 19 100 percent of the hydrogen back, but you 20 can't. 21 BY MR. PHILLIPS: 22 Q. So the hydrogen that's not	100 1 hydrogen-rich stream? 2 A. It could -- 3 MR. COLLARD: Object to form. 4 A. It could be. It could be more 5 than 50 percent; it could be less than 6 50 percent hydrogen. 7 BY MR. PHILLIPS: 8 Q. When would it be less than 9 50 percent hydrogen? 10 A. Again, depending on what -- the 11 composition of the stream that went into the 12 PSA; if it had lots of methane, nitrogen, CO. 13 You know, it could be a whole 14 host of things that you're purifying the 15 hydrogen from, so it really depends on the 16 purity of the stream going in, which determines 17 the purity of the tail gas going out. 18 Q. So when you replace natural gas 19 with a hydrogen-rich stream as fuel to a 20 furnace, is that the same combustion reaction 21 as with using natural gas fuel to a furnace? 22 MR. COLLARD: Object to form.

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Page 26 of 147

Conducted on July 23, 2026

101 1 A. No. It's a different reaction. 2 Hydrogen combusts with oxygen 3 to just make steam, as opposed to making CO and 4 CO2 and steam. 5 BY MR. PHILLIPS: 6 Q. Isn't it true that burning 7 hydrogen-rich streams creates special design 8 considerations for a furnace? 9 MR. COLLARD: Object to form. 10 A. Certainly hydrogen has a much 11 higher burning velocity, laminar flame speed, 12 than natural gas, so they typically require 13 different combustion conditions. 14 BY MR. PHILLIPS: 15 Q. Does it have different burners? 16 A. Possibly. A totally different 17 -- could be -- again, I'm not -- don't know 18 about the specifics. But, yes, I would expect 19 there'd be a very different configuration of 20 the burner burning natural gas versus hydrogen. 21 Q. Would you expect higher peak 22 flame temperatures using a hydrogen-rich stream	103 1 heightened with the use of a hydrogen-rich 2 stream as a fuel to a furnace? 3 MR. COLLARD: Object to form. 4 A. They possibly could be. Again, 5 it depends on the specifics. 6 Your car has a catalytic 7 converter. It doesn't have any hydrogen going 8 in it, but it's there to prevent knocks coming 9 out. 10 BY MR. PHILLIPS: 11 Q. Is there a way to design a 12 furnace to mitigate knocks emissions? 13 MR. COLLARD: Object to form. 14 A. Yes, there are different ways 15 to operate a furnace. 16 Again, things I mentioned 17 before, such as controlling how the gas -- how 18 the fuel and the oxygen are mixed and the -- 19 again, the total structure of it, exactly how 20 it burns. 21 Yes, that will impact how it -- 22 the knocks formation coming out of it.
102 1 as fuel to a furnace? 2 MR. COLLARD: Object to form. 3 A. Again, that question is very -- 4 depends very much. 5 There's a number of other 6 parameters, such as the stoichiometric ratio. 7 Is it fuel rich? Is it fuel lean? How is the 8 oxygen -- is it premixed or is it a diffusion 9 flame? 10 And so you can get a wide 11 variety of different flame temperatures; many 12 of them overlapping. 13 BY MR. PHILLIPS: 14 Q. Are there concerns with 15 generating knocks when using hydrogen-rich 16 streams as a fuel for a furnace? 17 MR. COLLARD: Object to form. 18 A. There are general concerns 19 about making knocks under any combustion 20 process. 21 BY MR. PHILLIPS: 22 Q. But are those concerns	104 1 BY MR. PHILLIPS: 2 Q. And all the issues that we 3 described -- knocks formation, higher flame 4 speed, higher peak flame temperatures -- these 5 are all issues that were managed by a POSA 6 before 2017. Is that right? 7 MR. COLLARD: Object to form. 8 Misstates testimony. 9 A. Again, you're talking about a 10 very complex process. And, you know, I don't 11 exactly know what you're asking specifically. 12 BY MR. PHILLIPS: 13 Q. Sure. 14 We're talking about a POSA 15 before 2017. 16 A. Okay. Sure. 17 Q. So in that context, was a 18 POSA -- was it known to a POSA how to deal with 19 higher flame speed, higher peak flame 20 temperatures, knocks formation when using 21 hydrogen-rich streams to fuel a furnace? 22 MR. COLLARD: Object to form.

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Page 27 of 147

Conducted on July 23, 2026

105 1 A. You know, that's not clear to 2 today. 3 That is a very active subject 4 of research, as to how to burn hydrogen-rich 5 inflames; and it's not totally solved and 6 understood. 7 So if it's not solved and 8 understood today, I don't think it was at that 9 time. 10 BY MR. PHILLIPS: 11 Q. But the problems were 12 appreciated at that time by a POSA. 13 Wouldn't you agree? 14 MR. COLLARD: Object to form. 15 A. I would agree that they would 16 understand the problems, but not necessarily 17 the solutions. 18 BY MR. PHILLIPS: 19 Q. But they were working on the 20 solutions prior to 2017. Would you agree with 21 that? 22 MR. COLLARD: Object to form.	107 1 BY MR. PHILLIPS: 2 Q. But you do understand it's the 3 operation of pumps, for example? 4 MR. COLLARD: Object to form. 5 A. Yes, I understand the pumps. 6 BY MR. PHILLIPS: 7 Q. But that that's a power 8 requirement in an ammonia synthesis plant. 9 Would you agree with that? 10 MR. COLLARD: Object to form. 11 A. Pumps are a requirement in most 12 chemical processes. 13 BY MR. PHILLIPS: 14 Q. Compressors as well? 15 A. Oftentimes. 16 MR. COLLARD: Object to form. 17 BY MR. PHILLIPS: 18 Q. I'm going to direct you to 19 column 7, line 29. And this is of 20 Exhibit 1001, the '168 patent. 21 A. Yes. So 7. I'm sorry. What 22 line?
106 1 A. I don't know. 2 BY MR. PHILLIPS: 3 Q. So we talked about steam 4 reformers, steam boilers, steam superheaters, 5 and feed preheating furnaces. Are there any 6 other sources of flue gas emissions in an 7 ammonia synthesis plant? 8 MR. COLLARD: Object to form. 9 A. Again, there certainly could 10 be. It depends on -- there's very -- as you 11 see in all these documents, there's very -- 12 there's many different configurations of 13 ammonia synthesis plants. 14 So I can't, you know, speak to 15 every possible configuration, but those are the 16 main ones. 17 BY MR. PHILLIPS: 18 Q. Do you have a sense for the 19 power and electricity requirements in an 20 ammonia synthesis plant? 21 MR. COLLARD: Object to form. 22 A. Not quantitatively.	108 1 Q. Line 29. 2 A. (Document[s] reviewed.) 3 Q. It says, "The missing energy 4 may be conveniently imported from outside the 5 plant as electricity with reduced CO2 6 emissions..." 7 Do you see that? 8 A. Yep. 9 Q. Is that what you were 10 describing to me earlier when you were talking 11 about a plant may bring in electricity that's 12 wind power, solar power, et cetera? 13 A. Yes. Exactly. 14 The electricity source is not 15 known. Right? It could be nuclear, solar, 16 renewable, et cetera. 17 Q. But it's important to have 18 electricity with reduced CO2 emissions; is that 19 right? 20 MR. COLLARD: Object to form. 21 A. It's beneficial to -- if your 22 goal is to reduce CO2 emissions, to bring

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Page 28 of 147

Conducted on July 23, 2026

109 1 electricity that has reduced carbon intensity. 2 BY MR. PHILLIPS: 3 Q. And it's your understanding 4 that CO2 emissions from electricity count 5 toward the carbon intensity of the ammonia 6 product. 7 Would you agree with that? 8 MR. COLLARD: Object to form. 9 A. Again, it depends. 10 These various models, such as 11 the GREET model that you specified, they put 12 boxes around different parts of what's included 13 and what's not included. And so it depends on 14 how the ammonia plant is defined. 15 BY MR. PHILLIPS: 16 Q. Let's look at column 7, row 44. 17 The section starts by saying "The invention 18 also allows to produce the electricity 19 necessary for the synthesis of ammonia or of 20 its derivatives (for example, urea) with low 21 emissions of CO2, using as fuel CO2-depleted 22 synthesis gas, for example in the following	111 1 belief that the inventors of the '168 patent 2 have intentionally excluded firing CO2-depleted 3 syngas in gas turbines from the claim scope of 4 the '168 patent? 5 MR. COLLARD: Object to form. 6 A. I'm sorry. Could you restate 7 the question so I exactly understand how to 8 respond? 9 Are you talking about the 10 reexamination, where they modified the claims? 11 BY MR. PHILLIPS: 12 Q. I'm talking about the 13 '168 patent claims -- sure -- post 14 reexamination. 15 A. Okay. 16 Q. Is it your belief that the 17 inventors of the '168 patent have intentionally 18 excluded firing CO2-depleted syngas in gas 19 turbines from the claim scope of the 20 '168 patent? 21 MR. COLLARD: Object to form. 22 A. I don't think that the
110 1 ways." 2 Do you see that? 3 A. Yes. 4 Q. And then the second of the two 5 ways is -- and this is, again, starting at line 6 52 -- "combustion in a gas turbine or in a gas 7 engine, fed by the CO2-depleted synthesis gas 8 as fuel." 9 Do you see that? 10 A. Yes. 11 Q. So does this corroborate the 12 understanding that blue ammonia requires that 13 we have -- that requires the inclusion of power 14 and electricity that has low CO2 emissions 15 associated with it? 16 MR. COLLARD: Object to form. 17 A. In general, yes, blue -- again, 18 it's -- the CO2 is captured in a blue ammonia 19 process at some way or form. 20 BY MR. PHILLIPS: 21 Q. So we'll get to this in a 22 little more detail later. But is it your	112 1 '168 patent makes any statement about that. 2 BY MR. PHILLIPS: 3 Q. But the claims of the 4 '168 patent relate to burning the CO2-depleted 5 syngas in a furnace. Is that right? 6 A. That is correct. 7 Q. And you've limited -- you 8 believe that the inventors had limited the 9 definition of "furnace" to exclude burning CO 10 syngas -- CO2-depleted syngas in a gas turbine. 11 MR. COLLARD: Object to form. 12 A. The authors, as I understand 13 it, can exercise their own lexicographers. And 14 they've defined -- it says very clearly what 15 they define the furnace as, the four things; 16 you know, a preheater, a steam generator, 17 et cetera. And a gas turbine is not included 18 in that list. 19 BY MR. PHILLIPS: 20 Q. So here's my question for you: 21 Why would a POSA disregard gas turbine flue gas 22 emissions from the scope of the '168 patent?

PLANET DEPOS

888.433.3767 | WWW.PLANETDEPOS.COM Topsoe, Inc. - EX1066

Page 29 of 147

Conducted on July 23, 2026

113 1 MR. COLLARD: Object to form. 2 If you understand, you can 3 answer. 4 A. Could you restate the question, 5 please? 6 BY MR. PHILLIPS: 7 Q. Why would a POSA disregard gas 8 turbine flue gas emissions from the scope of 9 the '168 patent? 10 MR. COLLARD: Object to form. 11 A. I don't think a POSA would 12 object to it. It's not – gas turbines are not 13 part of the '168 patent. 14 It's an option, but it's not 15 part of the claims, which are reducing the CO2 16 emissions from the reforming section. 17 BY MR. PHILLIPS: 18 Q. Well, we read earlier from 19 column 2, line 6, that the object of the 20 invention is to provide a method for conducting 21 ammonia synthesis processes with CO2 emissions 22 into the atmosphere which are greatly reduced	115 1 right? 2 A. In general. 3 You can run – again, you can 4 get your – the CO2 emissions for – attributed 5 to electricity are a very minor part of the CO2 6 emissions for an ammonia plant. It's from the 7 reforming step primarily. 8 Q. Why would you say it's a minor 9 part? 10 MR. COLLARD: Object to form. 11 A. The energy required for pumps 12 is minor compared to the energy required for 13 reforming. 14 BY MR. PHILLIPS: 15 Q. From a technical perspective, 16 would a POSA find that there's a difference 17 between combustion of CO2-depleted syngas in a 18 steam boiler versus the combustion of the same 19 CO2-depleted syngas in a gas turbine? 20 MR. COLLARD: Object to form. 21 A. Those combustion processes 22 would be conducted very differently.
114 1 compared to the prior art. 2 You agreed with that; right? 3 A. I did. 4 Q. Are emissions from a gas 5 turbine in the ammonia synthesis plant part of 6 the CO2 emissions into the atmosphere? 7 A. A gas – 8 MR. COLLARD: Object -- sorry. 9 Object to form. 10 A. A gas turbine is not 11 necessarily part of the ammonia synthesis 12 plant, especially as defined in the 13 '168 patent. 14 BY MR. PHILLIPS: 15 Q. You said "is not necessarily." 16 But it can be; right? 17 MR. COLLARD: Object to form. 18 A. It's not – a gas turbine is 19 not part of the '168 patent. 20 BY MR. PHILLIPS: 21 Q. But it can be part of an 22 ammonia synthesis plant. You agree with that;	116 1 BY MR. PHILLIPS: 2 Q. So the equipment is different. 3 A. Yeah – 4 MR. COLLARD: Object to form. 5 A. -- the equipment is very 6 different. 7 BY MR. PHILLIPS: 8 Q. Is the reaction very different? 9 MR. COLLARD: Object to form. 10 A. The reaction – the combustion 11 reaction is the same. Hydrogen is converted to 12 steam. 13 BY MR. PHILLIPS: 14 Q. So is there a difference in the 15 composition of the flue gas between combustion 16 in a steam boiler versus combustion in a gas 17 turbine? 18 MR. COLLARD: Object to form. 19 A. Typically there would be 20 because no one in their right mind would put 21 hydrogen-depleted syngas into a gas turbine. 22 ///

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Page 30 of 147

Conducted on July 23, 2026

117 1 BY MR. PHILLIPS: 2 Q. Why is that? 3 A. It would blow up. 4 Q. Are there ways to mitigate 5 that? 6 A. No one knows. Not yet. 7 The only way they do it is 8 dilute it significantly; typically run mostly 9 with methane or you could dilute it with 10 nitrogen or you have to do significant changes 11 to the input composition to a gas turbine as 12 opposed to a diffusion flame that you'd use in 13 a steam superheater. 14 Q. Is that because the hydrogen 15 combustion operates at a higher temperature -- 16 a higher flame temperature? 17 A. No, not really temperature. 18 It's because the hydrogen has a much higher 19 flame speed. 20 Q. Could you operate with excess 21 oxygen in a gas turbine to help mitigate that 22 issue?	119 1 BY MR. PHILLIPS: 2 Q. And when you say "at that 3 time," you're referring to prior to 2017? 4 A. Yes. At the time of this 5 patent. 6 Q. Is it your testimony today that 7 gas turbines cannot be rated for more than 8 10 percent hydrogen combustion in the 9 combustion chamber of the gas turbine? 10 MR. COLLARD: Object to form. 11 A. I can't speak definitively. 12 To my knowledge, the highest 13 premixed gas turbine's gotten up to is maybe 14 25 percent hydrogen, is at current. Maybe the 15 best. Yeah. 16 I don't know of one actually 17 doing that, but that's what -- it's active 18 research to try to increase that fraction. 19 BY MR. PHILLIPS: 20 Q. Let's switch gears. 21 Paragraph 42 of your declaration. 22 A. Oh. Back to the declaration.
118 1 MR. COLLARD: Object to form. 2 A. I would not advise it. That 3 would make it worse, in general. 4 You'll blow yourself up faster. 5 BY MR. PHILLIPS: 6 Q. Well, excess oxygen wouldn't 7 completely combust. You'd agree with that; 8 right? 9 A. Sure, but it would -- the 10 reaction would go much faster. 11 There's some great video on 12 YouTube on what happens when you're exposed to 13 highly enriched oxygen. 14 Q. Are you saying a POSA wouldn't 15 consider using a hydrogen-rich stream at least 16 as a portion of the fuel for a gas turbine? 17 MR. COLLARD: Object to form. 18 A. At best, I think GT turbines at 19 that time were rated to maybe 10 percent 20 hydrogen as the most that you could accept and 21 do a gas turbine. 22 ///	120 1 Q. I'm sorry. Of your 2 declaration. This is Exhibit 2007. 3 A. Yep. Sorry. 4 (Pause.) 5 Okay. Right before the figure 6 on 12? Yep. 7 Q. That's correct. 8 So the first sentence of 9 paragraph 42, "Desulfurized natural gas and 10 steam are first preheated in a furnace (AUX) 11 before being converted into a" -- "before being 12 converted using a prereformer (PRE) followed by 13 an autothermal reformer (ATR) supplied with 14 oxygen-enriched air (22) to form synthesis gas 15 (primarily a mixture of hydrogen and CO), which 16 is then treated in a shift reactor (SHF) which 17 converts CO into CO2 and produces additional 18 hydrogen." 19 Do you see that? 20 A. I do. 21 Q. Would you describe the furnace 22 (AUX) as a charge preheater?

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Page 31 of 147

121 1 A. Yes, I would. 2 (Crosstalk.) 3 THE DEPONENT: Sorry. 4 MR. COLLARD: No. Go ahead. 5 You're fine. 6 A. Yes, I would. 7 BY MR. PHILLIPS: 8 Q. And that's because it burns 9 fuel and transfers heat to the feed to the 10 prereformer. Is that right? 11 A. That is correct. 12 Q. And, again, just to be clear, 13 in an ATR, the heat for reforming is 14 generally -- is generated inside the ATR by 15 partial oxidation reaction. Is that right? 16 A. In the ATR, yes. 17 Q. So the ATR does not need to be 18 directly fired like a traditional steam methane 19 reformer; is that right? 20 MR. COLLARD: Object to form. 21 A. That is correct. 22 ///	123 1 MR. COLLARD: Object to form. 2 A. Are you talking about the 3 desulfurization process, which is kind of -- is 4 upstream of what's talked about here? 5 BY MR. PHILLIPS: 6 Q. That's right. 7 A. Yeah. 8 So, yes, the desulfurization 9 process can -- is done at elevated temperature, 10 typically. 11 Q. So you say "the desulfurization 12 is upstream of what's talked about here." Is 13 that right? 14 A. That's -- yes, because it's 15 already -- that's what's being delivered to the 16 auxiliary, is natural gas that's already been 17 through a desulfurization process. 18 Q. So the '168 patent doesn't 19 describe the desulfurization practice at all; 20 right? 21 A. It does not -- 22 MR. COLLARD: Object to form.
122 1 BY MR. PHILLIPS: 2 Q. But the charge entering an ATR 3 must be preheated; right? 4 A. Typically. 5 In this case, they -- yeah, 6 they charged it before it went to a 7 prereformer. 8 Q. Same for the prereformer: its 9 feed needs preheating as well; right? 10 A. Yes, it does. 11 MR. COLLARD: Object to form. 12 A. That's what it says there, yes. 13 The desulfurized natural gas and steam are 14 preheated before they go to the prereformer. 15 BY MR. PHILLIPS: 16 Q. Does the feed to the 17 desulfurization bed need preheating as well? 18 MR. COLLARD: Object to form. 19 A. Potentially. 20 BY MR. PHILLIPS: 21 Q. Is that because it operates at 22 elevated temperatures?	124 1 A. It does not describe it. It 2 just says that it's required. Desulfurized 3 natural gas is required for the process. 4 BY MR. PHILLIPS: 5 Q. And it does not describe in any 6 way whether it needs preheating or not. Is 7 that right? 8 MR. COLLARD: Object to form. 9 A. It does not discuss the 10 desulfurization process in any extent. 11 BY MR. PHILLIPS: 12 Q. Was using a charge preheater 13 before the prereformer in the ATR well known to 14 a POSA before 2017? 15 MR. COLLARD: Object to form. 16 A. Yes, I think it's generally 17 known that you have to preheat the gas before a 18 prereformer -- before entering a prereformer. 19 Yes. 20 BY MR. PHILLIPS: 21 Q. And that was before 2017; 22 right?

Conducted on July 23, 2026

125 1 A. Yes. 2 Q. So I just want to confirm your 3 testimony. 4 You're saying that the -- prior 5 to 2017, in ammonia synthesis plants, the 6 furnaces are in the same location as described 7 in the '168 patent. Those prior furnaces were 8 fired by natural gas. 9 And the '168 patent -- the 10 '168 patent's contribution is a substitution of 11 the fuel, not the existence of the furnaces 12 themselves. 13 Is that right? 14 MR. COLLARD: Object to form. 15 A. So the '168 patent describes 16 the process with the furnace before the 17 preheater, and, yes, changing the fuel from 18 natural gas to a hydrogen-rich stream. 19 BY MR. PHILLIPS: 20 Q. But the existence of that 21 furnace, that's not new. 22 A. The need to heat the gas prior	127 1 Do you agree with that? 2 MR. COLLARD: Object to form. 3 A. There are many different 4 configurations for doing reforming, but that is 5 one of them. 6 BY MR. PHILLIPS: 7 Q. And that particular flow sheet, 8 there's nothing new about that prior to 2017. 9 Do you agree with that? 10 MR. COLLARD: Object to form. 11 A. Well, what's different is the 12 fuel provided to the auxiliary heater. 13 BY MR. PHILLIPS: 14 Q. Exactly. 15 But the flow sheet, itself, 16 is -- there's nothing new about that flow 17 scheme. Is that right? 18 A. The generic -- 19 MR. COLLARD: Sorry. 20 Object to form. 21 A. The generic process of doing 22 that is one of the many reforming processes
126 1 to the prereformer is not new. 2 Q. So the location of that furnace 3 is not new, upstream of the prereformer and 4 ATR. Is that right? 5 A. It needs to be before the 6 prereformer. 7 Q. Going back to paragraph 42. 8 The next sentence -- the second sentence of 9 paragraph 42, you state, "The subsequent CO2 10 removal unit (CDR) extracts the majority of the 11 carbon." 12 Do you see that? 13 A. Yep. 14 Q. Okay. So the flow sheet so far 15 from those two sentences is we have a charge 16 preheater, a prereformer, an ATR, a water-gas 17 shift reactor, and CO2 removal. 18 Do you agree with that? 19 A. That is correct. 20 Q. There's nothing new about that 21 flow sheet prior to 2017. That all existed 22 prior to 2017.	128 1 that was available at that time. 2 BY MR. PHILLIPS: 3 Q. So the order of those unit 4 operations was not new in this patent. Do you 5 agree with that? 6 MR. COLLARD: Object to form. 7 A. There's many different ways to 8 operate reforming. And this is one of them. 9 BY MR. PHILLIPS: 10 Q. And this way was available 11 prior to 2017; right? 12 MR. COLLARD: Object to form. 13 A. This configuration was 14 available prior to 2017, yes. 15 BY MR. PHILLIPS: 16 Q. So the next sentence in 17 paragraph 42, which is the last sentence, 18 "After decarbonation, part of the resulting 19 CO2-depleted syngas (14) is routed back as 20 furnace fuel for AUX, while the remainder (18) 21 proceeds to ammonia synthesis (which requires a 22 methanation treatment (MET) to remove any

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Page 33 of 147

Conducted on July 23, 2026

129 1 residual CO and adds nitrogen (19) from the air 2 separation unit (ASU) to create the final 3 product: ammonia (NH₃, stream 23) in the 4 synthesis reactor (SYN))." 5 Do you see that? 6 A. Yep. 7 Q. Would you agree that the 8 methanation step is also not new to this flow 9 sheet? 10 MR. COLLARD: Object to form. 11 A. Yes. 12 In general, it's very well 13 known that you have to remove CO prior to 14 supplying hydrogen to an ammonia synthesis 15 step. 16 Methanation – there's 17 different ways to do that CO₂ removal. 18 Methanation is one option. Pressure swing 19 absorption, as we talked about, is another 20 option. Drying and cryogenic separation is 21 another option. Membranes are another 22 separation option.	131 1 And what they're doing is 2 purifying that stream and recycling the 3 hydrogen to the – back to the ammonia 4 synthesis. 5 Q. So that would be -- that stream 6 is 15 that's being recycled. Is that right? 7 A. Stream 20 is what's being 8 recycled to the synthesis plant. That's the 9 pure hydrogen that comes out of the hydrogen 10 recovery unit. 11 Q. Okay. What's stream 15? 12 A. 15 is going to be the junk. 13 So, for example, as we've just 14 talked about, the methanation step creates some 15 methane. It's not adverse to the ammonia 16 synthesis process, but it builds up and has to 17 be vented. 18 So that stream 15 would be a 19 mixture of hydrogen, methane, probably some 20 nitrogen; other impurities from the ammonia 21 synthesis process. 22 Q. Would you consider that to be a
130 1 But, yes, the – generically, 2 methanation is one of the approaches to remove 3 CO from the stream for the synthesis plant. 4 BY MR. PHILLIPS: 5 Q. So you had mentioned Figure 1. 6 I think that's following paragraph 42. 7 A. Yep. 8 Q. Does Figure 1 accurately depict 9 what we just described in paragraph 42? 10 A. Yes, I think so. It didn't 11 talk about oxygen coming from the air 12 separation unit to the ATR, but I think it 13 mentions pretty much everything else. 14 Q. What about the box HRU? 15 A. Sure. 16 Q. What is that? 17 A. That is a hydrogen recovery 18 unit. 19 So in the synthesis step, not 20 all the ammonia – or not all the nitrogen and 21 hydrogen is converted to ammonia, so there's a 22 lot of unreacted gases.	132 1 hydrogen-rich stream? 2 MR. COLLARD: Object to form. 3 A. Again, it – most likely. 4 I mean, again, it's going to be 5 a mixture of methane and hydrogen and other 6 gases. It would depend on the specifics of its 7 operation, yeah. 8 BY MR. PHILLIPS: 9 Q. Could it be a hydrogen-rich 10 stream? 11 A. It could be, certainly. 12 Q. And, again, just for 13 definitional purposes, when I say "hydrogen- 14 rich stream," is that -- when you say 15 "hydrogen-rich stream," what are you talking 16 about? 17 What do you think that means? 18 A. Well, I mean, specifically in 19 the patent, it's stream 14 after the CDR 20 process, is the hydrogen-rich stream as defined 21 in the patent. And that is what goes back to 22 the auxiliary stream.

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Page 34 of 147

Conducted on July 23, 2026

133 1 15 is optionally mixed in with 2 that. And it would have hydrogen, but it would 3 be, for example, less hydrogen-rich than stream 4 14. 5 Q. So it would be a lower 6 composition of hydrogen? 7 A. It would be a lower hydrogen 8 composition, yes. 9 Q. Is stream 15 also a CO2- 10 depleted stream? 11 MR. COLLARD: Object to form. 12 A. Yes, it is, because CO2 was 13 removed and the CO was converted to methane in 14 the methanation unit. 15 So, as I said, it's -- 16 primarily could be methane, hydrogen, and, 17 again, byproducts of the ammonia synthesis 18 process, which could include nitrogen and 19 ammonia, actually. 20 BY MR. PHILLIPS: 21 Q. Do you consider -- the recycle 22 of stream 15, which you referred to as a "junk	135 1 MR. COLLARD: Object to form. 2 A. Again, not the exact 3 composition, but, yes, it would have some 4 methane, some impurities of lower quality. 5 Yeah. 6 BY MR. PHILLIPS: 7 Q. But it's also an example of a 8 waste stream that would be used as fuel in a 9 furnace prior to 2017? 10 MR. COLLARD: Object to form. 11 A. Yes, it's a waste stream. And, 12 you know, it often was flared, but could be 13 potentially used as a fuel. 14 BY MR. PHILLIPS: 15 Q. What determines whether a 16 stream gets flared versus being used as a fuel? 17 MR. COLLARD: Object to form. 18 A. I think that's a very complex 19 question. 20 It depends on the quality of 21 that waste stream. It depends on environmental 22 regulations at the site you're at. It depends
134 1 stream," do you consider that to be new before 2 2017 to a POSA? 3 MR. COLLARD: Object to form. 4 A. No, I would not consider that 5 new. 6 I mean, every ammonia synthesis 7 needs a purged stream and would create a purged 8 stream such as that. 9 Whether it went through 10 hydrogen -- HRU unit, there would be a purged 11 stream off the synthesis stream that would have 12 a similar composition. 13 BY MR. PHILLIPS: 14 Q. And that would be recycled to 15 fuel prior to 2017? 16 MR. COLLARD: Object to form. 17 A. There's examples of that being 18 used to -- as a fuel in various places. 19 BY MR. PHILLIPS: 20 Q. And that's -- we mentioned 21 earlier PSA tail gas stream. That would be a 22 similar type stream?	136 1 on what the value that you could get by that. 2 Is it cheaper to flare it 3 versus to use it? You know, it's really an 4 economic choice of what you would do with that 5 gas. 6 It's not a big stream. Right? 7 It's just a -- it's a residual waste treatment. 8 BY MR. PHILLIPS: 9 Q. But that's a decision that a 10 process engineer would be able to make. 11 MR. COLLARD: Object to form. 12 BY MR. PHILLIPS: 13 Q. Correct? 14 A. It would be, again -- yes, it 15 would be a -- probably more the businessperson 16 who's running the plant to -- would say that's 17 a profitable thing or not a profitable thing. 18 Q. And so a person of ordinary 19 skill in the art would then advise whether that 20 was a feasible solution to recycle it to a 21 furnace. Is that right? 22 MR. COLLARD: Object to form.

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Page 35 of 147

Conducted on July 23, 2026

137 1 A. A POSA could make 2 recommendations on what would be the most 3 appropriate thing to do, depending on the size 4 of the stream, the composition of the stream, 5 any other factors. 6 BY MR. PHILLIPS: 7 Q. Let's look at paragraph 43, 8 right below that figure in your declaration. 9 A. Sure. 10 Q. You state, "This internal 11 recycling of low-carbon syngas allows the plant 12 to supply its own heat demand without relying 13 on fossil-fuel combustion." 14 Do you see that? 15 A. Yes. 16 Q. So my first question is: What 17 did you mean by the term "heat demand"? 18 A. Well, primarily in this 19 process, the heat demand is in the auxiliary 20 furnace, AUX. And that is being supplied by 21 the hydrogen-rich gas. 22 Q. Would that also include using	139 1 steam, electricity, or potentially other 2 chemicals." 3 Do you see that? 4 A. Yes. 5 Q. What did you mean by that 6 statement? 7 A. Well, again, this is the 8 significant contrast between ammonia synthesis 9 and methanol and hydrocarbon synthesis. 10 In ammonia synthesis, hydrogen 11 is the rate-limiting reagent. In those other 12 processes that do employ syngas, they produce 13 excess hydrogen that's required – you don't 14 need that much hydrogen for the methanol or the 15 hydrocarbon. 16 So the prior art just focuses 17 on how to use that excess hydrogen, as I said, 18 in a variety of ways. 19 Q. But you're acknowledging that 20 the prior art knew to use that excess hydrogen 21 to raise steam, electricity, and potentially 22 other chemicals. Right?
138 1 the low-carbon syngas for steam generation? 2 MR. COLLARD: Object to form. 3 A. It could potentially, but it's 4 not part of this process. The process 5 explicitly described in Figure 1 does not have 6 a steam generation unit. And my comments are 7 referring to Figure 1, specifically. 8 BY MR. PHILLIPS: 9 Q. So when you say "allowing the 10 plant to supply its own heat demand," is the 11 heat demand that you're referring to the 12 existing conventional heat demand if natural 13 gas were used to fire the same furnaces? 14 MR. COLLARD: Object to form. 15 A. As I said very specifically, 16 the heat demand is the heat required by the 17 auxiliary unit. 18 BY MR. PHILLIPS: 19 Q. In paragraph 40 of your 20 declaration, Exhibit 2007, you admit that 21 "prior art processes focused on efficient 22 utilization of this excess hydrogen to produce	140 1 MR. COLLARD: Object to form. 2 A. To restate: there is no excess 3 hydrogen in an ammonia plant. 4 This is very specific to 5 methanol and hydrocarbon production where there 6 is excess hydrogen. And in those processes, 7 there was – it was known to try to use that 8 excess hydrogen. 9 BY MR. PHILLIPS: 10 Q. By burning that hydrogen to 11 raise steam and power; right? 12 MR. COLLARD: Object to form. 13 A. Again, as stated here, yes, 14 there's examples of where they use it for 15 electricity, for other chemicals, for steam. 16 BY MR. PHILLIPS: 17 Q. But a POSA knew that you could 18 burn that hydrogen-rich stream. 19 MR. COLLARD: Object to form. 20 BY MR. PHILLIPS: 21 Q. That you could combust it in a 22 furnace in other processes, maybe not ammonia,

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Page 36 of 147

141 1 but in methanol or other processes. 2 Is that right? 3 A. Again, there -- 4 MR. COLLARD: Sorry. 5 Object to form. 6 A. They're saying they're using 7 hydrogen for those things. Exactly how they're 8 using it is not necessarily -- does not 9 necessarily involve using a furnace. 10 BY MR. PHILLIPS: 11 Q. How are they using the hydrogen 12 to produce steam then? 13 A. Again, if you just combust 14 hydrogen, steam is a byproduct. There's no 15 furnace -- there's no heat transfer involved. 16 It's just making steam, for example. 17 Q. How is using the excess 18 hydrogen used to produce electricity? 19 MR. COLLARD: Object to form. 20 A. As described elsewhere, you 21 know, the hydrogen can be added, in part, to a 22 gas turbine, which, again, is not a furnace	143 1 We are going off the record. 2 The time is 11:18. 3 (Recess taken.) 4 THE VIDEOGRAPHER: We are back 5 on the record. The time is 11:28 a.m. 6 BY MR. PHILLIPS: 7 Q. Dr. Wolden, before the break, 8 we were looking at paragraph 40 of your 9 declaration. 10 A. Yes. 11 Q. If a POSA knew to burn 12 CO2-depleted syngas to make clean power for a 13 methanol plant, wouldn't the POSA also know 14 that they could also burn CO2-depleted syngas 15 in any furnace to reduce CO2 emissions? 16 MR. COLLARD: Object to form. 17 A. Again, I don't think the term 18 "any furnace" is appropriate. 19 You have to have specially 20 designed furnaces typically for hydrogen- 21 depleted -- or hydrogen-enriched gas. 22 ///
142 1 under the definition of the '168 patent. 2 And it's used to turn a 3 turbine, which, in turn, turns a mechanical 4 apparatus, which, in turn, creates electricity. 5 BY MR. PHILLIPS: 6 Q. But you're saying that that was 7 known in the prior art to a POSA. Is that 8 right? 9 MR. COLLARD: Object to form. 10 A. It was known that hydrogen 11 could be, in part, used in a gas turbine to 12 produce electricity. 13 BY MR. PHILLIPS: 14 Q. And we discussed that earlier. 15 You wouldn't want to use pure hydrogen; right? 16 A. I wouldn't. 17 MR. PHILLIPS: I tell you what. 18 Do you want to take a break now? 19 MR. COLLARD: Sure. 20 MR. PHILLIPS: And I think what 21 I'd like to do -- 22 THE VIDEOGRAPHER: Stand by.	144 1 BY MR. PHILLIPS: 2 Q. Okay. So that's within the 3 skill of a person of skill in the art though -- 4 right? -- the design of those furnaces? 5 MR. COLLARD: Hold on. 6 Object to form. 7 A. I don't know. 8 You know, furnace design is a 9 very specialized technique, exactly how you do 10 burners and gas delivery and et cetera. And 11 I would not -- the details of that are not, 12 I think, something a POSA would know. 13 BY MR. PHILLIPS: 14 Q. So a POSA is not a specialized 15 engineer that would understand that? 16 A. Well, for this, we're talking 17 about this full process; right? 18 And a POSA wouldn't understand 19 the process, kind of what goes in and what goes 20 out of each stages. But the intimate operation 21 of any stage -- whether it's a furnace or a 22 reformer, or a, you know, compressor -- pick

Conducted on July 23, 2026

145 1 your unit -- those are very specialized things. 2 And I don't think a POSA would know exactly how 3 to do that. 4 Q. But a POSA would appreciate the 5 issues; right? 6 MR. COLLARD: Object to form. 7 A. A POSA would understand, again, 8 the general process and what might be possible. 9 How to do it, not exactly. 10 BY MR. PHILLIPS: 11 Q. Are you familiar with EPC 12 companies? 13 A. I don't know -- 14 MR. COLLARD: Object to form. 15 BY MR. PHILLIPS: 16 Q. Engineering, procurement, and 17 construction companies? 18 A. I'm not familiar with that 19 acronym. But, yes, of course, there's 20 engineering companies. 21 Q. So companies like Fluor Daniel 22 or KBR, companies like that, are you familiar	147 1 though. 2 At one of those EPC companies, 3 you have process engineers and you have 4 engineers that specialize in designing pieces 5 of equipment like furnaces. Is that right? 6 MR. COLLARD: Object to form. 7 A. Again, I haven't worked at one 8 of those, but I would expect they probably have 9 a whole diverse set of people at those 10 companies. 11 BY MR. PHILLIPS: 12 Q. And you would expect that they 13 would work together to design a plant like 14 this; right? 15 MR. COLLARD: Object to form. 16 A. You know, I don't know the 17 internal operations of those firms. I can't 18 speak to it. 19 BY MR. PHILLIPS: 20 Q. So if you're making 1 kilogram 21 of ammonia in an ammonia synthesis plant, that 22 1 kilogram of ammonia is going to require X
146 1 with those type of companies? 2 A. Yes, I'm familiar with those 3 specific companies. Yeah. 4 Q. So those companies have process 5 engineers? 6 A. Um-hmm. 7 Q. And would you agree, those 8 would be POSAs in designing a process for an 9 ammonia synthesis plant? 10 MR. COLLARD: Object to form. 11 A. I think those are major 12 companies that have a whole host of different 13 people; some who are -- you know, lay out a 14 process on a computer and have absolutely no 15 idea on what those boxes are. And they have 16 very specialized people who take into account 17 how to do the intricacies of those individual 18 unit and operations. 19 So one person knowing all that, 20 I don't expect to. 21 BY MR. PHILLIPS: 22 Q. But that's where I was going,	148 1 kilojoules of energy. 2 Would you agree with that? 3 MR. COLLARD: Object to form. 4 A. It's going to require some 5 amount of energy. I don't know what that value 6 is. 7 BY MR. PHILLIPS: 8 Q. But it's just math. That could 9 be calculated -- 10 MR. COLLARD: Object to form. 11 BY MR. PHILLIPS: 12 Q. -- for a process, right? 13 A. For a specific process. Of 14 course, it could vary from process to process, 15 depending on what unit operations are involved 16 and how it's operated. 17 Q. So the energy that's required 18 to make a kilogram of ammonia, for example, 19 that energy is in the form of process-fired 20 heaters, for example. Right? 21 MR. COLLARD: Object to form. 22 I'm sorry. The energy is in

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Page 38 of 147

Conducted on July 23, 2026

149 1 the form of -- 2 BY MR. PHILLIPS: 3 Q. So the energy is provided -- 4 MR. PHILLIPS: I'll give you a 5 list. I didn't want you to object to the full 6 list. 7 BY MR. PHILLIPS: 8 Q. But energy to make a kilogram 9 of ammonia is provided by process-fired 10 heaters, steam made from fired heaters, power 11 made from fired heaters. 12 Do you agree with that? 13 MR. COLLARD: I don't mean to 14 be pedantic, but you're saying they use the 15 energy or provide the energy? 16 MR. PHILLIPS: Actually, I'll 17 ask that question. 18 BY MR. PHILLIPS: 19 Q. To make a kilogram of ammonia 20 requires that you -- 21 MR. COLLARD: Okay. I'm going 22 to let you --	151 1 A. There is energy required to 2 make ammonia. Exactly how that is provided 3 depends on the specific process involved and 4 could involve the things you mentioned. It 5 could also probably involve other sources of 6 energy. 7 BY MR. PHILLIPS: 8 Q. What other sources of energy 9 could it involve? 10 MR. COLLARD: Object to form. 11 A. Renewal electricity, heat from 12 nuclear plants. Lots of different types of 13 energy. 14 BY MR. PHILLIPS: 15 Q. So have you ever seen a 16 chemical plant in southeast Texas that has a -- 17 that gets its energy from a nuclear plant? 18 MR. COLLARD: Object to form. 19 A. I unfortunately have never been 20 to southeast Texas to look at plants. I could 21 not speak to that. 22 ///
150 1 BY MR. PHILLIPS: 2 Q. -- you need the energy to make 3 that kilogram of ammonia. Is that right? 4 MR. COLLARD: This is my fault, 5 because I messed up your question. 6 Do you mind asking a new 7 question, and we can go from that question? 8 I apologize. 9 MR. PHILLIPS: Sure. 10 BY MR. PHILLIPS: 11 Q. Hypothetical. We're making a 12 kilogram of ammonia. It's going to require a 13 certain amount of energy. 14 Do you agree with that? 15 A. I agree with that. 16 Q. Okay. So that energy is going 17 to be -- the energy required to make that 18 kilogram of ammonia, that comes from process- 19 fired heaters, steam made from fired heaters, 20 and power made from fired heaters. 21 Do you agree with that? 22 MR. COLLARD: Object to form.	152 1 BY MR. PHILLIPS: 2 Q. So ExxonMobil, for example, has 3 a massive chemical and refining complex at 4 Baytown, Texas. 5 Do they have wind turbines in 6 their plant to provide electricity? 7 MR. COLLARD: Object to form. 8 A. I can't -- I don't know. 9 There is -- Texas is one of the 10 biggest wind-producing states. Possibly 11 they're using that. I don't know. 12 BY MR. PHILLIPS: 13 Q. If a POSA already knows that 14 you can burn CO2-depleted syngas to make clean 15 power and clean steam, isn't it obvious to also 16 burn CO2-depleted syngas in other furnaces to 17 also reduce CO2 emissions? 18 A. Can you restate that? 19 MR. COLLARD: Hold on. 20 Object to form. 21 Go ahead. 22 A. Could you restate the question?

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Page 39 of 147

Conducted on July 23, 2026

153 1 I didn't -- you're making 2 assumptions on what a POSA would know. I want 3 to make sure I understand what you are 4 presuming the POSA knows. 5 BY MR. PHILLIPS: 6 Q. Sure. 7 If the POSA also already knows 8 that you can burn CO2-depleted syngas to make 9 clean power and clean steam, then isn't that 10 obvious to also burn CO2-depleted syngas in 11 other furnaces to also reduce CO2 emissions? 12 MR. COLLARD: Object to form. 13 A. Again -- so, I mean, the 14 premises in that -- you know, using 15 hydrogen-depleted fuel is not common for a 16 POSA. 17 So I really don't know. 18 BY MR. PHILLIPS: 19 Q. But earlier you testified that 20 hydrogen-rich streams like PSA tail gas were 21 used in the prior art to fire furnaces. 22 Do you remember that testimony?	155 1 greater than 50 percent. 2 Do you remember that? 3 MR. COLLARD: Object to form. 4 A. I do remember that. 5 Again, that's very different 6 than the 99 percent hydrogen that's coming -- 7 that is what's defined in the '168 as the 8 CO2-depleted gas. 9 BY MR. PHILLIPS: 10 Q. But you'll agree that a -- even 11 a 50 percent hydrogen stream would have less 12 CO2 emissions than burning just natural gas in 13 a furnace. 14 Do you agree with that? 15 MR. COLLARD: Object to form. 16 A. Again, the composition of these 17 waste streams is much more than just hydrogen. 18 It could have methane. It could have other 19 things. 20 If the question is specifically 21 a mixture of methane and hydrogen, yes, I would 22 have less CO2 than a mixture than just pure
154 1 MR. COLLARD: Object to form. 2 Object to characterization of prior testimony. 3 A. Yes, I -- tail gases, I would 4 distinguish from hydrogen-rich gases. Those 5 are two very different things. 6 So a tail gas -- waste gases 7 from, you know, PSA, hydrogen recovery units, 8 et cetera, they have been burned. But this is 9 -- this very hydrogen-rich -- or CO2-depleted 10 gas -- I'm sorry -- to use the right 11 language -- is something very different. 12 BY MR. PHILLIPS: 13 Q. So are you saying that a PSA 14 tail gas is not a CO2-depleted gas? 15 MR. COLLARD: Object to form. 16 A. It is CO2 depleted, but it's 17 not -- it's a very different compensation than 18 the CO2-depleted gas as defined in the 19 '168 patent, which is primarily hydrogen. 20 BY MR. PHILLIPS: 21 Q. Earlier you testified that the 22 PSA tail gas could have a hydrogen composition	156 1 methane. 2 But, again, I don't know the 3 composition of these waste gases that you're 4 discussing. 5 BY MR. PHILLIPS: 6 Q. And that was known before 2017; 7 right? 8 MR. COLLARD: Object to form. 9 What was known? 10 Object to form. 11 A. Burning hydrogen releases less 12 CO2 than burning natural gas. 13 BY MR. PHILLIPS: 14 Q. And a POSA knew that before 15 2017; right? 16 MR. COLLARD: Object to form. 17 A. Yes, a person would know that 18 there's no carbon produced from burning 19 hydrogen. 20 BY MR. PHILLIPS: 21 Q. You said you hadn't reviewed 22 Topsoe's invalidity contentions in the

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Page 40 of 147

Conducted on July 23, 2026

157 1 co-pending litigation. Right? 2 A. Yes. I'm not aware of that. 3 Q. So I will represent to you that 4 Topsoe provided process-flow diagrams going 5 back to the 1980s, where a CO2-depleted syngas 6 stream in an ammonia synthesis plant, upstream 7 stream of a methanator, is fired in a 8 traditional stream methane reformer. 9 Would that surprise you? 10 MR. COLLARD: Object to form. 11 A. I really don't know. I don't 12 know. 13 I don't know what Topsoe does, 14 what they did. I really only -- my extent of 15 Topsoe is what's provided in the 2007 IFA. 16 BY MR. PHILLIPS: 17 Q. Would it surprise you that a 18 CO2-depleted syngas was burned in a steam 19 reformer going back to the 1980s? 20 MR. COLLARD: Object to form. 21 A. Again, I was in -- I don't know 22 what was going on in the 1980s.	159 1 Objection. Form. 2 A. I've been around a long time. 3 Nothing surprises me much anymore. 4 BY MR. PHILLIPS: 5 Q. I have another question about 6 the flow sheet, so Figure 1, for example, of 7 the '168 patent that you depicted after 8 paragraph 42 in your declaration. 9 A. Yeah. 10 Q. I just want to confirm that the 11 CO2 split for fuel, whenever it is burned in 12 the ammonia plant, does not affect the process 13 flow sheet upstream of that split. 14 Would you agree with that? 15 MR. COLLARD: Object to form. 16 A. So specifically you're talking 17 the -- when you take the hydrogen off at stream 18 14, that doesn't affect the prereformers and 19 the shift reactor and the carbon removal step? 20 BY MR. PHILLIPS: 21 Q. The process side of those 22 units.
158 1 BY MR. PHILLIPS: 2 Q. But you know what was going on 3 prior to 2017. 4 A. The 1980s are much before 2017. 5 Q. Would it surprise you if you 6 found out that there's process-flow diagrams 7 predating 2017 that show a CO2-depleted syngas 8 in an ammonia synthesis plant fired in a 9 traditional steam methane reformer? 10 MR. COLLARD: Object to form. 11 A. I really don't feel like 12 speculating on it. I don't know what we're 13 talking about, so... 14 BY MR. PHILLIPS: 15 Q. Well, but you're a POSA, 16 though. 17 I just want to know -- you're a 18 POSA as of 2017. I just want to know if that 19 would shock you, that prior art like that 20 exists. 21 MR. COLLARD: He answered your 22 question.	160 1 Is that correct? 2 MR. COLLARD: Object to form. 3 A. Yes, those units would 4 generally be used to make hydrogen. 5 BY MR. PHILLIPS: 6 Q. In the same way that a 7 conventional ammonia synthesis plant would do 8 the same. Is that right? 9 A. It's one -- 10 MR. COLLARD: Sorry. 11 Object to form. 12 A. It's -- as I said before, it's 13 one of the many ways to do the reforming 14 process, yeah. 15 BY MR. PHILLIPS: 16 Q. I just want to confirm, though, 17 that using CO2-depleted syngas as the fuel 18 doesn't change the process. 19 MR. COLLARD: Object to form. 20 A. Yes, the basic process steps 21 are not impacted by the fuel employed. 22 ///

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Page 41 of 147

Conducted on July 23, 2026

161 1 BY MR. PHILLIPS: 2 Q. It's just a different way to 3 provide the duty -- 4 MR. COLLARD: Object -- 5 BY MR. PHILLIPS: 6 Q. -- for the furnace that you're 7 using that fuel for. Is that right? 8 A. That's correct. 9 Q. At the point where you take 10 the -- you split that CO2 fuel fraction from 11 the process, do you know the point I'm talking 12 about? 13 A. Are you talking about 14? Are 14 you talking about -- 15 Q. Yeah. Let's look at -- with 16 respect to Figure 1, yes, at the point where 17 stream 12 splits into stream 14 and stream 18. 18 A. Yes. 19 Q. If you take, let's say, 20 40 percent of stream 12 and you diverted 21 40 percent to stream 14 and 60 percent to 22 stream 18, does that mean you're going to	163 1 MR. COLLARD: Object to form. 2 Object to scope. 3 A. More -- whenever you use more 4 of anything, it's going to cost more. 5 But would it impact the 6 economics? Again, this is a question I don't 7 know. It goes to your questions about tax 8 incentives. 9 If the tax incentives make 10 that -- you know, offset that, maybe it's 11 economically viable. But I'm not an expert on 12 that, and I can't speak to that. 13 BY MR. PHILLIPS: 14 Q. You didn't do those 15 calculations, though, regarding economics; 16 right? 17 MR. COLLARD: Object to form. 18 A. As I just said, I'm not an 19 expert on that. I don't know the tax code. 20 I don't know those implications. 21 So, no, I did not. 22 ///
162 1 use -- you're going to make 40 percent less 2 ammonia in the process? 3 MR. COLLARD: Object to form. 4 A. In general, I think that would 5 be true, because the stream 12 which contains 6 the hydrogen that would go to the synthesis 7 plant. And if you take 40 percent of it away, 8 there would be 40 percent less to make ammonia. 9 BY MR. PHILLIPS: 10 Q. So in order to maintain an 11 ammonia capacity for the plant, you would need 12 to scale up the entire front end of the plant 13 upstream of that split. Is that right? 14 MR. COLLARD: Object to form. 15 A. Yes, I think that's exactly 16 what's disclosed in the '168 patent, is that 17 they increase their supply in order to 18 compensate for that. 19 BY MR. PHILLIPS: 20 Q. So that would be a significant 21 CapEx hit to a project's economics, wouldn't 22 it?	164 1 BY MR. PHILLIPS: 2 Q. Correct me if I'm wrong, but 3 doesn't methane have about 3.3 times the 4 heating value of hydrogen on a volumetric 5 basis? 6 MR. COLLARD: Object to form. 7 A. That's approximately true. 8 I don't know the exact number, 9 but the factor of 3 is about right. 10 BY MR. PHILLIPS: 11 Q. So you need a much higher 12 volumetric flow rate of hydrogen to deliver the 13 same heat input to a furnace as methane would 14 require. Is that right? 15 A. You're required -- 16 MR. COLLARD: Yeah, object to 17 form. 18 Go ahead. 19 A. Yes, for the same calorific 20 heating value, you need to supply more hydrogen 21 than methane. 22 ///

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Page 42 of 147

165 1 BY MR. PHILLIPS: 2 Q. So that's a significant OpEx 3 hit to a project's economics, isn't it? 4 MR. COLLARD: Object to form. 5 A. Again, as I said, you use more 6 stuff, it costs more money. 7 But, again, not knowing the tax 8 implications and other things like that, it may 9 not affect the overall economics or it may 10 affect it positively. I don't know. 11 BY MR. PHILLIPS: 12 Q. But that makes the tax 13 implications important, doesn't it? 14 MR. COLLARD: Object to scope. 15 I object to form. 16 A. Again, the objective -- the 17 economics are a very complex question. And 18 there's integration with other plants, other 19 things that I, you know, just simply don't 20 know. 21 BY MR. PHILLIPS: 22 Q. So in a conventional plant that	167 1 BY MR. PHILLIPS: 2 Q. And you need three times more 3 of that than the methane that you backed out. 4 MR. COLLARD: Same objections. 5 A. You need additional hydrogen to 6 supply the same amount of heat. 7 BY MR. PHILLIPS: 8 Q. I'm just trying to understand 9 if you agree with me that the tax implications 10 are important to justify all the extra 11 expense -- CapEx and OpEx expense -- with 12 reducing CO2 emissions in the manner described 13 by the '168 patent. 14 MR. COLLARD: Object to form 15 and scope. 16 A. In general, dumping pollutants 17 into the atmosphere is a lot cheaper than doing 18 a clean process, yes. 19 BY MR. PHILLIPS: 20 Q. And they depend on the 21 government in order to help make the economics 22 right sized for these type of capital projects.
166 1 burns methane, the plant's going to cost a 2 certain amount and it's going to operate with a 3 certain OpEx cost. 4 You agree with that; right? 5 MR. COLLARD: Object to form 6 and scope. 7 A. A plant with a given size is 8 going to have a different OpEx and a CapEx, 9 sure. 10 BY MR. PHILLIPS: 11 Q. So we're going to take some of 12 that natural gas fuel. We're going to run it 13 through a preheater, two reformers, a water-gas 14 shift, and a CO2 removal unit. And then we're 15 going to take 40 percent of that and we're 16 going to burn it. 17 That's sounds expensive, 18 doesn't it? 19 MR. COLLARD: Object to form 20 and scope. 21 A. Again, I don't know. 22 ///	168 1 You agree? 2 MR. COLLARD: Object to form. 3 Object to scope. 4 A. Again, I really don't know. 5 For example, our Excel -- our 6 local electricity company allows you to pay 7 different rates for renewable versus 8 carbon-based electricity. And the consumers 9 demand it sometimes. 10 So it's not -- I don't think 11 it's exclusively a question of government, but 12 consumers and probably a whole host of other 13 things that I don't pretend to understand 14 fully. 15 BY MR. PHILLIPS: 16 Q. So blue ammonia and blue 17 hydrogen, you suggest, may command a higher 18 price on the market. 19 MR. COLLARD: Object to form. 20 Object to scope. 21 A. Again, I'm not an economics 22 expert. I don't know.

169 1 BY MR. PHILLIPS: 2 Q. But the people investing in the 3 plants are, presumably; right? 4 MR. COLLARD: Object to form 5 and scope. 6 A. Again, I don't know the 7 investor class as well. I can't -- again, 8 I can't speak on their motivations or 9 expectations. 10 BY MR. PHILLIPS: 11 Q. Where I'm getting at, though, 12 is: A POSA may not appreciate the economics, 13 but his boss is going to tell him what he needs 14 to do in terms of CO2 emissions in order for 15 this project to work. 16 I mean, you'd agree with that; 17 right? 18 MR. COLLARD: Object to form 19 and scope. 20 A. Again, I don't know what's 21 going on in these plants or what the objective 22 of the company is or things like that. These	171 1 MR. COLLARD: Object to form 2 and object to scope. 3 You know, once again, you've 4 got to get closer to his opinion soon. 5 MR. PHILLIPS: We're getting 6 there. 7 MR. COLLARD: Okay. 8 A. Again, can you restate? 9 I don't exactly follow what 10 you're saying about a POSA here. 11 BY MR. PHILLIPS: 12 Q. Isn't a POSA economically 13 motivated to burn the CO2-depleted syngas in 14 the same manner that he already knew how to do 15 prior to 2017? 16 MR. COLLARD: Object to form 17 and scope. 18 A. Again, I would distinguish the 19 tail gas emissions that you're talking about 20 from, say -- a PSA unit or the hydrogen 21 recovery unit are very different from the 22 CO2-depleted gas here. So I don't think so.
170 1 are things I can't really comment on. 2 BY MR. PHILLIPS: 3 Q. I'm just trying to understand 4 if the CO2 emissions are important. 5 MR. COLLARD: Object to form. 6 A. In general, CO2 emissions are 7 destroying this planet; so, yes, I think 8 they're important. 9 BY MR. PHILLIPS: 10 Q. Does the '168 patent represent 11 a technological innovation or an economic 12 innovation? 13 MR. COLLARD: Object to form 14 and scope. 15 A. I think it pertains to 16 innovations of both technology and environment 17 and economics. 18 BY MR. PHILLIPS: 19 Q. Isn't a POSA economically 20 motivated to burn the CO2-depleted syngas in 21 the same manner that he already knew how to do 22 prior to 2017?	172 1 BY MR. PHILLIPS: 2 Q. If a CO2-depleted syngas was 3 used to fuel a steam methane reformer going 4 back to the 1980s in an ammonia synthesis 5 plant, wouldn't you agree with me that that is 6 prior knowledge of a POSA, in terms of the 7 ability to use these type of hydrogen-rich 8 streams? 9 MR. COLLARD: Object to form -- 10 object to form. 11 Go ahead. 12 A. Again, I can't speak on what 13 was known in the industry in the '80s. 14 And, again, you're being very, 15 I think, liberal with your definition of 16 "CO2-depleted gas." There are very different 17 types, and I would not -- they cannot be thrown 18 in the same bucket and treated equally, in my 19 opinion. 20 BY MR. PHILLIPS: 21 Q. So if I showed you a flow 22 diagram where Topsoe used a steam methane

Conducted on July 23, 2026

173 1 reformer, followed by a water-gas shift 2 reactor, followed by CO2 removal and split some 3 of that CO2-depleted syngas to burn in a steam 4 methane reformer, isn't that the same 5 application that we're talking about here in 6 the '168 patent? 7 MR. COLLARD: Object to form -- 8 object to the form of that question. 9 If you understand, you can 10 answer. 11 A. You know, I can't comment 12 without seeing -- as you've seen, these 13 diagrams are all very different in their 14 details. And without seeing the specific 15 diagram, I can't really comment. 16 BY MR. PHILLIPS: 17 Q. Okay. But the way I described 18 it, though, wouldn't that suggest that -- 19 A. Again, I don't think you can 20 describe it accurately enough for me to make a 21 comment. 22 Q. Okay. In paragraph 25 of your	175 1 BY MR. PHILLIPS: 2 Q. The very next sentence in 3 paragraph 25 where we read from, "These 4 apparatus, which operate by means of 5 combustion, are identified by the term 'fired 6 heater.'" 7 A. Um-hmm. 8 Q. Do you see that? 9 A. We're on what paragraph, 10 exactly? 11 Q. I'm sorry. Paragraph 25. 12 A. Oh. Sorry. 13 Q. It was just the next sentence. 14 A. Paragraph 25 or page 25? 15 Q. Paragraph 25 of your report. 16 A. Sorry. I was on the wrong -- 17 I was on the wrong place. That showed up a 18 couple places in here. 19 Yeah. Okay. So I'm reading 20 the right paragraph now. Yes. 21 So, yes, that was -- again, 22 this is the '168 patent owner's definition.
174 1 report -- and this is Exhibit 2007 -- you state 2 that "...the term 'furnace' should be construed 3 as: 'an apparatus chosen from among: a steam 4 reformer or a charge preheater or a steam 5 generator or a steam superheater." 6 Is that right? 7 A. Yes. I'm just simply repeating 8 the definition of a furnace in the '168 9 patent -- as defined by the authors of the 10 '168 patent. 11 Q. And that's how you view the 12 term "furnace" should be construed for purposes 13 of this -- 14 A. For the purposes of the 15 '168 patent, yes. 16 Q. Question: What is a steam 17 generator? 18 MR. COLLARD: Object to form. 19 A. Typically a steam generator is 20 a -- involves combustion heating water, and 21 that heat from combustion converts that water 22 into steam.	176 1 They called -- they lumped those four things 2 together as a fired heater. 3 BY MR. PHILLIPS: 4 Q. But down below that, two 5 sentences, you state, "I understand patent 6 owner submits that the term 'furnace' should be 7 construed as" -- 8 A. Those four things, yes. 9 Q. -- those four things, but 10 omitted the next sentence from the column 2. 11 Right? "These apparatus, which operate by 12 means of combustion, are identified by the term 13 'fired heater.'" 14 Why was that sentence omitted 15 from the construction? 16 MR. COLLARD: Object to form. 17 A. Again, these are the terms. 18 There was no means to omit anything. 19 Both the term "fired heater" 20 and their definition of the furnace are -- 21 again, I'm just pulling those out from the 22 '168 patent.

Conducted on July 23, 2026

177 1 BY MR. PHILLIPS: 2 Q. Is the specification equating 3 the term "furnace" with "fired heater"? 4 MR. COLLARD: Object to form. 5 A. May I turn to the '168 patent? 6 BY MR. PHILLIPS: 7 Q. Sure. So that's Exhibit 1001. 8 A. (Document[s] reviewed.) 9 If you look at column 2, 10 I guess it's about 47, this is -- I'm just 11 repeating exactly what's in these lines. "The 12 term 'furnace' is understood as meaning an 13 apparatus chosen from among: a steam" -- 14 MR. COLLARD: You have to 15 slow -- slower. 16 THE DEPONENT: Oh. Sorry. 17 Sorry. 18 MR. COLLARD: We tend to read 19 very fast, so go slower. 20 THE DEPONENT: I apologize. 21 I'll repeat. 22 A. "The term 'furnace' is	179 1 MR. COLLARD: Object to form. 2 A. In general, I do not think that 3 is the case. But, again, we're going with the 4 lexicography of this patent; and it defines it 5 that way. 6 BY MR. PHILLIPS: 7 Q. Well, on the issue of 8 lexicography, I'm just trying to understand why 9 y'all stopped after the first sentence and 10 didn't include the second sentence in the 11 lexicography. 12 That's really the issue, 13 I guess, at hand in this case -- right? -- is 14 the next sentence. Right? 15 "These apparatus, which operate 16 by means of combustion, are identified by the 17 term 'fired heater.'" 18 So does the specification of 19 the '168 patent equate the term "furnace" with 20 "fired heater"? 21 MR. COLLARD: Object to form. 22 Asked and answered.
178 1 understood as meaning an apparatus chosen from 2 among: a steam reformer or a charge preheater 3 or a steam generator or a steam superheater. 4 These apparatus, which operate by means of 5 combustion, are identified by the term 'fired 6 heater.'" 7 So, again, "fired heater" is 8 just a simplified way of saying those four 9 items. That was all I was trying to say in 10 that paragraph 25. 11 BY MR. PHILLIPS: 12 Q. So is the specification 13 equating the term "furnace" with "fired 14 heater"? 15 MR. COLLARD: Object to form. 16 A. The patent owner's -- their 17 definition of "furnace," they equate -- they're 18 using the term "fired heater" to match their 19 definition of "furnace," is how I read it. 20 BY MR. PHILLIPS: 21 Q. So were all furnaces fired 22 heaters?	180 1 (Pause.) 2 MR. COLLARD: You can go ahead. 3 THE DEPONENT: Oh. Sorry. 4 A. Again, the patent owners equate 5 "fired heaters" with their four specific 6 definitions of the furnace. 7 BY MR. PHILLIPS: 8 Q. So it's your testimony that all 9 furnaces are not fired heaters? Is that right? 10 MR. COLLARD: Object to form. 11 A. Again, in general, furnace has 12 a much larger definition. 13 But, again, for the purposes of 14 the '168 patent, the authors of that patent 15 made a very specific definition of what furnace 16 and fired heaters encompasses. 17 BY MR. PHILLIPS: 18 Q. What do you understand the -- 19 you described it as the larger definition of 20 the word "furnace." 21 What is your understanding of 22 the meaning of the word "furnace" to a POSA?

Conducted on July 23, 2026

181 1 MR. COLLARD: Wait. 2 Object to form. 3 And, I'm sorry, I do think we 4 need to clarify your question because you 5 started by saying the larger term and then you 6 said a POSA, which indicates it's tied to the 7 patent because that's how the patent is 8 interpreted. 9 So I just think we need to be 10 clear if you're tying it to the patent or if 11 you want something separate from the patent. 12 BY MR. PHILLIPS: 13 Q. Outside of the '168 patent -- 14 MR. COLLARD: Okay. 15 BY MR. PHILLIPS: 16 Q. -- what does a POSA believe the 17 term "furnace" to mean? 18 MR. COLLARD: All right. Thank 19 you. 20 A. Again, in general, a furnace 21 consists of basically two operations: a 22 combustion unit, which creates heat; and a heat	183 1 MR. COLLARD: Object to form. 2 A. Again, as -- are we talking 3 about the -- in general or talking about the 4 '168 -- 5 BY MR. PHILLIPS: 6 Q. In general. 7 A. Okay. Because those are -- 8 yes. Yes, it's a furnace. A fired heater is 9 a -- I think most people would say is a type of 10 furnace. Because, as you said, it's doing the 11 firing and doing the heating. 12 Q. Which is what you were saying 13 in terms of combustion and transferring the 14 heat. 15 A. Yes. Yes. 16 Q. So that would be fired heater. 17 A. Yeah. Combustion fired -- 18 equals fired heater equals heat exchanger, yes. 19 Q. Just so that we -- just to 20 clear the record, you understand that Topsoe's 21 position is that lexicography should not apply 22 to the definition of furnace.
182 1 exchanger, which transfers that heat from the 2 combustion gases to another fluid. 3 I think that's the more -- most 4 basic kind of general definition. 5 BY MR. PHILLIPS: 6 Q. Isn't that what the word "fired 7 heater" means? 8 I mean, the word "fired" is 9 combustion and the word "heater" is 10 transferring heat. 11 Is "fired heater" equivalent to 12 what you think the ordinary meaning of 13 "furnace" is? 14 MR. COLLARD: Object to form. 15 A. Yes, a fired heater is a 16 specific example that I think fits into the 17 general description of a furnace. It's one of 18 the many options that you could use as a 19 furnace. 20 BY MR. PHILLIPS: 21 Q. So a fired heater is a type of 22 furnace.	184 1 Do you understand that? 2 A. I also -- 3 MR. COLLARD: Sorry. 4 Object to form. 5 A. I don't know what Topsoe says 6 about anything outside of what's in Ritter's 7 deposition. 8 BY MR. PHILLIPS: 9 Q. Well, you understand from 10 Ritter's declaration and deposition that he 11 believes furnace should be given its ordinary 12 meaning. 13 Do you agree with that? 14 MR. COLLARD: Object to form. 15 A. Again, terms should be given 16 their ordinary meaning in interpreting patents. 17 And the '168 is -- goes -- I think that's why 18 the '168 patent goes to very -- be very 19 explicit on what its definition of a furnace 20 is, being those -- limiting it to those four 21 items. 22 ///

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Page 47 of 147

Conducted on July 23, 2026

185 1 BY MR. PHILLIPS: 2 Q. The reason I'm exploring the 3 ordinary meaning of "furnace" is because Topsoe 4 disagrees with the lexicography argument. 5 A. Yes. 6 Q. Which brings us to a world of 7 what is a furnace. 8 So that's why I wanted to 9 explore what your understanding of the word 10 "furnace" is generally, not outside the context 11 of lexicography. So that was the purpose. 12 A. Sure. Okay. 13 Q. So if I understand you right, 14 all furnaces operate by means of combustion. 15 MR. COLLARD: Object to form. 16 A. And I would say that's actually 17 not true. 18 BY MR. PHILLIPS: 19 Q. Okay. 20 A. You can have electrical 21 furnaces -- right? -- where electricity is used 22 to provide the heat, which is then transferred	187 1 A. Yep. 2 Q. Again, this is Exhibit 2007. 3 You state that "A furnace is a relatively 4 simple unit that involves combustion of fuel 5 followed by the transfer of thermal energy from 6 the hot combustion gas to another fluid." 7 Do you see that? 8 A. Yep. 9 Q. So you believe that a furnace 10 has a functional requirement, that it transfers 11 thermal energy? 12 Is that accurate? 13 MR. COLLARD: Object to form. 14 A. I would state that a furnace's 15 principal objective is heating another fluid. 16 BY MR. PHILLIPS: 17 Q. So I asked you earlier what's a 18 steam generator, because that's in the list. 19 A. Yeah. 20 Q. Is any apparatus that burns 21 fuel and transfers heat to water to raise steam 22 a steam generator and therefore a furnace
186 1 to another fluid. 2 Q. Okay. Do all fired heaters 3 operate by means of combustion? 4 MR. COLLARD: Object to form. 5 A. Again, it's -- when you say 6 "all," you get -- as a professor, you get 7 nervous about exceptions. But when you say 8 "fired," that generally implies combustion. 9 BY MR. PHILLIPS: 10 Q. And you would agree with the 11 '168 patent, that the list of four specific 12 furnaces that it identifies, those all operate 13 by combustion. 14 You'd agree with that? 15 MR. COLLARD: Object to form. 16 A. I would agree, yes, as defined, 17 yes, those four things operate principally by 18 combustion or combustion is a part of their 19 operation. 20 BY MR. PHILLIPS: 21 Q. So in paragraph 26 of your 22 report --	188 1 within the meaning of the '168 patent? 2 MR. COLLARD: Object to form. 3 A. So, again, I think a steam 4 generator has two inputs, one is liquid water 5 and one is the combustion source to provide the 6 heat. And that water is transformed into 7 steam. 8 BY MR. PHILLIPS: 9 Q. Also in paragraph 26, the last 10 sentence, you state that "A gas turbine" -- 11 actually, I'm going to back up. Scratch that. 12 Earlier in paragraph 26, you 13 state that "A turbine is a much more complex 14 device. In a turbine, air is typically 15 compressed, combusted with fuel at elevated 16 pressure, but instead of transferring heat, the 17 energy is converted first into mechanical 18 energy and secondly into electrical energy." 19 Do you see that? 20 A. Yes. 21 Q. And then the last sentence of 22 paragraph 26, you state that "A gas turbine

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Page 48 of 147

Conducted on July 23, 2026

189 1 (which is intended to generate electricity) is 2 not a 'furnace' as defined in the specification 3 or based on the ordinary and customary 4 understanding of a person of ordinary skill 5 (which is intended to generate heat and 6 transfer it to another fluid)." 7 You see that; right? 8 A. Yep. 9 Q. Why do you limit your 10 discussion to just gas turbine? 11 MR. COLLARD: Object to form. 12 A. I think I was responding to the 13 Ritter – the Ritter – the expert on your 14 side, who specifically equated a gas turbine to 15 a furnace. So I was basically rebutting his 16 opinion, is why I specifically focused. 17 I mean, it could include other 18 things. I could say a car is not a furnace. 19 I don't know anyone would consider a car a 20 furnace, even though combustion is part of it. 21 But I did not expand on all the other things 22 that aren't furnaces.	191 1 A. Heat recovery steam generation. 2 Q. We'll go with HRSG. 3 THE DEPONENT: We'll call it 4 HRSG, if that works for you. 5 THE STENOGRAPHER: Yep. 6 Thanks. 7 THE DEPONENT: Sure. 8 BY MR. PHILLIPS: 9 Q. So you believe that the gas 10 turbine and the HRSG are different pieces of 11 equipment? 12 A. Certainly. You don't need a 13 HRSG to create electricity. 14 Q. But do you need a HRSG to -- 15 scratch that. 16 In a gas turbine, when you 17 generate electricity, what happens to the 18 exhaust gas? 19 MR. COLLARD: Object to form. 20 A. In general – again, so the gas 21 that goes in is pressurized, gets combusted. 22 And it primarily loses its energy by turning
190 1 BY MR. PHILLIPS: 2 Q. Was Dr. Ritter pointing to a 3 gas turbine or was he referring to a gas 4 turbine with a heat recovery steam generator? 5 MR. COLLARD: Object to form. 6 MR. PHILLIPS: HRSG. 7 A. So he was referring – well, if 8 he's referring to the 2007 IFA -- 9 BY MR. PHILLIPS: 10 Q. Okay. 11 A. -- it is a gas turbine. And 12 then the unit that you mentioned follows that. 13 It's downstream of the gas turbine. 14 But the fuel is supplied only 15 to the gas turbine, not to the heat recovery -- 16 heat – I forget exactly what the terminology 17 is. 18 Q. So we're going to call it 19 "HRSG." 20 A. HRSG. 21 Q. I think that's what the cool 22 people at Topsoe and Casale call it.	192 1 the turbines. Right? And it comes out at a 2 much lower pressure and temperature. 3 BY MR. PHILLIPS: 4 Q. Do you have any sense for what 5 that temperature is? 6 MR. COLLARD: Object to form. 7 A. Again, it's definitely cooler 8 than the combustion of the gases going in, but 9 it, again, depends on the exact operation of 10 the turbine. 11 BY MR. PHILLIPS: 12 Q. But it's hot enough to raise 13 superheated steam in a HRSG; right? 14 MR. COLLARD: Object to form. 15 A. It potentially has a -- 16 depending, again, how it's operated and how 17 much air is used and other diluents, it could 18 potentially – yes, you only need a 19 hundred degrees to generate steam. Yeah. 20 BY MR. PHILLIPS: 21 Q. Would it surprise you if I told 22 you that the exhaust gas for a gas turbine

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Page 49 of 147

Conducted on July 23, 2026

193 1 operates around 600 degrees C? 2 MR. COLLARD: Object to form. 3 A. That would not surprise me. 4 I'm sure there's a range. But that's not an 5 unreasonable number. 6 BY MR. PHILLIPS: 7 Q. Is that enough to generate 8 steam? 9 A. Certainly. Yes. 10 Q. Is that similar to the 11 temperature found in a steam-generating 12 furnace? 13 MR. COLLARD: Object to form. 14 A. I would think it's 15 significantly lower. 16 In a steam-generating furnace, 17 you have the combustion that -- which, as we 18 talked about, can be between 1000 and 19 2000 degrees Cs. Combustion gases are much 20 hotter than the gases that come off of a 21 turbine exhaust. 22 ///	195 1 But, yes, you would want to use 2 that heat. And you would not want to directly 3 release it to the environment. 4 BY MR. PHILLIPS: 5 Q. And that's what you would teach 6 your students in the plant design class; right? 7 MR. COLLARD: Object to form. 8 A. Again, it's very specific on 9 what's being taught that week. 10 BY MR. PHILLIPS: 11 Q. But you'd agree, a POSA would 12 want to recover that heat in the gas turbine 13 exhaust. Right? 14 MR. COLLARD: Object to form. 15 A. In general, one wants to 16 recover heat from any process. Heat 17 integration is a critical aspect of any 18 chemical plant. 19 BY MR. PHILLIPS: 20 Q. Were you aware that a gas 21 turbine paired with a HRSG is usually 22 integrated into a single piece of equipment?
194 1 BY MR. PHILLIPS: 2 Q. So would you consider the 3 radiant section of a steam-generating furnace 4 to be analogous to the temperatures in the 5 combustion chamber of a gas turbine? 6 MR. COLLARD: Object to form. 7 A. I don't know the specifics. 8 BY MR. PHILLIPS: 9 Q. Is it your position that a POSA 10 in 2017 would believe that venting gas turbine 11 exhaust directly to the atmosphere is 12 economically viable? 13 MR. COLLARD: Object to form 14 and object to scope. 15 A. So, in general, in any chemical 16 plant, heat integration is a really important 17 part of making it work economically. 18 So I would agree that if there 19 was calorific heat in the exhaust, one would 20 want to use it. How you use that could be in 21 many ways. You could use it to heat other 22 things. You could use it to make steam.	196 1 MR. COLLARD: Object to form. 2 A. I am not aware. 3 BY MR. PHILLIPS: 4 Q. That the hot exhaust of the gas 5 turbine goes directly into the HRSG? 6 Are you aware of that? 7 MR. COLLARD: Object to form. 8 A. Yes, the hot exhaust goes into 9 the HRSG. 10 Are they connected in one piece 11 of equipment? I don't -- that, I do not know. 12 And as indicated in the 2007 IFA, there are 13 different unit operations. 14 BY MR. PHILLIPS: 15 Q. Well, but the 2007 IFA is a 16 process-flow diagram; right? 17 A. Sure. 18 Q. I mean, that's not what the 19 actual piece of equipment looks like. 20 Wouldn't you agree? 21 A. It's a process-flow diagram. 22 But in any process-flow diagram, when there's

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Page 50 of 147

Conducted on July 23, 2026

197 1 two distinct boxes, those are typically assumed 2 to be two distinct pieces of equipment. 3 Q. I'm going to hand you some 4 exhibits that I've marked as Exhibit 1, 2, 3, 5 and 4. 6 (Deposition Exhibits 1, 2, 7 3, and 4 were marked for 8 identification and attached to 9 transcript.) 10 Q. I pulled these from the 11 internet; and I did it because I'm terrible at 12 drawing. 13 A. That's fair. 14 Q. So there's those. 15 MR. PHILLIPS: There's a copy 16 for you. 17 MR. COLLARD: I have five. 18 MR. PHILLIPS: Oh. Let me see. 19 Oh, I probably gave you -- 20 yeah, I gave you one that looks like this too, 21 I guess. 22 MR. COLLARD: Yeah.	199 1 drew it, but I can't draw. So I just wanted to 2 ask questions about this. I'm not trying to 3 prove a point. I just want to ask questions 4 about this. 5 MR. COLLARD: Okay. 6 THE DEPONENT: Okay. 7 MR. PHILLIPS: Although I will 8 tell you, Exhibit 2 and 3 are Siemens units. 9 I do recall that. 10 MR. COLLARD: That's fine. 11 But I'm just saying, we don't 12 have a date. 13 MR. PHILLIPS: That's fine. 14 MR. COLLARD: I know you're 15 saying it's a source. 16 MR. PHILLIPS: It's just 17 demonstratives. 18 MR. COLLARD: Okay. Fine. 19 BY MR. PHILLIPS: 20 Q. Are you familiar with combined 21 cycle gas turbines, Dr. Wolden? 22 A. Yep.
198 1 BY MR. PHILLIPS: 2 Q. I'm going to give this to you, 3 then. I'll give you Exhibit 5 as well. 4 (Deposition Exhibit 5 was 5 marked for identification and 6 attached to transcript.) 7 A. Sure. 8 Q. I won't lose the thing, 9 although I've already lost it. There it is. 10 Okay. So Exhibits 1 through 4 11 are schematics/renderings of -- I believe each 12 of these are considered combined cycle gas 13 turbines. 14 Are you familiar with the 15 term "combined" -- 16 MR. COLLARD: Hold on. 17 We don't have a URL or anything 18 on these or a date. Do we have any source? 19 Anything on this? 20 MR. PHILLIPS: No. 21 MR. COLLARD: Okay. All right. 22 MR. PHILLIPS: It's as if I	200 1 Q. Does Exhibit 1 appear to be a 2 combined cycle gas turbine? 3 A. It looks to have the components 4 of a combined cycle, yes. 5 Q. What are the components of a 6 combined cycle gas turbine? 7 A. Again, there's -- typically -- 8 first, you have a gas turbine, which 9 independently produces electricity. The 10 exhaust gas from that gas turbine goes to a 11 HRSG, which generates steam. And then that 12 steam is used to power a secondary turbine to 13 produce additional electricity. 14 So it's combining, if you will, 15 a gas turbine with a steam turbine. 16 Q. What's the difference -- well, 17 let me know if you disagree with this 18 statement. 19 What you described, I agree 20 with, is a combined cycle gas turbine. There's 21 also the cogeneration of steam and power, which 22 is, I presume, where you do not have the steam

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Page 51 of 147

Conducted on July 23, 2026

201 1 turbine piece. Where you take the superheated 2 steam and then you use the steam. 3 Do you agree with that? 4 MR. COLLARD: Object to form. 5 A. I would not call that a 6 combined cycle. Right? 7 Yeah, there's the possibility 8 of using the exhaust gas to make superheated 9 steam, not for power generation but for other 10 processes. 11 BY MR. PHILLIPS: 12 Q. Right. 13 A. If that's what you're 14 describing. 15 Q. Right. 16 So that would be the 17 cogeneration of power and steam in that 18 instance. 19 A. Sure. Sure. 20 Q. But it would look like 21 Exhibit 1; you just would use the steam for 22 some other purpose and not a steam turbine.	203 1 connected together. 2 BY MR. PHILLIPS: 3 Q. Do you have any understanding 4 as to whether these are sold as one unit? 5 MR. COLLARD: Object to form 6 and scope. 7 A. No, I don't know. 8 BY MR. PHILLIPS: 9 Q. If you could look at Exhibit 4. 10 A. Sure. 11 Q. This shows a layout of a -- of 12 the steam-generating tubes within a HRSG. 13 Do you see that? 14 MR. COLLARD: I object to the 15 foundation. 16 A. It's not labeled a HRSG, but, I 17 -- I don't know. It's difficult to know 18 exactly. The terminology is a little 19 different. 20 It's also very different in 21 that there's a separate burner supplying the 22 superheater and not just the exhaust gas from
202 1 Do you agree with that? 2 MR. COLLARD: Object to form. 3 A. There would be no steam 4 generator -- steam turbine generator or the 5 associated components with that. 6 There -- yes, the steam that 7 comes out of the HRSG would presumably go to 8 something else. Then you'd have -- yes, you'd 9 have electricity from the generator and then 10 superheated steam from the HRSG. 11 BY MR. PHILLIPS: 12 Q. Looking at Exhibit 1. When you 13 reviewed the IFA presentation, was this the -- 14 what you envisioned for a gas turbine paired 15 with a HRSG? 16 MR. COLLARD: Object to form. 17 A. The 2007 IFA has -- unit 18 operations are designated a gas turbine, a 19 HRSG, and a steam generator, as -- yes. So the 20 components that are here. 21 I would not consider this one 22 thing. I would consider it a bunch of things	204 1 the gas turbine. 2 So this is not exactly the same 3 thing as Figure 1, in my opinion. 4 BY MR. PHILLIPS: 5 Q. Well, it doesn't show the gas 6 turbine, but -- 7 A. It does. 8 Q. Where does it show the gas 9 turbine? 10 A. That's the trapezoid. 11 Q. The trapezoid? Which 12 trapezoid? 13 A. Oh. That's a steam generator 14 -- steam turbine. Okay. 15 The trapezoid before the 16 generator. 17 Yes, this does not show the gas 18 turbine at all. 19 Q. Okay. So is this your 20 understanding of how steam is generated in a 21 HRSG? 22 MR. COLLARD: Object to form.

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Page 52 of 147

Conducted on July 23, 2026

205 1 Foundation. 2 A. No. This is a very different 3 unit operation. This is an independently fired 4 steam generator – steam turbine, because 5 there's a burner. A HRSG is simply a heat 6 exchanger recovering the energy from the flue 7 gas. That does not exist in this diagram. 8 BY MR. PHILLIPS: 9 Q. Because it doesn't show the gas 10 turbine? 11 MR. COLLARD: Object to form. 12 And misstates testimony. 13 A. Two reasons. One, it doesn't 14 show a gas turbine. It also has explicitly 15 here – there's a burner. There's a burner 16 that's combusting fuel that is used to 17 superheat the steam for the steam turbine. 18 BY MR. PHILLIPS: 19 Q. Would that be considered a duct 20 burner in a HRSG? 21 MR. COLLARD: Object to form. 22 A. A HRSG doesn't have a burner.	207 1 feedwater economizer on the right, followed by 2 an evaporator into a boiler drum, with steam 3 then going into the hottest portion of this -- 4 you didn't want to call it a HRSG, but -- 5 A. It's not a HRSG. 6 Q. -- steam on the hottest 7 portion of -- 8 A. Let me be very clear: It's not 9 a HRSG. 10 Q. Okay. 11 A. Yes, a burner -- 12 MR. COLLARD: Hold on. 13 THE DEPONENT: I'm sorry. 14 MR. COLLARD: Object to the 15 form of the question. And I object to the 16 foundation of this thing that you say you want 17 to treat as a drawing, but it's not a drawing 18 and you're asking him what it is. 19 So I object to the foundation. 20 Answer, if you can. 21 A. Well, again, without words, 22 it's difficult to say exactly because there's
206 1 BY MR. PHILLIPS: 2 Q. So what would you consider this 3 diagram to depict? 4 A. This, in my opinion, is 5 depicting a steam turbine apparatus, where you 6 burn fuel, you create steam, and the steam 7 creates electricity. It's just an independent 8 steam furnace – or, sorry – steam generator. 9 Q. So you would consider this a 10 furnace within the definition of the 11 '168 patent? 12 MR. COLLARD: Object to form. 13 A. This is -- well, again, you 14 have to put boxes around this thing. 15 What's shown here is a steam 16 turbine. 17 BY MR. PHILLIPS: 18 Q. Well, that's a steam turbine; 19 right? The upper left is a steam turbine. 20 A. Sure. 21 Q. You don't believe that what 22 we're viewing in the middle of this is a blower	208 1 no specifications on what's going in. You 2 know, what are the -- what are the flows? What 3 are the compositions of things here? 4 But a burner connected to -- 5 that small part of this would -- could be a 6 furnace. 7 BY MR. PHILLIPS: 8 Q. Okay. 9 A. A very small portion of this as 10 a furnace component. 11 But, again, it's not defined. 12 It's very difficult to explicitly say anything. 13 Q. What is your understanding of 14 how a HRSG works? 15 A. Again, the definition -- the 16 acronym stands for heat recovery steam 17 generation. 18 Q. Correct. 19 A. So it's nothing more than a 20 heat exchanger. 21 There is heat, not provided by 22 combustion but, you know, by some source, just

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Page 53 of 147

Conducted on July 23, 2026

209 1 in general. It doesn't have a combustion 2 source within it. It is a heat – it's 3 basically a heat exchanger. 4 It's supplied with some fluid 5 that has high energy. It transfers that heat 6 to water to create steam. It's a heat 7 exchanger. 8 Q. So in paragraph 26 of your 9 declaration, you said, "A furnace is a 10 relatively simple unit that involves combustion 11 of fuel followed by the transfer of thermal 12 energy from the hot combustion to another 13 fluid." 14 A. Um-hmm. 15 Q. You're saying a HRSG is not a 16 furnace because it doesn't involve combustion 17 of fuel. Is that right? 18 A. That's correct. 19 Q. But a gas turbine paired with a 20 HRSG, does that involve combustion of fuel 21 followed by the transfer of thermal energy from 22 the hot combustion gas to another fluid?	211 1 Exhibit 3, aren't these all interconnected as 2 one unit? 3 MR. COLLARD: Object to form. 4 A. There are many other 5 operations – 6 MR. COLLARD: Sorry. 7 And object to foundation. 8 Go ahead. 9 THE DEPONENT: I'm sorry. 10 A. Yes, there's other operations 11 between the turbine before it gets to the HRSG; 12 again, involving the transfer of power – 13 right? – the transfer of energy to mechanical 14 and electrical things as opposed to just 15 transferring that energy explicitly as heat. 16 BY MR. PHILLIPS: 17 Q. But you'll agree that heat is 18 transferred from the exhaust of a gas turbine 19 to water to generate steam in a HRSG. Correct? 20 A. A HRSG is a heat exchanger – 21 THE DEPONENT: Sorry. 22 MR. COLLARD: Object to form.
210 1 MR. COLLARD: Object to form. 2 A. It also involves, as I stated, 3 many other things. Transfer of that energy to, 4 first, mechanical energy, and then that 5 mechanical energy to electrical energy. Again, 6 being much more complex and, in my view, not a 7 furnace. 8 I stated over and over again, 9 the furnace is a very simple thing: combustion 10 plus heat exchanger. The HRSG is just a heat 11 exchanger. A HRSG is agnostic, if you will, to 12 the hot fluid coming into it. 13 BY MR. PHILLIPS: 14 Q. Isn't a steam-generating 15 furnace also agnostic to the heat that's being 16 provided to the tubes? 17 MR. COLLARD: Object to form. 18 A. No. In that case, there is 19 actually a fuel being combusted to supply that 20 heat explicitly as part of the unit. 21 BY MR. PHILLIPS: 22 Q. But in Exhibit 1, Exhibit 2,	212 1 Go ahead. 2 A. As I said, a HRSG is a heat 3 exchanger which transfers heat to make steam. 4 BY MR. PHILLIPS: 5 Q. And that heat in a gas turbine 6 is created by the combustion of fuel; right? 7 MR. COLLARD: Object to form. 8 A. There is – its processed gas 9 coming off a gas turbine after it was used to 10 produce electricity and mechanical energy. 11 BY MR. PHILLIPS: 12 Q. You could generate steam from 13 the effluent of an exothermic reactor as well; 14 right? 15 A. Certainly. 16 MR. COLLARD: Object to form. 17 THE DEPONENT: Sorry. 18 BY MR. PHILLIPS: 19 Q. But in a gas turbine paired 20 with a HRSG, the heat doesn't come from the 21 exothermic reaction; it's coming from 22 combusting of fuel. Correct?

Conducted on July 23, 2026

213 1 A. Combusting of fuel is an 2 exothermic reaction. 3 Q. Fair enough. 4 But that's what's occurring in 5 a gas turbine. That's what's providing the 6 heat to the exhaust that's generating steam in 7 the HRSG. Right? 8 MR. COLLARD: Object to form. 9 A. After much of that energy was 10 removed from mechanical and electrical work. 11 BY MR. PHILLIPS: 12 Q. But there's still energy; 13 right? 14 A. There is residual energy after 15 that, yes. 16 Q. Does a furnace require that you 17 recover all of the energy that's generated 18 during combustion? 19 MR. COLLARD: Object to form. 20 A. Fortunately entropy does not 21 allow for recovering all of it, as we know. 22 But, yes, that is the goal of any furnace, is	215 1 A. I can't really say because 2 I don't know, again, the very specifics of 3 those operations. 4 Again, it's simply a heat 5 exchanger. 6 BY MR. PHILLIPS: 7 Q. Would you agree that the 8 convection section of a furnace often operates 9 as a heat exchanger? 10 A. Yeah, I can't -- not 11 exclusively, no. 12 Q. But it can; right? 13 A. No, because a turbine, it's 14 using that energy, again, not to deliver heat, 15 but to do other things. 16 Q. It does other things and it 17 delivers heat though. Is that correct? 18 A. Primarily -- 19 MR. COLLARD: Objection to 20 form. 21 Go ahead. 22 A. It primarily -- you know,
214 1 to recover 100 percent of it. 2 Again, that's why I paid more 3 for my high-efficiency furnace which delivers, 4 you know, over 90 percent of the energy. So 5 it's cheaper for me to run my furnace in my 6 house. 7 BY MR. PHILLIPS: 8 Q. But a HRSG is also trying to 9 recover as much of the energy as it can -- 10 MR. COLLARD: Object to form. 11 BY MR. PHILLIPS: 12 Q. -- from the gas turbine 13 exhaust; isn't that right? 14 MR. COLLARD: Object to form. 15 A. The heat exchangers are 16 operated to recover as much heat as possible. 17 BY MR. PHILLIPS: 18 Q. Would you say that the HRSG is 19 analogous to the convection section of a 20 furnace -- steam-generating furnace? 21 MR. COLLARD: Objection to 22 form.	216 1 energy is, again, as I said, first transferred 2 to mechanical energy, then transferred to 3 electrical energy. If there's residual energy 4 left over, that's what they're trying to 5 recover. 6 BY MR. PHILLIPS: 7 Q. In a steam generator; right? 8 MR. COLLARD: Object to form. 9 A. The HRSG is a steam generator 10 -- let me restate that. 11 A HRSG is a heat exchanger that 12 produces steam to distinguish it from a steam 13 generator, as we've been using the term in the 14 '168 patent. 15 BY MR. PHILLIPS: 16 Q. But the heat recovery steam 17 generator is a steam generator; right? 18 A. Steam is produced from that 19 heat exchanger. 20 Q. Is the downstream use of the 21 steam relevant to whether the unit that 22 produces the steam consider it a steam

Conducted on July 23, 2026

217 1 generator? 2 MR. COLLARD: Object to form. 3 A. Can you repeat? 4 I'm trying to understand your 5 question. 6 BY MR. PHILLIPS: 7 Q. Sure. 8 Does the downstream use of the 9 steam generated by a steam generator, is that 10 downstream use relevant to whether you classify 11 that apparatus as a steam generator? 12 MR. COLLARD: Object to form. 13 A. Again, I just want to clarify. 14 The '168 patent defines a steam 15 generator as one based on combustion. A HRSG 16 is something different. It's just a heat 17 exchanger that produces steam. And what the 18 steam is used for could be used for many 19 things. 20 BY MR. PHILLIPS: 21 Q. So a steam generator within the 22 meaning of the '168 patent -- a steam generator	219 1 A. Sure. 2 Q. Again, I'm going to represent 3 to you that I randomly pulled this off the 4 internet. 5 But what I have attempted to 6 show -- what I was attempting to find was an 7 example of a furnace-fired steam generator. 8 So if you could take a look at 9 that and agree or disagree, I'd appreciate it. 10 MR. COLLARD: Sorry. Object to 11 form. And object to the foundation. 12 A. Again, it's very -- you know, 13 there's names here, but there's no description 14 of these names, so -- and it's a very complex 15 diagram so it's very difficult for me to say 16 too much definitive on what's going on here. 17 BY MR. PHILLIPS: 18 Q. You said furnaces are simple 19 units. Right? 20 A. Yeah, relatively speaking. 21 Q. Is this not a simple unit? 22 A. It does not look like a simple
218 1 within the meaning of the '168 patent -- 2 MR. COLLARD: Yeah. Go ahead. 3 BY MR. PHILLIPS: 4 Q. -- if that steam were then used 5 in a steam turbine to generate power, would 6 that unit still be considered a steam 7 generator? 8 MR. COLLARD: Object to form. 9 A. In the '168 patent? 10 BY MR. PHILLIPS: 11 Q. Yes. 12 A. Yes. 13 Q. Even if the primary purpose of 14 the steam generator was to generate electricity 15 and not the steam. 16 MR. COLLARD: Object to form. 17 A. As I said, a combustion-fired 18 steam generator will produce steam which can be 19 used for a multitude of applications. 20 BY MR. PHILLIPS: 21 Q. So look at Exhibit 5 that 22 I listed.	220 1 unit to me. 2 Q. Okay. Would you agree that the 3 steam that's coming from this unit is going to 4 a steam turbine to generate power? 5 MR. COLLARD: Object to form. 6 And object to foundation. 7 A. There is steam that is entering 8 a unit called a turbine, which is, again, 9 powering a generator, which appears to be 10 generating electricity. 11 BY MR. PHILLIPS: 12 Q. The only reason why I'm showing 13 you this is, again, I'm coming back to the 14 question of: Does the purpose of what you're 15 using the steam for matter as to whether 16 something is considered a furnace or not? 17 A. Is there a question there? 18 MR. COLLARD: Yeah, is there a 19 question? 20 MR. PHILLIPS: Sure. Let me 21 rephrase. 22 ///

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Page 56 of 147

Conducted on July 23, 2026

221 1 BY MR. PHILLIPS: 2 Q. A furnace for generating steam, 3 if the purpose of that steam is to 100 percent 4 be used for power generation, would that still 5 be considered a steam generator within the 6 meaning of the '168 patent? 7 MR. COLLARD: Object to form. 8 I'm sorry. Is that tied to 9 this diagram or is that just a general 10 question? 11 MR. PHILLIPS: That's a general 12 question. 13 MR. COLLARD: Okay. All right. 14 I still object to the form. 15 A. Sorry. Can you rephrase one 16 more time, just so I -- 17 BY MR. PHILLIPS: 18 Q. Sure. 19 A furnace for generating steam, 20 if the purpose of that steam is to 100 percent 21 be used for power generation, would that still 22 be considered a steam generator within the	223 1 back on the record. The time is 1:16. 2 BY MR. PHILLIPS: 3 Q. Dr. Wolden, welcome back from 4 lunch. I just want to remind you, again, we're 5 still under oath. 6 Before the break, we were 7 talking about furnaces. I wanted to make sure 8 the record is clear. The type of fuel that is 9 used for firing does not matter as to whether 10 something is considered a furnace or not. 11 Correct? 12 A. Yes, I think that's, in 13 general, correct. You can use multiple -- 14 different -- you can use different fuels in 15 furnaces. 16 Q. So something you would consider 17 a furnace, burning natural gas, burning a 18 hydrogen-rich fuel, it's still a furnace; 19 right? 20 A. Yeah. The configuration of the 21 furnace might be different, but it's still a 22 furnace.
222 1 meaning of the '168 patent? 2 MR. COLLARD: Same objection. 3 A. A steam generator is just 4 simply that: it is a combustion unit which 5 turns water into steam. 6 BY MR. PHILLIPS: 7 Q. Regardless of what you're going 8 to use the steam for; right? 9 A. I think -- yeah, it makes no 10 statement on what it's used for. It just 11 creates steam. 12 MR. COLLARD: We've been going 13 a little over an hour. Is this a good spot for 14 a break? 15 MR. PHILLIPS: You know what? 16 I think it is, actually. This is probably 17 pretty good. 18 MR. COLLARD: All right. 19 THE VIDEOGRAPHER: We are going 20 off the record. The time is 12:35. 21 (Recess taken.) 22 THE VIDEOGRAPHER: We are going	224 1 Q. And you would agree that 2 burners capable of firing hydrogen-rich fuel 3 existed before 2017. Right? 4 A. Again -- 5 MR. COLLARD: Sorry. 6 THE DEPONENT: Go ahead. 7 MR. COLLARD: Object to form. 8 A. There's -- the big distinction 9 is how you mix the fuel and the oxidizers. 10 There weren't, and there still 11 are not, burners to -- for premixed air and 12 hydrogen; but there were other diffused 13 burners -- other configurations which could 14 burn hydrogen before 2017. 15 BY MR. PHILLIPS: 16 Q. So it's a work in progress 17 still today? 18 A. Yes, it is. 19 Q. And it was a work in progress 20 before 2017 as well? 21 A. Yes. 22 MR. COLLARD: Object to form.

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Page 57 of 147

Conducted on July 23, 2026

225 1 BY MR. PHILLIPS: 2 Q. So in paragraph 25 -- again, 3 we've kind of done this quote before, from the 4 '168 patent. 5 A. Oh, from the '168 patent or 6 from my declaration? 7 Q. Paragraph 25 of your 8 declaration where you quote column 2, line 47, 9 from the '168 patent, and specifically the 10 sentence "These apparatus, which operate by 11 means of combustion, are identified by the term 12 'fired heater.'" 13 Do you recall that sentence? 14 A. Yes. 15 Q. The term "fired heater," would 16 you agree that that's a term of art in chemical 17 engineering? 18 MR. COLLARD: Object to form. 19 A. Not necessarily. 20 I mean, there's a -- you know, 21 as most fields, there's lots of terms that are 22 used in a variety of ways in different fields.	227 1 considered fired heaters as well; right? 2 MR. COLLARD: Object to form. 3 A. Yes. I think if you burn a 4 fuel and convert, as I said, there's a heat 5 exchanger component that converts that water 6 into steam. 7 BY MR. PHILLIPS: 8 Q. So we had a discussion about 9 gas turbines earlier. 10 Would you agree that a gas 11 turbine has a combustion chamber where fuel is 12 combusted? 13 A. Yes, there's a combustion 14 aspect in a gas turbine. 15 Q. And that's the same combustion 16 of fuel that would occur in a fired heater; 17 right? 18 MR. COLLARD: Object to form. 19 A. The combustion reaction is the 20 same. How it is executed -- mixing, how it 21 proceeds -- can be very different; but the 22 overall reaction is the same.
226 1 BY MR. PHILLIPS: 2 Q. So I think you agreed with me 3 earlier, fired heaters operate by means of 4 combustion of a fuel. Is that right? 5 A. Yes, that part is correct. The 6 "fired" part indicates combustion of some fuel. 7 Q. A steam methane reformer -- a 8 traditional steam methane reformer, those would 9 be considered fired heaters? 10 Is that right? 11 MR. COLLARD: Object to form. 12 A. Yes. In my opinion, yes, 13 they're -- they fire round tubes, yes, it's a 14 fired heater. 15 BY MR. PHILLIPS: 16 Q. And the steam methane reforming 17 reaction is endothermic? 18 A. Yes. 19 Q. So it needs the heat? 20 A. It needs the heat. That drives 21 the endothermic reaction. Correct. 22 Q. And steam boilers could be	228 1 BY MR. PHILLIPS: 2 Q. Are gas turbines always a -- 3 MR. PHILLIPS: And you're going 4 to object to form, but that's okay. This isn't 5 really an important piece of testimony. 6 BY MR. PHILLIPS: 7 Q. Are gas turbines always an 8 integral one piece of equipment such that it 9 has an intake, a chamber, the expander, the 10 vanes? 11 Is that all usually encompassed 12 in one apparatus? 13 MR. COLLARD: Object to form. 14 A. In my expectation, gas furnace, 15 it involves everything from combustion to the 16 electrical power coming out. So it includes 17 the turbines. The turbines then, you know, 18 rotate through a solenoid coil which generates 19 the electricity. 20 BY MR. PHILLIPS: 21 Q. So there's literally an input 22 port for air --

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Page 58 of 147

Conducted on July 23, 2026

229 1 A. Fuel. 2 Q. -- and fuel. There's going to 3 be an exhaust after the turbine blades and the 4 vanes? Correct? 5 MR. COLLARD: Object to form. 6 A. Yes. There would be exhaust 7 from the gas turbine, yes. 8 BY MR. PHILLIPS: 9 Q. And that would be -- that's 10 generally what you consider a gas turbine: one 11 integral unit; correct? 12 MR. COLLARD: Object to form. 13 A. Again, along with the 14 apparatuses used to convert it to -- convert 15 the mechanical energy to electricity. 16 BY MR. PHILLIPS: 17 Q. But that would all be 18 encompassed in one piece of equipment? 19 MR. COLLARD: Object to form. 20 A. I think, in general, that would 21 be the definition of what people consider a gas 22 turbine.	231 1 fuel. 2 A. Yes. There's not a combustion 3 component of a HRSG. It's just a heat 4 exchanger. 5 Q. But it does transfer heat to 6 water to generate steam. You agree with that 7 part? 8 A. I agree, yes. It's a heat 9 exchanger that transfers energy from water to 10 convert -- to make steam. 11 Q. I asked you earlier about 12 supplementary-fired or duct-fired HRSGs, where 13 fuel is combusted in duct burners using the 14 oxygen remaining in the gas turbine exhaust. 15 I think you told me you didn't 16 think that existed. Is that right? 17 A. I don't -- 18 MR. COLLARD: Object to form. 19 A. I don't recall you talking 20 about that, supplemental heaters or anything 21 about that. 22 ///
230 1 BY MR. PHILLIPS: 2 Q. Can the combustion chamber be 3 an external chamber to the gas turbine? 4 MR. COLLARD: Object to form. 5 A. It certainly could be. I think 6 in most configurations, it's an integral part 7 of the gas turbine. 8 BY MR. PHILLIPS: 9 Q. So back to the term "steam 10 generators." 11 A. Okay. 12 Q. Hopefully you'll agree with me 13 that a boiler fired by a fuel is a steam 14 generator because the combustion is used to 15 transfer heat to the water and generate steam. 16 Is that right? 17 A. That's the definition, I think 18 -- a fair definition of a steam generator, 19 yeah. 20 Q. But you wouldn't consider a 21 heat recovery steam generator -- a HRSG -- to 22 be a steam generator because it doesn't combust	232 1 BY MR. PHILLIPS: 2 Q. Okay. Are you aware of 3 supplemental-fired or duct-fired HRSGs, where 4 fuel was combusted in duct burners using the 5 oxygen remaining in the gas turbine exhaust? 6 A. I am not aware. 7 Q. If that were to exist, would 8 you consider that a furnace -- 9 MR. COLLARD: Object to form. 10 BY MR. PHILLIPS: 11 Q. -- within the definition of the 12 '168 patent? 13 MR. COLLARD: Object to form. 14 A. Again, I'd have to see a very 15 detailed kind of schematic and description of 16 it. 17 BY MR. PHILLIPS: 18 Q. Let's get back to your claim 19 construction for the term "furnace." 20 Your construction is that it is 21 "An apparatus chosen from among: a steam 22 reformer or a charge preheater or a steam

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Page 59 of 147

Conducted on July 23, 2026

233 1 generator or a steam superheater." 2 Is that right? 3 A. Again, that's not my 4 definition. That's the definition of the 5 authors of the '168 patent. 6 Q. So that's the construction that 7 you applied to the prior art all throughout 8 Exhibit 2007, your declaration. Is that right? 9 A. Yes, I used their definition in 10 my analysis of this case. 11 Q. And your construction did not 12 include the words "operate by means of 13 combustion or fired heater." Isn't that right? 14 A. I used the words -- the 15 definition. And they included "fired heater" 16 as kind of encompassing those four apparatus. 17 So in that sense, I included fired heater. 18 Q. So under your construction, 19 must a furnace operate by means of combustion? 20 Yes or no? 21 MR. COLLARD: Object to form. 22 Wait. Sorry.	235 1 Q. So you've adopted the 2 combustion requirement in your analysis in 3 Exhibit 2007; right? 4 A. I am using the term as they 5 defined it, yes, in my analysis. 6 Q. But that term, including the 7 combustion requirement. 8 A. Yes. 9 Q. Because that's -- I mean, 10 correct me if I'm wrong, that's -- you're 11 excluding HRSGs because they don't have 12 combustion. 13 A. Correct. Correct. Yes. 14 Q. You're considering that not a 15 steam generator, even though it generates 16 steam, because it doesn't generate combustion? 17 (Crosstalk.) 18 MR. COLLARD: Object to form. 19 Hold on. 20 You can -- let's just question 21 and answer is all. 22 MR. PHILLIPS: Right.
234 1 You said under your definition, 2 and he's -- do you mean the definition he's 3 using from the patent? 4 MR. PHILLIPS: If that's his 5 construction. If he's using the definition 6 from the patent. 7 MR. COLLARD: That's fine. 8 BY MR. PHILLIPS: 9 Q. Under that definition, must a 10 furnace operate by means of combustion? 11 Yes or no? 12 A. As defined in the '168 patent, 13 yes, that's the construction I used. 14 Q. And you say that because of the 15 second sentence in column 2, 47 through 52, 16 that we saw earlier. Right? Specifically, 17 "These apparatus, which operate by means of 18 combustion, are identified by the term 'fired 19 heater.'" 20 A. Yes. So I'm using "fired 21 heater" to -- as equivalent to those four 22 terms.	236 1 Question. Objection. Answer. 2 MR. COLLARD: Yeah. 3 But you can go ahead and -- if 4 you -- did you finish your question? 5 MR. PHILLIPS: I can re- -- 6 MR. COLLARD: Okay. 7 A. Could you rephrase it? Just to 8 be clear. 9 BY MR. PHILLIPS: 10 Q. So I asked you: So you've 11 adopted the combustion requirement in your 12 analysis in Exhibit 2007. Right? 13 A. Correct. 14 Q. And then I asked: But that 15 term included the combustion requirement. 16 You said: Yes. 17 A. Yes. 18 Q. And I said because, correct me 19 if I'm wrong, you're excluding HRSGs from being 20 a furnace because they don't have combustion. 21 MR. COLLARD: Object to form. 22 ///

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Page 60 of 147

Conducted on July 23, 2026

237 1 BY MR. PHILLIPS: 2 Q. And you said: Correct. 3 A. Yes. That's why I don't 4 consider a HRSG a furnace. 5 Q. So you're considering that not 6 a steam generator, even though it generates 7 steam, because it doesn't include combustion of 8 a fuel. 9 MR. COLLARD: Object to form. 10 A. So there's many ways to 11 generate steam. And the furnace that -- as 12 defined in the patent is a steam generator. 13 Yes, a HRSG generates steam, 14 but is not a furnace. 15 BY MR. PHILLIPS: 16 Q. Because you've incorporated 17 this functional requirement of combustion. Is 18 that right? 19 A. That's correct. 20 MR. COLLARD: Object to form. 21 BY MR. PHILLIPS: 22 Q. I wanted to ask you a few	239 1 ATR. Isn't that correct? 2 A. Yes, that's correct. 3 Q. Is there any other fired 4 equipment in the front end of the ammonia 5 synthesis plant? 6 A. Not in the configuration that's 7 shown in Figure 1. 8 Q. So if a POSA's boss says we 9 need to reduce CO2 emissions to get the 45V tax 10 credits for blue ammonia, a POSA would view the 11 charge preheater as the obvious choice. Right? 12 MR. COLLARD: Object to form. 13 And object to scope. 14 A. Again, I don't know how bosses 15 worked in that industry. But that is the 16 largest CO2 emitter in the process. So that 17 would be the one to target. 18 Again, you could target that 19 many different ways by doing carbon capture, 20 which is probably how most people would have 21 targeted it. 22 ///
238 1 questions about ATRs. We haven't talked about 2 ATRs much. 3 Remember, we discussed the term 4 "front end" earlier? 5 A. Yes. 6 Q. I think we established that the 7 front end of an ammonia synthesis plant 8 included a prereformer, followed by an ATR, 9 followed by a water-gas shift, followed by CO2 10 removal. 11 Is that accurate? 12 MR. COLLARD: Object to form. 13 A. That is the arrangement that's 14 in the '168 patent. As I said, there's many 15 other ways to do it, but that is the specific 16 one in Figure 1. 17 BY MR. PHILLIPS: 18 Q. So in that arrangement, the one 19 that goes to Figure 1 in the '168 patent. 20 A. Figure 1. Okay. 21 Q. The only fired heater is the 22 charge preheater before the prereformer and	240 1 BY MR. PHILLIPS: 2 Q. When you say "carbon capture," 3 you're talking about post combustion -- 4 A. Yes. 5 Q. -- CO2 removal? 6 A. Yep. Flue gas capture and 7 removal. 8 Q. But if you were going on use 9 technique for the '168 patent where you have a 10 CO2-depleted fuel fraction and you're going to 11 back out some natural gas, the obvious choice 12 is that charge preheater for reducing CO2 13 emissions. Isn't that right? 14 MR. COLLARD: Object to form. 15 Sorry. 16 THE DEPONENT: Sure. 17 MR. COLLARD: I don't 18 understand the question. 19 You're saying the obvious 20 choice to use the '168 patent in Figure 1 of 21 the '168 patent? I just don't really 22 understand what you're saying.

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Page 61 of 147

Conducted on July 23, 2026

241 1 It's an embodiment of it, so 2 how is there a choice? They're saying -- 3 MR. PHILLIPS: That wasn't my 4 question, Mr. Collard. 5 MR. COLLARD: Okay. 6 MR. PHILLIPS: So let me 7 rephrase the question. 8 BY MR. PHILLIPS: 9 Q. And, again, I'm not trying to 10 trick anybody. I'm just trying to make a clear 11 record. So I appreciate if it's not clear, 12 let's do it. 13 If you were going to use the 14 '168 patent's technique for reducing CO2 15 emissions, you would agree with me that is 16 using a CO2-depleted fuel fraction as fuel. 17 Would you agree with that? 18 MR. COLLARD: Object to form. 19 A. Again, the goal here is to 20 reduce CO2 emissions from ammonia synthesis. 21 And so actually selection of the process that 22 they've shown in Figure 1 is part of that	243 1 MR. COLLARD: Object to form. 2 A. Again, it's -- the whole 3 process. You can't look at one single unit in 4 operation. And that's part of what they did in 5 the '168 patent, was come up with a novel 6 process that provides these benefits for 7 reducing CO2 emissions, which were a number of 8 innovative design choices, at least in my view. 9 BY MR. PHILLIPS: 10 Q. So -- but I thought you agreed 11 with me earlier, that the flow sheet of 12 Figure 1, the ordering of the unit operations, 13 was not new in 2017. 14 MR. COLLARD: Object to form. 15 A. Again, it was one of many 16 configurations and was not the most popular 17 configuration at the time, but it's a potential 18 configuration. 19 BY MR. PHILLIPS: 20 Q. But it was a potential configuration 21 before 2017. 22 A. It was a potential
242 1 decision in the first place. And so it's all 2 coupled. 3 BY MR. PHILLIPS: 4 Q. Does that mean that the 5 prereformer ATR arrangement reduces fuel firing 6 in general? 7 Is that what you're referring 8 to? 9 MR. COLLARD: Object to form. 10 A. I would say, yes, a prereformer 11 ATR configuration requires less fuel than a 12 steam reformer. 13 So you're minimizing it, in 14 part. But that steam reforming is probably 15 still the most prominent way to do reforming. 16 And so part of it was the choice to go to the 17 ATR to, you know, help address that. 18 BY MR. PHILLIPS: 19 Q. So that's one way the '168 20 patent reduces CO2 emissions; right? It's by 21 reducing the amount of fuel you're firing, in 22 general.	244 1 configuration before 2017. 2 Q. So the other way that the 3 '168 patent inventors reduced CO2 emissions is 4 by using a hydrogen-rich, CO2-depleted syngas 5 stream as fuel. 6 A. That's correct. They used that 7 to replace natural gas in their fuel-firing 8 capabilities. 9 Q. So my question was: In the 10 Figure 1 flow sheet, the obvious choice on 11 where to use that technique is in the charge 12 preheater to a prereformer and ATR. Isn't that 13 right? 14 MR. COLLARD: No. I have the 15 same objection to form of this question. 16 The '168 patent and the '168 17 disclosure is Figure 1. You're saying it's 18 obvious to use the '168 patent in the '168 19 patent. It doesn't make -- it's a circular 20 question that does not -- it's not answerable. 21 BY MR. PHILLIPS: 22 Q. Outside of Figure 1, is there

Conducted on July 23, 2026

245 1 any other place in an ammonia synthesis front 2 end where you could use this technique of 3 burning CO2-depleted syngas? 4 MR. COLLARD: Object to form. 5 A. I mean, certainly, again, in 6 other configurations, if you used this -- you 7 could use it to power a steam reformer. You 8 could use it to power steam generation that you 9 might use elsewhere. 10 There's other configurations 11 that will have additional -- could potentially 12 have additional combustion needs that is not in 13 this configuration. 14 BY MR. PHILLIPS: 15 Q. In this configuration, the only 16 furnace is the -- the only fired heater in 17 Figure 1 is the charge preheater. 18 A. That is correct. 19 Q. So that's the only choice. 20 That's the only tool a POSA has for reducing 21 CO2 emissions using this technique. 22 MR. COLLARD: Sorry. Object to	247 1 Q. And you said that you reviewed 2 this before -- in preparation for this 3 deposition; right? 4 A. I did. 5 Q. In paragraph 59 of your 6 declaration, Exhibit 2007 -- 7 A. Yep. 8 Q. -- you state that "2007 IFA is 9 a slide deck on the CO2 reduction potential in 10 ammonia synthesis." 11 Do you see that? 12 A. Yep. That's correct. 13 Q. So you'd agree that the IFA -- 14 2007 IFA slide deck is -- specifically outlined 15 strategies for reducing CO2 emissions in 16 ammonia synthesis? 17 A. That's what the title of it 18 says. 19 Q. This is a presentation from 20 2007. Were you there? 21 A. I was not. 22 Q. Do you know how this was
246 1 form. Same objection. 2 Figure 1's description is the 3 first embodiment of the invention, so it is the 4 invention. 5 BY MR. PHILLIPS: 6 Q. Do you understand my question, 7 Dr. Wolden? 8 A. I do. 9 And I'll say again, the -- 10 I mean, I don't think you can just segregate 11 out one unit operation. It's -- it is part of 12 the whole invention, the whole process, to 13 reduce CO2 emissions. 14 Q. I'm going to hand you what's 15 been previously marked as Exhibit 1006. 16 (Previously marked Topsoe, 17 Inc. - Exhibit 1006 was tendered 18 to the witness.) 19 Q. This is the IFA -- 2007 IFA 20 presentation. 21 Do you recognize this? 22 A. I do.	248 1 presented? 2 A. I have no idea. 3 Q. Do you have any evidence to 4 suggest this was not one author presenting one 5 slide deck to one audience? 6 MR. COLLARD: Object to form. 7 A. Again, I have no idea how this 8 was presented or slides uploaded. I have no 9 idea. 10 BY MR. PHILLIPS: 11 Q. Have you spoken to the author? 12 A. No. I have no idea. I don't 13 know that person. 14 Q. You don't know Svend Erik 15 Nielsen? 16 A. Outside of his name on this, 17 I don't know. 18 Q. Have you spoken to anybody that 19 was at this presentation? 20 A. No, I have not. 21 Q. So you have reviewed nothing 22 about this presentation other than the

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Page 63 of 147

Conducted on July 23, 2026

249 1 presentation itself. Is that right? 2 A. That's not exactly true. 3 I also tried to look it up and 4 tried to find out how to find it, and 5 I couldn't find it. 6 Q. Okay. 7 MR. COLLARD: He read Ritter's 8 deposition transcript, I believe, too, which 9 discusses the presentation. 10 MR. PHILLIPS: That's fair. 11 MR. COLLARD: Okay. 12 THE DEPONENT: Sorry. 13 MR. PHILLIPS: No. That's 14 fair. 15 THE DEPONENT: Yeah. 16 BY MR. PHILLIPS: 17 Q. Do you agree that a POSA would 18 read a technical presentation slide deck like 19 this as a whole document, as if it were 20 delivered as a single, continuous talk? 21 MR. COLLARD: Object to form. 22 And object to scope.	251 1 followed by a shift reactor, followed by CO2 2 removal, followed by a methanator, and then off 3 to the ammonia. Those components are the same. 4 Q. It shows a split before the 5 methanator of what's labeled at H2 Fuel. 6 Do you see that? 7 A. Yep. 8 Q. So what's your understanding of 9 what H2 fuel is? 10 MR. COLLARD: Object to form. 11 A. Similar to the CO2-depleted 12 H2 stream in the '168 patent. 13 BY MR. PHILLIPS: 14 Q. The slide on the bottom of 15 page 9, it also differs from Figure 1 of the 16 '168 patent because of the presence of a 17 hydrogenator and sulfur absorber upstream of 18 the prereformer. 19 Do you agree with that? 20 A. Yes. That's the 21 desulfurization component. 22 Q. Is this what you understand a
250 1 A. It's a collection of slides. 2 Nothing more, nothing less. 3 BY MR. PHILLIPS: 4 Q. But you have no evidence to 5 suggest they were presented separately. 6 MR. COLLARD: Object to form. 7 BY MR. PHILLIPS: 8 Q. Do you have any evidence to 9 suggest that these slides weren't presented all 10 together in one -- at this meeting? 11 A. I have -- like I said, I have 12 no idea. 13 Q. Let's look at Exhibit 1006, on 14 the bottom of page 9. 15 A. Sure. 16 Q. Will you agree that this shows 17 an ATR-based ammonia synthesis flow sheet? 18 A. I would agree, yes. 19 Q. Is this a similar flow sheet to 20 what is found in Figure 1 of the '168 patent? 21 A. Yes, it's similar in that it 22 has a prereformer, an autothermal reformer,	252 1 typical conventional hydrogenator - sulfur 2 absorber would look like in this type of flow 3 sheet? 4 A. Yes. This is a typical 5 desulfurization part of the process. 6 Q. So would you agree that the H2 7 fuel has the same composition as the 8 CO2-depleted syngas that's going to the 9 methanator? 10 A. Yes. When those two streams 11 split, yes, they would -- the stream going to 12 the methanator and -- well, you've got to be 13 very specific here. 14 If you look at where the H2 15 fuel -- where the label H2 Fuel is, it occurs 16 after the mixing with nitrogen. So that would 17 be different. But at the split point, they 18 would be the same. I want to be very clear -- 19 Q. That was my question. And I'm 20 glad you were clear on that. That's good. 21 And, actually, it leads to my 22 next question: Why is nitrogen added to the

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Page 64 of 147

Conducted on July 23, 2026

253 1 hydrogen fuel in this -- 2 MR. COLLARD: Object to form. 3 BY MR. PHILLIPS: 4 Q. -- process? 5 A. You know, again, this is one of 6 the real challenges with this presentation. 7 It's nothing more than a slide 8 deck, so there's no words to explain what's 9 going on. And I was not there. I cannot 10 imagine what the individual presenting this 11 might have said. So I have to speculate, based 12 on my judgment and the limited information 13 here. 14 But if you look, that H2 fuel 15 stream is then mixed with the natural gas 16 stream and is supplied to GT, which I'm going 17 to assume is a gas turbine. 18 And, as I've said before, 19 certainly in 2007, there's no way you could 20 supply hydrogen directly to a gas turbine, 21 which is why it's diluted with, first, nitrogen 22 and then with natural gas.	255 1 Q. So you would agree that -- 2 I think you just mentioned this; I just want to 3 confirm -- that the hydrogen fuel stream is 4 combusted in what appears to be the gas 5 turbine, along with natural gas. Is that 6 right? 7 MR. COLLARD: Object to form. 8 A. This diagram indicates H2 fuel, 9 which is a mixture of hydrogen and nitrogen, is 10 then mixed with natural gas and as directed to 11 a gas turbine. 12 BY MR. PHILLIPS: 13 Q. And there's no CO2 in that 14 hydrogen fuel stream; is that right? 15 MR. COLLARD: Object to form. 16 A. Again, it's mixed with natural 17 gas, which is all methane and hydrocarbons. 18 BY MR. PHILLIPS: 19 Q. Sure. 20 I was referring just to the 21 hydrogen fuel before it mixes with the natural 22 gas, that stream.
254 1 BY MR. PHILLIPS: 2 Q. So do you believe the nitrogen 3 is just a diluent? 4 A. If it's going to a gas turbine, 5 yes. I mean, it's -- yes, it's changing -- 6 it's to make it able to burn safely in the gas 7 turbine, is how it's used. 8 Q. So it will reduce flame 9 temperature, flame speed, things like that? 10 MR. COLLARD: Object to form. 11 A. Again, I can't -- again, it's 12 hard to get to the specifics, but, yes, change 13 the combustion characteristics of the mixture. 14 BY MR. PHILLIPS: 15 Q. And the nitrogen that's added 16 to the -- so nitrogen is added. It goes into 17 the hydrogen fuel. It also goes into the 18 stream that's going to ammonia synthesis. 19 That's typical to add nitrogen 20 to that stream; is that right? 21 A. If you make ammonia, you need 22 hydrogen and nitrogen.	256 1 A. That stream would probably, 2 again, have nitrogen in it and hydrogen 3 predominantly. 4 Q. Okay. There will be unreacted 5 methane? 6 A. There will be some -- there 7 will be some CO, CO2. There will be minor 8 impurities, but primarily hydrogen with -- 9 again, diluted with nitrogen to whatever degree 10 it was diluted. 11 Q. So in a slide deck devoted to 12 CO2 emission reduction, would you agree that 13 the purpose of combusting this hydrogen fuel is 14 to reduce CO2 emissions? 15 MR. COLLARD: Object to form. 16 A. This is directed at partially 17 reducing emissions with regard to electricity 18 production. 19 I will also note that it has 20 nothing to do with the ammonia synthesis 21 loop -- the ammonia synthesis process. 22 ///

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Page 65 of 147

Conducted on July 23, 2026

257 1 BY MR. PHILLIPS: 2 Q. Well, it has something to do 3 with the ammonia synthesis process -- right? -- 4 because it's taking a stream from the ammonia 5 synthesis process. 6 Wouldn't you agree with that? 7 MR. COLLARD: Object to form. 8 A. It is taking an off-stream of 9 the ammonia synthesis process, but at least in 10 this figure, none of the energy -- the 11 carbon-free energy, if you will, is being 12 directed back to the ammonia synthesis process 13 or to reduce the CO2 emissions of the ammonia 14 synthesis process. 15 BY MR. PHILLIPS: 16 Q. But you would agree that the 17 CO2 emissions relating to power generation, 18 that that's counted in the CO2 emissions for 19 carbon and sensitivity calculation for the 20 product ammonia? Wouldn't you agree with that? 21 MR. COLLARD: Object to form. 22 A. Again, not necessarily. It	259 1 BY MR. PHILLIPS: 2 Q. Right? 3 A. Well, there are very clear 4 inputs on this diagram to the ammonia synthesis 5 process. They include oxygen, natural gas, 6 processed steam, nitrogen. They do not include 7 the -- what comes out of the gas turbine does 8 not go back to the ammonia synthesis process. 9 Q. But the electricity could 10 operate pumps and compressors in the ammonia 11 synthesis process; right? 12 MR. COLLARD: Object to form. 13 A. The electricity could be used 14 for anything. 15 BY MR. PHILLIPS: 16 Q. But it could be used to run 17 pumps and compressors in the ammonia process; 18 right? 19 MR. COLLARD: Object to form. 20 A. It's possible, but not 21 indicated in this diagram. 22 ///
258 1 depends on where boxes are defined. Again, 2 that electricity could be provided by renewable 3 sources. 4 As far as, you know, the 5 ammonia synthesis is -- consists of the 6 hydrogen production through the reforming step 7 and the ammonia synthesis itself. This process 8 for making electricity seems external to the 9 ammonia synthesis process, at least as 10 described in Figure 9. 11 BY MR. PHILLIPS: 12 Q. So you're assuming there's 13 another plant next to this ammonia synthesis 14 plant? 15 MR. COLLARD: Object to form. 16 A. I have no idea what's next to 17 this. 18 BY MR. PHILLIPS: 19 Q. I'm just curious why you assume 20 this doesn't relate to ammonia synthesis. You 21 assume it relates to something else. 22 MR. COLLARD: Object to form.	260 1 BY MR. PHILLIPS: 2 Q. Pumps and compressors need 3 electricity; right? 4 A. I agree with that. That's 5 true. 6 Q. And they're intentionally 7 investing in CapEx and OpEx to generate 8 electricity. 9 A. I don't know that. 10 They're generating electricity, 11 yeah. 12 Q. So you don't think it follows 13 that that electricity is being used for the 14 actual ammonia process that's listed here? 15 A. I'm just going by what's in 16 this figure, and it doesn't indicate that that 17 electricity is going back to the ammonia 18 process. 19 Q. Would you think that it's more 20 likely than not going back to the ammonia 21 synthesis process? 22 MR. COLLARD: Object to form.

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Page 66 of 147

Conducted on July 23, 2026

261 1 A. I really don't know. 2 BY MR. PHILLIPS: 3 Q. Let's look at page 7 -- 4 A. Sure. 5 Q. -- the top slide. 6 A. Yep. 7 Q. CO2 Emissions From Ammonia 8 Plants. 9 A. Um-hmm. 10 Q. Do you see that? 11 A. Yep. 12 Q. So it shows in the left box the 13 reformer. It shows fuel. We have flue gas 14 with CO2 in it. 15 Do you see that? 16 A. I do. 17 Q. And then in the bottom right, 18 it shows an auxiliary boiler with fuel and a 19 flue gas with CO2 there. 20 A. Correct. 21 Q. Do you see that? 22 A. Yep.	263 1 Do you agree with that? 2 MR. COLLARD: Object to form. 3 A. This diagram shows CO2 coming 4 off of the -- in the flue gas from the reformer 5 and the auxiliary burner and also shows CO2 6 coming off the acid gas removal step. 7 BY MR. PHILLIPS: 8 Q. Would that be considered -- the 9 CO2 coming off the acid gas removal gas step, 10 would that be considered an emission or would 11 that be considered CO2 that's captured for 12 sequestration? 13 MR. COLLARD: Object to form. 14 A. Again, this is a very -- you 15 know, not labeled diagram. It's CO2 coming 16 off. What they do with it, it could be 17 anything. They could emit it. 18 BY MR. PHILLIPS: 19 Q. But you agree, on this slide, 20 that the author, Mr. Nielsen, was indicating 21 that flue gas from an auxiliary boiler is part 22 of the ammonia plant.
262 1 Q. So would you agree that the 2 purpose of this slide is to show that there's 3 two potential CO2 emission points for an 4 ammonia plant? 5 MR. COLLARD: Object to the 6 form. 7 And I think it shows three. 8 Sorry. 9 BY MR. PHILLIPS: 10 Q. Is that an emission, though? 11 The emission coming from the 12 acid gas removal, is that an emission or is 13 that going to be a sequestered liquid CO2? 14 MR. COLLARD: Sorry. I know 15 I interrupted, so I screwed up the question, 16 but do you mind going with a clean question? 17 MR. PHILLIPS: Sure. 18 MR. COLLARD: Okay. 19 BY MR. PHILLIPS: 20 Q. So we discussed, Dr. Wolden, 21 there's two flue gas streams, potential CO2 22 emissions points in an ammonia plant.	264 1 Would you agree with that? 2 MR. COLLARD: Object to form. 3 A. Again, this doesn't show the 4 exact configuration of this ammonia plant. And 5 presumably it does contain an auxiliary boiler. 6 It's kind of odd because it's just sitting off 7 to the side. It's not part of the process 8 integration. 9 BY MR. PHILLIPS: 10 Q. Well, the auxiliary boiler is a 11 utility; right? 12 MR. COLLARD: Object to form. 13 A. It's -- again, I don't know 14 what it is. It's a box on this diagram. 15 BY MR. PHILLIPS: 16 Q. Is an auxiliary boiler normally 17 part of the process flow for an ammonia 18 synthesis plant? 19 MR. COLLARD: Object to form. 20 A. Possibly, but not necessarily. 21 BY MR. PHILLIPS: 22 Q. But the title of this slide is

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Page 67 of 147

Conducted on July 23, 2026

265 1 CO2 Emissions From Ammonia Plants; right? 2 A. Yes. As we've discussed, 3 there's many configurations of ammonia plants. 4 Q. But at least for purposes of 5 what he was presenting here, he was suggesting 6 that there's -- the auxiliary boiler was part 7 of the ammonia plant and is a potential flue 8 gas CO2 emission point. 9 Would you agree with that? 10 MR. COLLARD: Object to form. 11 A. Based on the title, you would 12 assume that the auxiliary boiler is supplying 13 the ammonia process in some way that's not 14 indicated at all exactly how it would be. 15 BY MR. PHILLIPS: 16 Q. The bottom of page 7, there's 17 another slide titled CO2 Reduction Potential. 18 Do you see it? 19 A. Yep. 20 Q. Third bullet, "How much can the 21 CO2 emission be reduced in the (near) future in 22 an ammonia plant?"	267 1 capture. 2 BY MR. PHILLIPS: 3 Q. Well, you can remove CO2 4 emission from flue gases with a precombustion 5 removal as well; right? 6 MR. COLLARD: Object to form. 7 A. Not as defined in this -- in 8 the process-flow diagram shown on 7. That's 9 not part of what they're doing. 10 They're obviously supplying 11 fuel. And, as you said, CO2 is coming outside 12 of the flue gases. So that's not part of this. 13 BY MR. PHILLIPS: 14 Q. So back to the bottom of 15 page 9, that slide, with hydrogen fuel. 16 A. Yep. 17 Q. I mean, are we in agreement 18 that this is -- this presentation, that the 19 author is using hydrogen fuel as a means for 20 reducing CO2 emissions in flue gas from this 21 gas turbine HRSG arrangement? 22 MR. COLLARD: Object to form.
266 1 Do you see that? 2 A. I see that. 3 Q. Page 8, the top slide, it's 4 titled -- this slide is entitled CO2 Reduction 5 Potential (2). 6 Do you see that? 7 A. Yep. 8 Q. Second bullet, "Remove CO2 from 9 flue gases (reformer and auxiliary boiler) - up 10 to 90 percent can be removed." 11 Do you see that? 12 A. Yep. 13 Q. I mean, is that suggesting 14 removing CO2 from flue gases? 15 A. Yeah, it suggests scrubbing the 16 flue gases and capturing the CO2. 17 Q. So you think this is only 18 post-combustion CO2 removal? 19 MR. COLLARD: Object to form. 20 A. With respect to the second 21 bullet, when you're talking about flue gases, 22 that is, by definition, post-combustion	268 1 A. There's really nothing 2 connecting the slide on page 8 with the top of 3 page 8 and the bottom of page 9. 4 BY MR. PHILLIPS: 5 Q. Except they're in the same 6 presentation; right? 7 A. Sure. 8 Q. Why else would hydrogen fuel be 9 burned in a gas turbine, Dr. Wolden? 10 MR. COLLARD: Object to form. 11 A. Hydrogen would be burned -- 12 again, not hydrogen, but partially hydrogen is 13 burned in the gas turbine to partially reduce 14 the CO2 emissions of that electricity 15 generation. 16 BY MR. PHILLIPS: 17 Q. And that's what this entire 18 PowerPoint is about -- right? -- reducing CO2 19 emissions. 20 Would you agree with that? 21 A. It talks about different ways 22 of reducing CO2 emissions in ammonia power

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Page 68 of 147

Conducted on July 23, 2026

269 1 plants writ large. 2 Q. If we could go to paragraph 91 3 in your declaration. 4 A. Sure. Yep. 5 Q. You're discussing the 2007 IFA. 6 You're talking about the hydrogen fuel being 7 mixed with natural gas -- is that right? -- as 8 the fuel supply to the GT. 9 Is that right? 10 A. As I said, it's mixed with 11 nitrogen and methane -- or natural gas, yes -- 12 Q. Right. 13 A. -- prior to entering the GT. 14 Q. You state after that, the very 15 last portion of paragraph 91, that "the 16 latter" -- and by "the latter," I'm assuming 17 you mean the natural gas -- "would be expected 18 to be the dominant component based on the 19 typical fuel requirements of gas turbines 20 around the year 2000 as understood by a POSA." 21 Do you see that? 22 A. Yep.	271 1 A. Um-hmm. 2 Q. Do you see that? 3 A. Yep. 4 Q. How do you square that with 5 burning primarily natural gas in that gas 6 turbine? 7 MR. COLLARD: Object to form. 8 A. Again, as it's just a few 9 bullets and there's no elaboration, this is 10 subject to -- you know, you have to speculate 11 here. 12 But my best guess is that 13 they're talking about CO2 capture and 14 sequestration off-site. 15 So you're burning natural gas, 16 you're capturing it, but then you're delivering 17 it somewhere else to sequester it. 18 BY MR. PHILLIPS: 19 Q. So the use of -- you're 20 considering the use of hydrogen fuel played no 21 part in reducing the CO2 emission to zero? 22 A. Not if -- you would not
270 1 Q. Respectfully, how would you 2 know that? 3 A. Again, as I mentioned before, 4 gas turbines, at most, could operate with 5 10 percent hydrogen going in as a fuel source 6 at that time. 7 So that would mean the rest of 8 it, 90 percent, would be new methane, due to 9 the technology available at the time. 10 Q. Look at page 10 of 11 Exhibit 1006. 12 A. Page 10. Oh. On the back. 13 Q. Yeah. It's the very last 14 slide, the bottom -- 15 A. Yeah. 16 Q. -- slide? 17 The last bullet. Do you see 18 that? 19 A. Yes. 20 Q. "Technology exists to integrate 21 the plant with the off-sites to reduce the CO2 22 emission to zero."	272 1 consider that at all from here. 2 In fact, if you look at the 3 diagram above it, it shows exactly that, CO2 4 injection into a well, which is what I would 5 presume that's what they're talking about in 6 this slide. 7 Q. I want to touch on your 8 paragraph 68 in your declaration. 9 A. Sure. 10 Q. In paragraph 68, you say that 11 the term "fuel" as used in the 2007 IFA 12 presentation is used exclusively to refer to 13 hydrocarbon or natural gas. 14 Do you see that? 15 A. Yep. 16 Q. And you cite page 7 -- 17 A. Yep. 18 Q. -- of IFA, which is 19 Exhibit 1006. 20 A. Correct. 21 Q. And I guess, in particular, 22 that first bullet: "About 75 percent of the

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Page 69 of 147

Conducted on July 23, 2026

273 1 hydrocarbon is used as feed and 25 percent as 2 fuel in a steam reformer-based ammonia plant." 3 MR. COLLARD: Object to form. 4 A. Yes. It's really my -- that 5 analysis comes from looking at both slides. 6 Look at the slide above, the fuel produces CO₂, 7 so it must be a hydrocarbon fuel, and then 8 exclusively calls it a hydrocarbon fuel in the 9 first bullet. And he calls it "fuel." The 10 term "fuel" is a hydrocarbon. 11 BY MR. PHILLIPS: 12 Q. So you think that the two 13 slides on page 7 are tied to each other? Is 14 that right? 15 A. Yes. 16 MR. COLLARD: Object to form. 17 A. Yes, I do. I believe that the 18 bullets -- again, he's talking about 19 hydrocarbons are fed to that reformer, and he 20 was saying 75 percent of it goes in as the feed 21 and 25 percent is used as the fuel. 22 So I think it directly relates	275 1 Do you see that? 2 A. Yep. 3 Q. And it shows a portion as Ref. 4 Feed and a portion of Ref. Fuel. 5 I assume "Ref" is reformer. 6 Would you agree with that? 7 A. I think they're referring to -- 8 again, he said that split of 75 percent of the 9 hydrocarbon goes as feed and the other 10 25 percent goes as fuel. I think that's 11 what -- I don't know what "Ref" means, but 12 that's my interpretation of that. 13 Q. But, again, they're using the 14 term "natural gas," not "fuel" at that point. 15 Is that right? 16 A. Sure. 17 And when it's called "natural 18 gas," but then it's -- that exact natural gas 19 stream is redefined as fuel right next to it. 20 It's also defined as the auxiliary fuel that's 21 going into the steam and production power unit. 22 The fuel universally in this
274 1 to the slide above it, or most likely. Again, 2 we have to speculate, since no one was there at 3 the presentation. 4 BY MR. PHILLIPS: 5 Q. Well, someone was there at the 6 presentation; right? 7 A. Well, no one here was at the 8 presentation. 9 Q. So you're saying the bottom of 10 page 4, in that slide, the word "fuel" is 11 natural gas? 12 A. Sorry. I'm trying to find 13 slide 4. 14 Q. Bottom slide on page 4. 15 A. Yeah. Yeah. Everything -- 16 wherever "fuel" is used in this presentation is 17 described as a hydrocarbon. 18 Q. Let's look at page 9, the top 19 slide. 20 A. Sure. 21 Q. In the upper left, it shows 22 natural gas as the feed to the ammonia unit.	276 1 slide is natural gas. 2 Q. So look at the lower slide on 3 page 9. 4 A. Yeah. 5 Q. And the top left, it clearly 6 shows natural gas, which feeds the reformers, 7 with a portion that's mixed with the H₂ fuel. 8 Do you see that? 9 A. Above the gas turbine? 10 Q. Yeah, so in the upper-left 11 portion of the slide of that process-flow 12 diagram, it shows natural gas coming in just 13 below oxygen. 14 Do you see that? 15 A. Yes. 16 Q. But they don't use the term 17 "fuel" there. Why? 18 MR. COLLARD: Object to form. 19 A. I didn't make the slides. I 20 have no idea. 21 BY MR. PHILLIPS: 22 Q. I thought you said earlier,

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Page 70 of 147

Conducted on July 23, 2026

277 1 though, that every time they said "fuel," they 2 meant natural gas. 3 MR. COLLARD: Object to form. 4 A. Okay. 5 BY MR. PHILLIPS: 6 Q. It seems like when they want to 7 mention natural gas, they say "natural gas." 8 MR. COLLARD: Object to form. 9 BY MR. PHILLIPS: 10 Q. Isn't that right? 11 A. In this presentation, as they 12 say very clearly in 7, natural gas is used as a 13 feed and it's used as a fuel. 14 So natural gas is what's being 15 used. And they just distinguish it as fuel 16 when it's being used as fuel and they 17 distinguish it as feed when it's being supplied 18 to the reformer. 19 So natural gas is being used in 20 two different ways, and they're just 21 distinguishing how it is used. 22 Q. Well, on page 9, the bottom	279 1 BY MR. PHILLIPS: 2 Q. I'm wondering if it's plausible 3 that the fuel is actually a mixture of natural 4 gas and H2 fuel. 5 MR. COLLARD: Object to form. 6 A. "Fuel" is not used in slide 9, 7 the term "fuel." It's just not used in the 8 bottom of slide 9. 9 BY MR. PHILLIPS: 10 Q. So in the -- page 8, the bottom 11 slide, wouldn't you agree that the listed fuel, 12 which is in two places, is likely the mixture 13 of natural gas and H2 fuel, informed by the 14 title of the slide, Integration of Gas Turbine 15 Driver in the Ammonia Process? 16 MR. COLLARD: Object to form. 17 Go ahead. 18 A. I absolutely disagree. 19 That term "fuel," as listed on 20 the slide above it, the slide before it, every 21 slide in this presentation refers exclusively 22 to natural gas. The slide following it, it's
278 1 slide, "natural gas" is used for both: the 2 feed and the reformer and as fuel. Right? 3 They're not distinguishing at all. 4 MR. COLLARD: Object to form. 5 BY MR. PHILLIPS: 6 Q. It's just natural gas; right? 7 A. So here, they show natural gas 8 stream coming in and it's split. One stream 9 goes as essentially feed to the reformer in the 10 ammonia synthesis plant; the other is sent 11 externally to a gas turbine. 12 Q. Isn't it equally plausible that 13 that mixture of natural gas and hydrogen fuel 14 is the fuel -- quote, unquote, fuel for the gas 15 turbine? 16 MR. COLLARD: Object to form. 17 I'm sorry. What do you mean by 18 "quote, unquote"? I don't understand what 19 you -- 20 MR. PHILLIPS: We were talking 21 about the use of the word "fuel" throughout 22 this presentation. I'm just wondering if --	280 1 exclusively natural gas. 2 BY MR. PHILLIPS: 3 Q. But this slide title 4 specifically says we're integrating -- 5 integration of the gas turbine driver in the 6 ammonia process. 7 Where is that integration but 8 for the fuel being at least partially the 9 CO2-depleted hydrogen fuel? 10 MR. COLLARD: Object to form. 11 A. Again, this is a completely 12 unrelated process and precedes slide 9. So 13 there's no reason anyone would expect anything 14 to do with slide 9, which is two slides later, 15 would have anything to do with this slide. 16 BY MR. PHILLIPS: 17 Q. Well, I was just looking at one 18 slide, page 8, bottom slide. 19 A. I understand that. 20 Q. Where is the integration with 21 the ammonia process if fuel is natural gas? 22 A. This looks like -- as if I go

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Page 71 of 147

Conducted on July 23, 2026

281 1 back to the diagram on -- that we discussed on 2 the top of Figure 7, it showed the ammonia 3 process and then showed this -- you know, this 4 set-of-ways slide -- fuel auxiliary, burner -- 5 which, as you suggested, you think supplies the 6 ammonia process. 7 At this point, that's what 8 I would think this is related to, is that 9 auxiliary burner and processes related to the 10 ammonia. There's nothing else I could think of 11 at this point in the presentation. 12 Q. Well, now you're tying two 13 slides together. 14 You didn't like it when I tied 15 two slides together, but you're going to tie 16 slide 7 and slide 8 together? 17 A. Well, I'm trying -- yes, 18 because they follow in chronological order. 19 7 comes before 8 where 9 follows 8. 20 Q. But isn't it true, though, that 21 -- you said there could be no other 22 integration. But isn't it true, on page 8, the	283 1 A. And they also describe fuel 2 exclusively as natural gas. 3 BY MR. PHILLIPS: 4 Q. How so? 5 A. Go back to slide 7. 75 percent 6 of hydrocarbons is used as the feed, 25 percent 7 is used as the fuel. 8 Q. I'm sorry. What -- what 9 page are you on? 10 A. The bottom slide of 7. Sorry. 11 Q. Okay. Go ahead. 12 A. Right? 13 As we talked about in the 14 figure above, which it's referencing, they show 15 a feed and a fuel. They explicitly say in the 16 bottom slide that that is a hydrocarbon. 17 It doesn't say natural gas, but 18 that is most likely what the specific 19 hydrocarbon is. So "fuel" is defined as a 20 hydrocarbon here and throughout this 21 presentation. 22 Again, as you said on the top
282 1 bottom slide, that the fuel -- the integration 2 could be that the fuel is H2 fuel mixed with 3 natural gas? 4 MR. COLLARD: Object to form. 5 A. There's nothing in this 6 presentation that would lead a reasonable 7 person to think that that fuel was anything but 8 natural gas on page 8. 9 BY MR. PHILLIPS: 10 Q. Other than the fact that they 11 actually say "natural gas" when they mean 12 natural gas? 13 MR. COLLARD: Object to form. 14 A. Exactly what are you asking? 15 BY MR. PHILLIPS: 16 Q. Well, page 9, the top slide, 17 natural gas. Page 9, the bottom slide, natural 18 gas. 19 They use "natural gas" as a 20 term when they want to describe natural gas, 21 don't they? 22 MR. COLLARD: Object to form.	284 1 of slide 9, natural gas is broken up. It says 2 explicitly that natural gas is used as a feed, 3 it's used as a fuel, it's also used as the 4 auxiliary fuel for the boiler. 5 Everything in this 6 presentation, "fuel" is used interchangeably 7 with natural gas -- the fuel is natural gas in 8 this presentation, as defined, as far as anyone 9 could pick out from this presentation. 10 Q. Wouldn't you agree, though, 11 that page 7, the top slide, makes more sense if 12 fuel is actually a mixture of natural gas and 13 H2 fuel? 14 I mean, that would actually 15 relate to the reduction of CO2 emissions, which 16 is what this whole PowerPoint is about. Right? 17 MR. COLLARD: Sorry. You're on 18 page 7? 19 MR. PHILLIPS: Page 7, top 20 slide. 21 MR. COLLARD: Okay. 22 MR. PHILLIPS: The title of the

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Page 72 of 147

Conducted on July 23, 2026

285 1 slide is CO2 Emissions From Ammonia Plants. 2 BY MR. PHILLIPS: 3 Q. Wouldn't it make more sense if 4 the fuel were a mixture of natural gas and 5 hydrogen, because that would actually result in 6 a reduction of CO2 emissions, which is the 7 whole point of the PowerPoint? 8 Wouldn't you agree? 9 MR. COLLARD: Object to form. 10 A. I would strenuously not agree 11 because it explicitly says in the bullet point 12 below that the hydrocarbon -- that it's a 13 hydrocarbon. Hydrogen is not a hydrocarbon. 14 It also talks about, on the 15 next page, how they're going to reduce that 16 CO2; and it's by scrubbing the CO2 emissions 17 from the combustion of that hydrocarbon. 18 I mean, that's actually the 19 innovation of the '168 patent, is that they 20 replace that with hydrogen. That's what makes 21 it an innovation. 22 ///	287 1 BY MR. PHILLIPS: 2 Q. But it also could be a mixture 3 of nitrogen -- or not nitrogen -- a mixture of 4 CO2-depleted, hydrogen-rich gas and natural 5 gas, couldn't it? 6 MR. COLLARD: Object to form. 7 A. There's nothing in this 8 presentation that would lead one to think that 9 that is fuel. 10 The only time that that comes 11 up is at the bottom of slide 9 and actually use 12 the term "H2 fuel" to distinguish it from the 13 term "fuel." 14 If this was supposed to be an 15 H2 fuel, I would expect they would have used 16 the term "H2 fuel" here. But they don't. They 17 use "fuel," which, as I've said multiple times 18 now, is exclusively natural gas throughout this 19 presentation. 20 BY MR. PHILLIPS: 21 Q. But the actual feed to the gas 22 turbine on the bottom of page 9 is not the H2
286 1 BY MR. PHILLIPS: 2 Q. What about page 4, the bottom 3 slide? The author used the term "fuel" to fire 4 the prereformer and uses the term "hydrocarbon 5 feed" for the process feed. 6 Why would they use two 7 different terms? 8 A. That's very consistent with how 9 they used the terms on slide 7. 10 Hydrocarbon is used as both a 11 feed and a fuel. And just to be specific, 12 they're not using -- they're not supplying the 13 fuel to the prereformer; they're supplying it 14 to what is a steam reformer here. 15 Q. Why didn't they just say "fuel" 16 for -- instead of "hydrocarbon feed" on the 17 bottom of page 4? 18 MR. COLLARD: Object to form. 19 A. Why did he label anything? 20 Again, I'm just -- if he was self-consistent, 21 fuel is a hydrocarbon. 22 ///	288 1 fuel. You've explained that. Right? 2 It's actually a combination of 3 H2 fuel and natural gas; right? 4 A. They mix H2 -- they mix the H2 5 fuel and natural gas going to the external gas 6 turbine. 7 Q. So he didn't provide a label 8 for what's actually being combusted in the gas 9 turbine. Is that right? 10 MR. COLLARD: Object to form. 11 A. They just show two streams 12 mixing. You have no idea what the proportions 13 are or exactly what it is. 14 BY MR. PHILLIPS: 15 Q. But on the bottom of page 8, 16 they show that the stream going to the gas 17 turbine in the same way as on the bottom of 18 page 9 is just labeled as "fuel." Right? 19 MR. COLLARD: Sorry. Object to 20 form. 21 A. Again, you know, what's shown 22 on the bottom of page 8 is an auxiliary process

Conducted on July 23, 2026

289 1 for making steam and electricity. There's no 2 relationship to that and Figure 9. 3 BY MR. PHILLIPS: 4 Q. Well, both slides relate to the 5 integration with the ammonia process. Wouldn't 6 you agree? 7 MR. COLLARD: Object to form. 8 A. The power cycle is separate in 9 slide 9 from the ammonia synthesis. 10 BY MR. PHILLIPS: 11 Q. But it's using a stream from 12 the ammonia synthesis. 13 A. Sure. 14 Q. So that's its integration with 15 the ammonia synthesis; right? 16 A. I guess if there's nothing 17 going back to the ammonia process. 18 Q. Is that needed for there to be 19 integration? 20 MR. COLLARD: Object to form. 21 A. It depends on how you define -- 22 the extent of integration, I guess.	291 1 -- unless it's a perfect separation, some very 2 small residual parts of the CO2. 3 Q. Like ppm level? 4 A. Yeah. I would guess, yes. 5 Q. Same slide, you see the ATR. 6 It's right in the middle of the flow diagram. 7 A. Yep. 8 Q. Again, we're on page 9, the 9 bottom slide. 10 A. Yeah. 11 Q. It's fed pure oxygen. Do you 12 see that -- 13 A. Yes. 14 Q. -- instead of air? 15 A. Yes. 16 Q. Do you agree that the 17 advantages of oxygen-enriched ATR operation was 18 known before 2017? 19 MR. COLLARD: Object to form. 20 A. I mean, again, you'll find in 21 the literature -- so the possibility of adding 22 oxygen -- enriched oxygen to an ATR was
290 1 BY MR. PHILLIPS: 2 Q. So a few odds and ends. Let's 3 look at page 9, bottom slide again. 4 A. Sure. Page 9? 5 Q. Yeah. Page 9, bottom slide. 6 A. Yep. Yep. 7 Q. You'll agree, the methanator on 8 the far right of that process flow, the purpose 9 is to convert the residual CO, CO2 because 10 oxygenates poison the ammonia synthesis 11 catalyst. Is that right? 12 MR. COLLARD: Object to form. 13 A. Yeah, there's -- the CO2 should 14 have been removed at the CO2 removal step. But 15 there will be residual CO that's converted into 16 methane in the methanator because it's the CO 17 that's actually detrimental, not the CO2, to 18 the process. 19 BY MR. PHILLIPS: 20 Q. Is CO2 methanated as well? 21 A. No. CO2 is removed. 22 I mean, there's probably some	292 1 certainly known. 2 You'll find people disagree 3 whether that was a beneficial thing or not, 4 depending on what the process is. 5 BY MR. PHILLIPS: 6 Q. But the process shown on the 7 bottom of page 9 shows pure oxygen. 8 A. It shows pure oxygen being 9 supplied to the ATR. That's what's indicated 10 there, yes. 11 Q. All right. In paragraph 61 to 12 64 of your declaration -- 13 MR. COLLARD: Are we moving to 14 a different document or we still on 2007 IFA? 15 MR. PHILLIPS: We're still -- 16 we're actually just going on talk about the IFA 17 website for a bit. 18 MR. COLLARD: That's fine. 19 MR. PHILLIPS: Let's do this 20 segment and then take a break. 21 MR. COLLARD: That's what I was 22 going to say.

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Page 74 of 147

Conducted on July 23, 2026

293 1 MR. PHILLIPS: So hopefully 2 less than ten minutes, if that's okay. 3 MR. COLLARD: Is that okay with 4 you? 5 THE DEPONENT: That's perfectly 6 fine. 7 BY MR. PHILLIPS: 8 Q. So paragraph 61 to 64 of your 9 declaration, you indicate that you ran a series 10 of searches on the IFA website. 11 The question is: When did you 12 run those searches? 13 A. I can't give you the precise 14 date. It was after I was engaged in the course 15 and read Ritter's declaration in doing my, you 16 know, preliminary research for this case. 17 So that was probably last 18 November, maybe December. 19 Q. Of 2025? 20 A. Of 2025. 21 It was probably about -- 22 approximately. I don't remember the exact	295 1 meeting. 2 Is that right? 3 A. Yeah. Returned a ton of things 4 if you put "ammonia" in the IFA website. 5 Q. Okay. 6 And one of those things was a 7 full set of slides from this March 2007 IFA 8 meeting. Is that right? 9 A. That was one of the many things 10 that was returned for that search, yes. 11 Q. I just wanted to confirm that 12 Exhibit 1006, the 2007 IFA, was one of the 13 items that was in the full deck of slides from 14 the March 2007 meeting. 15 A. Yes, it was in the full deck of 16 slides. 17 Q. The proceedings are titled 18 Energy Efficiency and CO2 Reduction Prospects 19 in Ammonia Production. 20 Do you see that? 21 A. Yes. 22 Q. Would a POSA interested in CO2
294 1 date. 2 Q. So you don't know the IFA 3 website layout between 2007 and 2017? 4 A. I do not. 5 Q. You don't know what the search 6 functionality was like between 2007 and 2017 on 7 the IFA website? 8 A. I couldn't comment on that, no. 9 Q. You don't know what the 10 indexing on the IFA website looked like between 11 2007 and 2017? 12 A. Nope. 13 Q. Do you have any evidence that 14 the 2007 IFA slides were not available on the 15 IFA website between 2007 and 2017? 16 MR. COLLARD: Object to form. 17 A. I don't know what was on the 18 IFA website prior to 2025. 19 BY MR. PHILLIPS: 20 Q. In paragraph 64, you state that 21 you searched the term "ammonia" and returned a 22 full set of the IFA slides for that March 2007	296 1 emissions reduction recognize that title as 2 pertinent? 3 MR. COLLARD: Object to form. 4 A. So I think that title is 5 pertinent to the group of slides. 6 BY MR. PHILLIPS: 7 Q. So just to confirm. The 8 March 2007 meeting, itself, you already stated 9 you weren't there. 10 Do you dispute that the slides 11 were presented to industry attendees without 12 confidentiality restrictions? 13 A. I have no idea what was 14 confidential or what wasn't or how it was 15 presented. 16 Q. And you have no evidence 17 contradicting that Nielsen presented his 18 complete slide deck to the IFA for publication? 19 A. I don't know that he did or 20 I don't know that he didn't. 21 MR. PHILLIPS: Let's go ahead 22 and take a break.

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Page 75 of 147

Conducted on July 23, 2026

297 1 MR. COLLARD: Great. 2 MR. PHILLIPS: If that's okay. 3 THE VIDEOGRAPHER: Stand by. 4 We are going off the record. 5 The time is 2:22. 6 (Recess taken.) 7 THE VIDEOGRAPHER: We are back 8 on the record. The time is 2:31. 9 BY MR. PHILLIPS: 10 Q. Dr. Wolden, I'm handing you 11 what's been marked as Exhibit 1020. 12 (Previously marked Topsoe, 13 Inc. - Exhibit 1020 was tendered 14 to the witness.) 15 Q. Do you recognize this document? 16 A. I don't, actually. 17 Q. This was a document submitted 18 with the -- that Topsoe submitted in support of 19 its IPR petition. I can walk you through it. 20 I just have a few questions about it, actually. 21 The first two pages -- actually 22 the first page is a Declaration of Mina Ching.	299 1 to read the date in that web.archive.org e-mail 2 address, but it's -- it was archived on 3 July 11th, 2009. And that's basically what 4 this Internet Archive is declaring -- what this 5 declaration is declaring. 6 It's a paper written by P. 7 Lako -- I don't know how to pronounce it. It 8 bears March 2009 on the cover. Again, it was 9 archived in July 11th, 2009, indicating that it 10 was at least published on the internet at that 11 point. 12 I want to direct you to -- so 13 this is a paper by P. Lako. The title is 14 Energy Conservation Potential of the Nitrogen 15 Fertiliser Industry. 16 Do you see that? 17 A. Yeah, I see the title. 18 Q. Are you familiar with ECN? 19 A. No, I'm not. I'm reading the 20 title there. It looks like an energy industry 21 association or government association in The 22 Netherlands.
298 1 Are you familiar with the 2 Internet Archive, Dr. Wolden? 3 A. Very vaguely. 4 Q. Okay. 5 A. I basically became aware of it 6 kind of in Ritter's deposition to this case. 7 Q. Right. 8 So you may have read actually 9 about this in Dr. Ritter's -- 10 A. That's the extent that I'm 11 familiar with this, is whatever was in Ritter's 12 declaration. 13 Q. So this is an authenticating 14 declaration by Internet Archive on the first 15 page. And the Exhibit B cover sheet has a back 16 page to it. I did this two-sided to save 17 trees. It shows the Internet Archive, the 18 web.archive address for where this document was 19 stored and where it was found. 20 A. Okay. 21 Q. I will represent to you, if you 22 were to read the front, it would tell you how	300 1 Q. I want to direct you to page 42 2 of 54. 3 A. Page 42? 4 Q. Yeah. So there's two sets of 5 page numbers. I'm going by the actual -- very 6 bottom page 42 of 54. That may be the easiest 7 way to refer to things. 8 A. Okay. Which also says 38 or 9 the reference page? 10 Q. Correct. 11 A. Okay. 12 Q. So these are -- just to orient 13 you to the document, there was actually an 14 article that he wrote, a paper. And then he 15 has a list of references starting on page 42 of 16 54. 17 The fourth reference on page 42 18 is the last name is Balken. Do you see that? 19 A. Yes. 20 Q. And it's an article, Best 21 Available Technologies for the Production of 22 Ammonia from IFA 2007 Technical Committee

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Page 76 of 147

Conducted on July 23, 2026

301 1 Meeting. 2 Do you see that? 3 A. Yep. 4 Q. On page 44 of 54, the very last 5 entry on the bottom of the page -- 6 A. JVP? 7 Q. No. 44 of 54. 8 A. Sorry. I was on 43. Sorry. 9 Yeah. 44. Yep. 10 Q. The very last entry is SE 11 Nielsen, Future Energy Efficiency in CO2 12 Reduction Potential, IFA 2007 Technical 13 Committee Meeting. 14 Do you see that? 15 A. Yep. 16 Q. This, I believe, is what we 17 were looking at before, Exhibit 1006. You can 18 cross-reference that, if you want. 19 A. Yep. 20 Q. And then on page 46 of 54, the 21 next to last of the articles that's referenced 22 is the Williams, et al., Ansari reference --	303 1 BY MR. PHILLIPS: 2 Q. You don't know whether you have 3 evidence? 4 A. I don't have evidence either 5 way. 6 Q. Do you have any evidence that 7 Lako was not an interested researcher who 8 searched for and found these three 9 presentations from the 2007 IFA meeting? 10 MR. COLLARD: Object to form 11 and scope. 12 A. Again, I don't know exactly how 13 he obtained them. The proceedings might have 14 been published somewhere else and printed for 15 him. 16 I really don't know. Maybe he 17 attended the 2007 meeting. I have no idea. 18 BY MR. PHILLIPS: 19 Q. That's it for that document. 20 You can put that aside. 21 I'm going to hand you now what 22 should be -- let's see if I can find it.
302 1 Ali Ansari reference? 2 A. Yeah. Sure. 3 Q. Or Al-Ansari reference. 4 And, again, you see it's IFA 5 Benchmarking of Global Energy Efficiency in 6 Ammonia Production, IFA 2007 Technical 7 Committee Meeting. 8 Do you see that? 9 A. Um-hmm. 10 Q. Do you have any evidence that 11 Mr. Lako attended the 2007 IFA meeting? 12 A. No. 13 MR. COLLARD: Object to form. 14 THE DEPONENT: Sorry. 15 MR. COLLARD: Scope. 16 BY MR. PHILLIPS: 17 Q. Do you have any evidence that 18 Lako obtained the three presentations other 19 than through the IFA website? 20 MR. COLLARD: Object to form 21 and scope. 22 A. I don't know.	304 1 (Pause.) 2 It should be a familiar 3 reference for you. This is Exhibit -- marked 4 as Exhibit 1008. 5 (Previously marked Topsoe, 6 Inc. - Exhibit 1008 was tendered 7 to the witness.) 8 Q. This is the Rytter reference. 9 A. Yes. 10 Q. R-y-t-t-e-r. 11 (A discussion was had off 12 the stenographic record.) 13 Q. Let's look at column 4, line 14 30. 15 A. Column 4, line 30, yep. 16 Q. It says, "Particularly the 17 autothermic reformer will be fed natural gas as 18 natural gas is a lower hydrocarbon gas, and it 19 may beneficially be a prereformed natural gas." 20 Do you see that? 21 A. Yep. 22 Q. Is there any mention of a

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Page 77 of 147

Conducted on July 23, 2026

305 1 primary steam reformer between the ATR and the 2 prereformer, the prereformer to natural gas? 3 A. Well, it doesn't -- this 4 statement doesn't exactly say how it was 5 pre-formed. 6 And I would note just a few 7 lines above, that it "Particularly preferred 8 the reforming plant consists of an autothermic 9 reformer combined with a steam reformer and a 10 prereformer." 11 Q. Are those the same embodiments 12 or would you consider those separate 13 embodiments? 14 A. Again, this patent is not very 15 explicit on what it means by anything, and is 16 often inconsistent, quite honestly. 17 Q. But the part you just read in 18 column 4, line 17 to 20, when the patent 19 intends to discuss a primary reformer, it says 20 it. Right? 21 MR. COLLARD: Object to form. 22 A. Part of the --	307 1 BY MR. PHILLIPS: 2 Q. You said that -- "preferred"? 3 A. That's what the words say: 4 "Particularly preferred the reforming plant 5 consists of an autothermic reformer combined 6 with a steam reformer and a prereformer." 7 Q. What about the part at 8 column 4, line 30, where it also says 9 "particularly"? 10 A. Again, this follows after that 11 previous statement. 12 So, you know, one could assume 13 that that prereformer goes into a steam 14 reformer or that there's a steam reformer as 15 well. It doesn't say exactly how the natural 16 gas is prereformed. 17 Q. I think there's only one figure 18 in the Rytter reference. Is that right? 19 A. There is only one. 20 Q. Can you point to any place in 21 this figure where there's a primary reformer 22 between a prereformer and an ATR?
306 1 MR. COLLARD: I'm sorry. Did 2 you say "primary"? 3 What did you say? 4 MR. PHILLIPS: Primary. 5 MR. COLLARD: Okay. 6 A. So your question is what again, 7 exactly? 8 I'm sorry. 9 BY MR. PHILLIPS: 10 Q. Sure. 11 I'm just saying, looking at 12 column 4, line 17 to 20 -- 13 A. Yeah. 14 Q. -- when the patent wants to 15 discuss a steam reformer between a prereformer 16 and autothermic reformer, it says so 17 explicitly; right? 18 MR. COLLARD: Object to form. 19 A. It just simply says that that's 20 the preferred reforming combination, includes 21 those three elements. 22 ///	308 1 A. You can't point to anything on 2 this figure because it's so poorly described. 3 It describes one as a 4 pretreatment plant, and it describes two as the 5 reforming station. It makes no explicit thing 6 -- outside of saying the reforming station has 7 to have an ATR -- it does say that -- but it 8 says nothing else about what's included in it. 9 Q. Will you agree that prior to 10 2017, a POSA would understand that a possible 11 flow scheme includes a prereformer with an ATR 12 without a primary reformer there between? 13 MR. COLLARD: Object to form. 14 A. Again, it's certainly a 15 possible configuration. We just talked about 16 that. And that was a -- one of the 17 configurations in the 2007 IFA. 18 But it doesn't explicitly say 19 anything about it in this proposal -- or in 20 this patent -- sorry -- besides being the 21 particularly preferred embodiment. 22 BY MR. PHILLIPS:

Conducted on July 23, 2026

309 1 Q. In paragraph 26 of your 2 declaration, you said that "A furnace is a 3 relatively simple unit that involves the 4 combustion of fuel followed by the transfer of 5 thermal energy from the hot combustion gas to 6 another fluid." 7 Is that right? 8 A. Yep. I think we covered that. 9 Q. So Rytter, at column 6, lines 10 10 through 13 -- 11 A. Yes. 12 Q. I'm going to strike that. 13 A. Sorry. 14 Q. No, no, no. You were right for 15 saying that. I kind of dangled that out there. 16 I'm going to strike that. 17 A. Sorry. I read it. But you can 18 ask your question. 19 Q. I certainly dangled that 20 question in the middle so I'll strike that. 21 So starting at column 10 -- 22 sorry -- column 6, line 10, it describes	311 1 throughout this patent. 2 BY MR. PHILLIPS: 3 Q. Does it discuss gas turbines 4 with respect to hydrogen power station 7? 5 A. Yes. 6 Q. Where? 7 A. Many places. We can go look 8 wherever it says "gas turbine" on this. If I 9 go -- give me a moment to look through the 10 exact spots. 11 (Document[s] reviewed.) 12 I think I saw that earlier. 13 (Document[s] reviewed.) 14 "A possible new use is as fuel 15 for gas turbines, for heat-generation stations, 16 and thus considerably reducing the emission of 17 CO2 in the production of electrical power." 18 I'm reading column 1, lines 32 19 through 36. 20 Q. But that's not describing power 21 station 7, is it -- hydrogen power station 7, 22 is it?
310 1 hydrogen power station 7. 2 Do you see that? 3 A. Yep. 4 Q. Which is also supplied with air 5 for the combustion of the hydrogen gas to steam 6 producing electrical power. 7 Do you see that? 8 A. Yes. 9 Q. So I want to focus on that for 10 a second, the steam producing electrical power. 11 A. Um-hmm. 12 Q. Would you agree that this is 13 a -- that this describes producing steam and 14 then using that steam in a steam turbine to 15 produce power? 16 MR. COLLARD: Object to form. 17 A. I would not agree. 18 He exclusively describes the 19 turbine as a gas turbine, which is distinct 20 from a steam turbine. And he doesn't mention 21 steam turbine at all, not once. He just 22 exclusively describes it as gas turbines	312 1 A. That is the hydrogen power 2 station. That's the only place electricity is 3 produced in this figure. That is the 4 definition of what 7 is. 5 Q. Well, what you read from 6 column 1 does not necessarily relate to the 7 figure, does it? 8 A. Again, the only mention of a 9 turbine is a gas turbine throughout this 10 presentation -- throughout this patent. 11 So one can -- that's the only 12 place power is generated in the figure, so 13 the -- again, it's called the hydrogen power 14 unit. 15 Q. Well, it's a hydrogen power 16 station 7. 17 A. Yeah. 18 Q. It uses the hydrogen gas -- the 19 combustion of the hydrogen gas -- 20 A. In a gas turbine. 21 Q. -- to steam producing 22 electrical power. It doesn't say "to a gas

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Page 79 of 147

Conducted on July 23, 2026

313 1 turbine." 2 Again, I'm reading from 3 column 6 -- 4 A. Sure. 5 Q. -- line 10. 6 You agree with that; right? 7 MR. COLLARD: Sorry. 8 Object to form. 9 Do you mind reasking the 10 question? I feel like there were just two 11 parts. 12 MR. PHILLIPS: Sure. 13 BY MR. PHILLIPS: 14 Q. I'm going back to specifically 15 the description of hydrogen power station 7, 16 which is very specific. It's only mentioned 17 two or three times in this patent. 18 It's supplied with air for the 19 combustion of the hydrogen gas to steam 20 producing electrical power. 21 So the straightforward reading 22 of that is it's producing steam and then going	315 1 referenced in column 1, lines 33 to 36, 2 describes heat-generating stations. 3 MR. COLLARD: I'm sorry. Where 4 he described it in what? 5 MR. PHILLIPS: He had cited in 6 column 1; I think it's line 33 to 36. 7 BY MR. PHILLIPS: 8 Q. Is that right, Dr. Wolden? 9 A. Yeah. Fuel for gas turbines of 10 heat generating stations. So it's a turbine of 11 a heat generating station. Again, combustion 12 is part of their gas turbine. 13 Q. So that's a heat generating 14 station, but this is hydrogen power station 7, 15 not a heat generating station. 16 You'd agree with that; right? 17 A. He lumps heat generation 18 station and power generation all in the same 19 thing. 20 Q. Well, you've lumped it into the 21 same thing; right? 22 A. No. These are his words, not
314 1 to produce electrical power from the steam. 2 Isn't that right? 3 MR. COLLARD: Object to form. 4 A. Again, he refers exclusively to 5 a gas turbine. 6 So, yes, the hydrogen and air 7 are combusted. And those combustion gases are 8 used to turn a turbine. And the combustion 9 products are steam, just like they are from a 10 methane-powered gas turbine, which has steam 11 plus CO2. 12 But it is a -- there's a 13 significant distinction between a steam 14 turbine, which separately produces steam and 15 then is used to turn a turbine. 16 BY MR. PHILLIPS: 17 Q. Right. 18 A. Gas turbines and steam turbines 19 are different things. 20 Q. Sure. 21 A. Yeah. 22 Q. But the -- what you had	316 1 mine. 2 Q. Where are his words where he 3 lumps them into the same thing? 4 A. (Document[s] reviewed.) 5 I'm trying to find a good 6 example for this. 7 (Document[s] reviewed.) 8 So another example would be the 9 end of column 4, line 63 through 67. "Further, 10 it will be beneficial that the streams from the 11 reformer are distributed between the methanol 12 synthesis reactor and heat generating station 13 depending on the demand of methanol, dimethyl 14 ether, and oxidation products thereof and 15 electrical power respectively." 16 So he is explicitly connecting 17 the heat generation stations with the 18 generation of electricity production. 19 Q. Well, I agree, the heat 20 generating stations appear to use a gas 21 turbine. But we're not talking about the heat 22 generation stations; we're talking about

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Page 80 of 147

Conducted on July 23, 2026

317 1 hydrogen power station 7. 2 You said that the Rytter 3 reference had lumped those two together. So 4 I'm just asking: Where is your support for 5 that conclusion? 6 A. I mean, again, this patent is 7 not very clear about much. All it really shows 8 is that hydrogen and air go into the -- into 7 9 and that steam and electricity come out. 10 But that electricity has to be 11 made by a turbine. And, again, throughout this 12 patent, he exclusively describes that turbine 13 being a gas turbine. 14 Q. But the language in column 6, 15 row 10 -- 10 through 13 -- "a steam producing 16 electrical power," I don't see any other 17 reading of that other than it's steam that's 18 then creating electrical power. I don't see 19 how you're creating electrical power and then 20 steam. 21 Can you explain that? 22 MR. COLLARD: Object to form.	319 1 Again, depending on the 2 requirements of the energy, that ratio can be 3 split between synthesis and electric power in a 4 gas turbine, and extreme being not producing 5 any electricity from the turbine. 6 Q. And you believe that relates to 7 hydrogen power station 7? 8 A. 7 is the only place that 9 there's power generation. You need a turbine. 10 Q. Well, it's the only place 11 listed in the figure. 12 A. It's the only place in the 13 patent, yes. 14 Q. Well, the patent talks about 15 lots of different embodiments. I think you'd 16 agree with that. Right? 17 MR. COLLARD: Object to form. 18 A. It's kind of -- like I said, 19 it's not a very explicit patent. But certainly 20 the only place that steam -- or electricity is 21 being generated is in box 7. 22 ///
318 1 A. Steam -- in a gas turbine, 2 steam will be the byproduct of exhaust gas. So 3 that's turning the turbines, making the 4 mechanical energy, turning into electrical 5 energy, and the exhaust is going to be steam 6 plus unburned air and nitrogen. 7 BY MR. PHILLIPS: 8 Q. So you're saying steam is the 9 exhaust of the gas turbine? 10 A. If you combust hydrogen, you 11 make steam, by definition. That will be the 12 exhaust of a gas turbine that is fired by 13 hydrogen. 14 Q. But you have no support in 15 Rytter that hydrogen power station 7 actually 16 utilizes a gas turbine; right? 17 A. I mean, it says that. It will 18 not be necessary to produce electrical power 19 with a gas turbine. 20 Q. Where are you reading from? 21 A. I'm sorry. That was column 2, 22 line 50 or so -- 51, 52.	320 1 BY MR. PHILLIPS: 2 Q. But steam could just be 3 generated from the combustion of hydrogen fuel; 4 right? 5 A. That's exactly what I'm saying, 6 is that steam is produced in -- by the 7 combustion process in the gas turbine. And 8 that is the exhaust of the gas turbine. 9 Q. But steam could also be 10 produced in a furnace within the meaning of the 11 '168 patent. Wouldn't you agree? 12 MR. COLLARD: Object to form. 13 A. In general, steam could be 14 produced in a steam-generating furnace. But 15 that's not what's described in this patent. 16 BY MR. PHILLIPS: 17 Q. Well, that's why I'm asking you 18 why you've eliminated that possibility. 19 A. Because he exclusively talks 20 about gas turbines. 21 So those are not steam 22 turbines. I encourage you to look through this

Conducted on July 23, 2026

321 1 patent and see if you can find a steam turbine. 2 Q. I have read this patent many 3 times. 4 A. That probably is -- yep, we all 5 have, actually. 6 Q. As we all have. 7 No, I just don't see the 8 correlation of gas turbines with hydrogen power 9 station 7. So that's why I'm asking you if 10 there's an explicit correlation. 11 MR. COLLARD: We don't have the 12 search function, as we sit here and look at 13 paper copies. So, you know, a little higher up 14 in column 2, line 43. Hydrogen as fuel in a 15 gas turbine. 16 MR. PHILLIPS: There's no doubt 17 that there's disclosure of hydrogen as a fuel 18 in a gas turbine. 19 MR. COLLARD: Okay. 20 MR. PHILLIPS: And I think that 21 agrees with what he cited in column 1 as well. 22 My only point is: There's no tie between that	323 1 conclude that the gas turbine is in 7. 2 BY MR. PHILLIPS: 3 Q. But hydrogen power station 7 4 could be a steam-generating furnace with a 5 steam turbine creating power? 6 A. I don't know. It's not -- 7 THE DEPONENT: Go ahead. 8 MR. COLLARD: Object to form. 9 Go ahead. 10 A. I don't know. He does not 11 discuss that, so that concept isn't part of 12 this patent. 13 BY MR. PHILLIPS: 14 Q. Well, I'm just reading the word 15 steam producing electrical power. I'm just 16 trying to interpret the literal words. 17 A. As I've mentioned, a gas 18 turbine using hydrogen as a fuel produces steam 19 as a byproduct. And that's how I interpret 20 that. 21 Q. Last thing on Rytter. Do you 22 have any basis for arguing that the hydrogen
322 1 embodiment and teaching and power station 7 -- 2 hydrogen power station 7, which is a very 3 specific part of the flow plan in the figure. 4 MR. COLLARD: Okay. I will -- 5 you can take it from there. That's fine. 6 BY MR. PHILLIPS: 7 Q. Do you agree with that, 8 Dr. Wolden? 9 A. Agree with what? 10 MR. COLLARD: Object to form. 11 A. Agree with what? 12 BY MR. PHILLIPS: 13 Q. That there's no explicit tie 14 between a gas turbine -- disclosure of a 15 hydrogen -- burning a hydrogen fuel in a gas 16 turbine and the hydrogen power station 7? 17 MR. COLLARD: Object to form. 18 A. The hydrogen power station is 19 where electricity is produced. That requires a 20 turbine. This patent explicitly and only 21 describes the use of a gas turbine. 22 So anyone, I think, would	324 1 fed to hydrogen power station 7 is not split 2 from the hydrogen stream separated downstream 3 of CO2 removal? 4 A. So are we talking about -- 5 MR. COLLARD: Sorry. Give me 6 one second. I'm actually still processing the 7 question. 8 THE DEPONENT: Sure, sure, 9 sure. I was, too. I was going to re-ask. 10 MR. COLLARD: So I'm going to 11 object to form. 12 MR. PHILLIPS: Okay. 13 MR. COLLARD: But go ahead. 14 BY MR. PHILLIPS: 15 Q. Let me strike that question. 16 A. Okay. 17 Q. And I'm going to break this 18 down into hopefully bite-sized pieces. 19 A. Sure. 20 Q. I think -- maybe you would 21 disagree with me. I think Figure 1 is an oddly 22 drawn process-flow diagram.

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Page 82 of 147

Conducted on July 23, 2026

325 1 Would you agree with that? 2 A. I would not -- 3 MR. COLLARD: Object to form. 4 THE DEPONENT: I'm sorry. 5 MR. COLLARD: Go ahead. 6 A. I would not have drawn it that 7 way. 8 BY MR. PHILLIPS: 9 Q. Okay. 10 A. I think it's poorly drawn. 11 Q. So the question I have relates 12 to box 6 -- 13 A. Sure. 14 Q. -- which is the CO2 removal 15 step in this process. 16 Would you agree with that? 17 MR. COLLARD: Object to form. 18 A. 6 is described as the CO2 19 removal step, yes. 20 BY MR. PHILLIPS: 21 Q. Right. 22 So from this box 6, there's a	327 1 in this figure. I would have drawn it 2 differently. But, yes. 3 Q. Let's take a look at -- so 4 we're done with that reference. 5 A. Oh, we're done here? 6 Q. Yeah. Yeah. 7 A. Okay. 8 Q. I think that reference gave 9 everybody headaches. 10 MR. COLLARD: I don't know how 11 long I spent on that one with Rytter, but 12 probably longer than that. It's a tough one. 13 BY MR. PHILLIPS: 14 Q. All right. I'm handing you 15 what's been marked as Exhibit 1010. 16 (Previously marked Topsoe 17 Inc. - Exhibit 1010 was tendered 18 to the witness.) 19 Q. I'm probably butchering this 20 name, but I'm going to call it Fjellhaug. 21 A. Fjellhaug, yeah. 22 Q. I'm going to divert you to
326 1 hydrogen stream that goes up to box 7 -- 2 A. Yep. 3 Q. -- hydrogen power station 7. 4 There's a hydrogen stream that 5 goes left to -- is that -- 6 A. That's methanol synthesis 7 reactor in 4. Yes. Yeah. 8 Q. Do you have any reason to 9 believe that those two hydrogen streams aren't 10 the same composition? 11 A. They should -- 12 MR. COLLARD: Object to form. 13 A. I would expect that they have 14 the same composition, although it could be very 15 different flow rates. 16 BY MR. PHILLIPS: 17 Q. Fair. 18 And I think we've seen with 19 some of the other prior art that they show that 20 split as an actual literal split from lines. 21 Right? 22 A. Again, it's not well described	328 1 column 4, line 32. It says, "A gas stream 17 2 from the CO2 absorber 16 consists mainly of 3 hydrogen and nitrogen, with minor amounts of 4 CO, CO2, and methane." 5 A. Okay. 6 Q. "The gas stream 17 will then be 7 used as fuel for a combined cycle gas turbine 8 24 to which air 25 is supplied." 9 Do you see that? 10 A. Yep. 11 Q. Okay. So would you agree, that 12 this is similar to the 2007 IFA process flow 13 with respect to this hydrogen-rich stream? 14 A. It's a hydrogen-rich stream 15 that's being delivered to a combined cycle. 16 Q. And would you agree, though, 17 that -- 18 A. I mean -- sorry. Just to 19 finish that. 20 Q. Go ahead. 21 A. You know, it is different in -- 22 from the IFA, that it doesn't include the

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Page 83 of 147

Conducted on July 23, 2026

329 1 mixing with natural gas and nitrogen. 2 Q. You're looking at my sheet. 3 A. I'm sorry? 4 Q. That was actually my next 5 question. 6 It's different from the 2007 7 IFA because it's using 100 percent of the 8 CO2-depleted syngas as fuel; is that right? 9 A. It appears to be -- 10 MR. COLLARD: Object to form. 11 A. It appears to be primarily 12 using that directly, yes. 13 BY MR. PHILLIPS: 14 Q. And this is a -- this is a 2003 15 reference; right? 16 A. Yep. 17 Q. And it was filed in -- would 18 you agree, it was filed in 1998? 19 A. That's what it says. 20 Q. On the first page, PCT filed? 21 A. That's what it says. Correct. 22 Q. You had called into question	331 1 the diagram -- to create the superheated 2 effect. 3 But, yes, it produces steam 4 through a heat exchanger like the HRSG. 5 BY MR. PHILLIPS: 6 Q. So I think Figure 1 is probably 7 illustrative. Right? 8 A. We're talking about -- yeah, 27 9 and 30 are heat exchangers. 10 Q. Right. 11 So it says that 30 is the 12 superheater. I guess that's the heat exchanger 13 that's closer to the outlet of the gas turbine. 14 And the saturated seems to be made in 27. 15 Would you agree with that? 16 A. Yeah, that's how it looks like. 17 MR. COLLARD: Object to form. 18 BY MR. PHILLIPS: 19 Q. Could -- is this necessarily a 20 HRSG or could this be two separate exchangers? 21 MR. COLLARD: Object to form. 22 A. As I said, these are two
330 1 the ability to use such a stream in a gas 2 turbine directly earlier. Is that right? 3 A. Yes. In a premixed gas 4 turbine, yes. 5 Q. Looking further down column 4, 6 at line 42, sort of in the middle of that 7 paragraph. "Exhaust 26 from the turbine 24 is 8 heat exchanged with water in a steam generator 9 27 and the steam therefrom may be superheated 10 in a heat exchanger 30 before stream 31 is 11 supplied to a power generator 32 to which the 12 steam 10 may be supplied." 13 Do you see that? 14 A. Yep. 15 Q. Do you consider this 16 description a HRSG? 17 MR. COLLARD: Object to form. 18 A. Again, the exhaust from 26 is 19 heat exchanged, as it says. It's a heat 20 exchanger, as I described, a HRSG. And then 21 actually this one uses two heat exchangers, 22 with another stream -- I would have to look at	332 1 distinct heat exchangers, where the HRSG 2 appears to be one heat exchanger, at least as 3 described in the previous work. 4 BY MR. PHILLIPS: 5 Q. A minute ago, when we were 6 talking about Rytter, I was asking you whether 7 hydrogen power station 7 could be a steam 8 generator first with a turbine generating 9 power. 10 Do you recall those questions? 11 A. I do. 12 Q. You said you doubted that. 13 This flow diagram, as well as 14 2007 IFA, show gas turbine first, then 15 generating steam. 16 Are both of those viable 17 options for co-generating power and steam? 18 MR. COLLARD: Object to form. 19 A. Can you restate, just to make 20 sure I'm clear on the question? 21 BY MR. PHILLIPS: 22 Q. Sure.

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Page 84 of 147

Conducted on July 23, 2026

333 1 So in Fjellhaug and in 2007 2 IFA, for sure, they're using the hydrogen-rich 3 stream to -- they're combusting the 4 hydrogen-rich stream in a gas turbine. 5 A. Um-hmm. 6 Q. And then using that hot exhaust 7 to generate steam. So they're generating power 8 first and then steam. 9 A. Um-hmm. 10 Q. I think we've talked about that 11 plenty today. 12 A. Um-hmm. 13 Q. The reading that I have for 14 Rytter, which you disagreed with, was 15 generating steam first and then using that 16 steam -- so using the hydrogen fuel to -- in a 17 traditional steam generator furnace and then 18 using that steam to generate power. 19 Are both of those 20 interchangeable methods for co-generating steam 21 and power? 22 MR. COLLARD: Object to form.	335 1 Q. I want to discuss your comment 2 that "The exhaust from gas turbine (24) is 3 primarily steam and nitrogen, with minor 4 amounts of oxygen being present only if the 5 turbine was supplied with excess air." 6 Do you see that? 7 A. Yep. 8 Q. You wrote that -- you wrote 9 that sentence in a way that suggests that gas 10 turbines are not operated with significant 11 excess air. 12 So why did you say that? 13 MR. COLLARD: Object to form. 14 A. In general, they're not. 15 BY MR. PHILLIPS: 16 Q. So it's your testimony that -- 17 A. I mean, it's still air, though. 18 Q. Right. 19 So it's your testimony that 20 excess air is not used in gas turbines? 21 A. I would -- yes, it can be. I'm 22 not saying -- it's just, in general, you'd
334 1 A. I would not describe them as 2 interchangeable. I would describe them as 3 alternatives. 4 BY MR. PHILLIPS: 5 Q. Are they both feasible 6 alternatives? 7 MR. COLLARD: Object to form. 8 A. Again, this is very specific to 9 what the constraints of the specific process 10 and the specific gases are available. But, in 11 general, you can produce electricity through 12 gas turbines or through steam turbines. 13 BY MR. PHILLIPS: 14 Q. Or both. We've seen combined 15 cycle -- 16 A. Or in a combined cycle, you can 17 do them both. Sure. 18 Q. Looking at your declaration on 19 paragraph 114. Are you there? 20 A. Not quite. Sorry. 21 Q. Okay. Paragraph 114. 22 A. Yeah. Okay. I'm there.	336 1 usually use more of a stoichiometric mixture in 2 these. 3 Q. Isn't it true that a POSA would 4 know that the stoichiometric air-fuel ratio for 5 natural gas fuel in a gas turbine is 17 to 1 by 6 mass? 7 MR. COLLARD: Object to form. 8 A. I work in moles, not mass. I'd 9 have to back it up. But there's a 10 stoichiometric ratio. 11 BY MR. PHILLIPS: 12 Q. Would you be surprised if I 13 told you that commercially acceptable air-fuel 14 ratios is often 40 to 1 or 70 to 1 by mass? 15 MR. COLLARD: Object to form 16 and scope. 17 A. I would not be surprised. 18 I don't know. 19 BY MR. PHILLIPS: 20 Q. That there is substantially 21 more air than is chemically required for 22 combustion?

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Page 85 of 147

Conducted on July 23, 2026

337 1 Would you agree with that? 2 MR. COLLARD: Object to form 3 and scope. 4 A. That would -- if it's excess 5 air, that would indicate excess, yes. 6 BY MR. PHILLIPS: 7 Q. Isn't it true that oxygen in 8 the exhaust gas of a gas turbine is typically 9 around 10 to 15 percent oxygen by volume? 10 MR. COLLARD: Object to form 11 and scope. 12 A. Is that -- when you're defining 13 it, they often define the exhaust composition 14 on a dry basis or a wet basis. 15 I don't know exactly what basis 16 you're using. 17 BY MR. PHILLIPS: 18 Q. Your testimony in paragraph 114 19 is that this would necessarily be oxygen 20 deficient, that exhaust stream 24 in Fjellhaug. 21 A. That's correct. Relative to 22 normal air, the gas stream would be oxygen	339 1 BY MR. PHILLIPS: 2 Q. So you're saying even if the 3 oxygen has 15 percent in the exhaust -- if 4 there's a 15 percent oxygen content in the 5 exhaust to turbine 24, that that would still 6 represent a lean oxygen stream that you're 7 adding to air. Is that right? 8 A. That is a lean -- yes, it's 9 oxygen-deficient air. 10 Q. Even if you're adding more 11 moles of oxygen to the reactor? 12 A. It would still be -- oxygen 13 deficient is the characteristic. How much you 14 add is immaterial. It doesn't change that it's 15 deficient or rich or whatever. 16 Q. But it's -- it's a lower 17 percentage because it's going to be accompanied 18 by what's going to amount to be inerts. Isn't 19 it? 20 MR. COLLARD: Object to form. 21 A. There will be steam, nitrogen. 22 I mean, yeah.
338 1 deficient, regardless if excess oxygen is added 2 or not. 3 Q. But if the oxygen in the 4 exhaust gas is in the 10 to 15 percent range? 5 A. Yep. 6 And normal air is 21 percent, 7 so that's less -- that's oxygen deficient 8 relative to 21 percent. 9 Q. Isn't what matters is the 10 amount of moles of oxygen that's being consumed 11 in the reaction though? 12 Why is the percentage of oxygen 13 important? 14 MR. COLLARD: Object to form. 15 A. When you're describing air as 16 either oxygen rich or oxygen lean, it is 17 described in terms of percentages. 18 Air is 21 percent oxygen, 19 79 percent nitrogen. Anything above 21 percent 20 is oxygen enriched, anything below is oxygen 21 deficient. 22 ///	340 1 BY MR. PHILLIPS: 2 Q. What really matters for the -- 3 that recycled oxygen is the moles of oxygen, 4 not the moles of the inerts that's going to 5 be -- 6 MR. COLLARD: Object to form. 7 A. I mean, that's absolutely not 8 true. The composition matters. And if you 9 dilute it too much, you can't burn it no matter 10 how many moles you send in. 11 BY MR. PHILLIPS: 12 Q. I'm going to ask you -- we're 13 done with Fjellhaug. 14 A. Okay. 15 Q. Believe it or not, that was 16 quick, huh? 17 A. Sure. 18 Q. A few topics and then we'll be 19 done -- at least I'll be done. Your counsel 20 may have some questions. 21 MR. COLLARD: I only have three 22 or four hours.

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Page 86 of 147

Conducted on July 23, 2026

341 1 MR. PHILLIPS: Oh, yeah. 2 Thanks. 3 BY MR. PHILLIPS: 4 Q. A POSA addressing CO2 reduction 5 in an ammonia front end, would they consult a 6 reference like Rytter, which is a methanol 7 patent? 8 MR. COLLARD: Object to form. 9 A. That's not where I think most 10 people would look because, again, the 11 requirements of methanol or hydrocarbon 12 production are very different than the 13 requirements for ammonia production. 14 BY MR. PHILLIPS: 15 Q. Doesn't -- Rytter, at column 4, 16 line 48, doesn't it say that all or part of the 17 CO2-depleted hydrogen steam can be fed to 18 ammonia synthesis? 19 A. He says that. He also says 20 very explicitly at the bottom of column 2 and 21 top of column 3 how different the requirements 22 are for methanol and ammonia.	343 1 So the syngas that he's 2 describing in this could not -- even though he 3 says it could go to a hydrogen plant -- or to 4 an ammonia plant, it couldn't go directly to an 5 ammonia plant. 6 It would need significant 7 purification and improvements before it could 8 be used in an ammonia synthesis plant. So he 9 explicitly calls out how they're different. 10 Q. What types of modifications 11 would need to be made for it to go to an 12 ammonia plant? 13 A. You'd have to operate a 14 number -- as I said, you'd have to operate the 15 reformer differently. So, for example, here, 16 they can accept not reforming all the methane. 17 They can let some of the methane go through. 18 You absolutely want to get every hydrogen 19 molecule you can out of methane. So you want 20 to do that. 21 You also will have multiple 22 water-gas shift reactors to turn as much CO
342 1 He basically says that you can 2 use a lower quality -- he's concerned about the 3 economics of methanol production. 4 So he says, Hey, you can get 5 away -- you don't need a water-gas shift 6 reactor. You don't need a methanation. You 7 don't have to have full conversion of the 8 methane. 9 I mean, it says explicitly you 10 can run this -- this is the top of page 3 -- at 11 conditions beneath those generally accepted in 12 industry and recommended in textbooks. 13 And then further -- a little 14 further in that -- let's see -- I'm trying to 15 find the exact place. Ah. 16 Further, if both low- 17 temperature shift and methanization of the 18 residual carbon monoxide may be unnecessary, 19 different from what is standard technology 20 today in the production of hydrogen for the 21 synthesis of ammonia. He explicitly describes 22 how they're different.	344 1 into hydrogen as you possibly can. And then, 2 of course, you need the cleanup of the CO 3 before it goes to the ammonia plant. 4 So all those things are not 5 required for methanol. So, again, you can just 6 get away with kind of junky syngas for 7 methanol, where you can't for ammonia 8 synthesis. 9 Q. But a POSA would understand 10 everything you just said, though; right? 11 MR. COLLARD: Objection to 12 form. 13 BY MR. PHILLIPS: 14 Q. A POSA would be able to make 15 modifications to these similar processes to 16 move between ammonia and methanol and hydrogen 17 production? 18 MR. COLLARD: Object to form. 19 A. I think a POSA would probably 20 not look to Rytter because it's about methanol. 21 We would look at ammonia synthesis alternatives 22 for those reasons, that they're so different

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Page 87 of 147

Conducted on July 23, 2026

345 1 requirements. 2 BY MR. PHILLIPS: 3 Q. But Rytter does say that the 4 hydrogen stream can be used in an ammonia 5 process. 6 MR. COLLARD: Object to form. 7 A. There's many -- there's a 8 number of inconsistencies in the Rytter patent, 9 and that is one of them, where he states in one 10 place that you could use it and states in 11 another place, it's not the quality that you 12 need for an ammonia process. 13 BY MR. PHILLIPS: 14 Q. And to be clear, I mean, one of 15 the reasons why it's cited in this IPR is 16 because Rytter does teach that using a 17 hydrogen-rich stream -- combusting a 18 hydrogen-rich stream to make steam and power. 19 Isn't that right? 20 MR. COLLARD: Object to form. 21 I mean -- sorry -- and object to scope. 22 A. I don't know why Topsoe	347 1 following a steam method reforming shift, that 2 the hydrogen-to-CO ratio is typically between 3 3 to 1 and 5 to 1. 4 Would you agree with that? 5 MR. COLLARD: Object to form. 6 A. Sorry. I want to be very 7 specific about those numbers. 3 to 1 -- 8 BY MR. PHILLIPS: 9 Q. Between 3 to 1 and 5 to 1. I 10 mean, that's obviously a big range. 11 The punch line that I'm getting 12 at is: Gas to liquids wants a 2-to-1 ratio. 13 Is that accurate? 14 MR. COLLARD: Object to form. 15 A. In general, yeah. Syngas, for 16 Fischer-Tropsch, is a 2-to-1 ratio, yeah. It 17 is the -- again, it's not very specific. 18 There's a range on that. But that's the 19 average, I would say. 20 BY MR. PHILLIPS: 21 Q. So Price teaches moving from 22 that higher ratio to the 2-to-1 by removing the
346 1 selected the patents they selected and the 2 materials they selected. 3 BY MR. PHILLIPS: 4 Q. So in paragraph 125 of your 5 declaration -- 6 A. Sure. 125. Yeah. Price? 7 Q. Price. 8 A. Yeah. 9 Q. Doesn't Price specifically 10 teach removing a hydrogen-rich stream for 11 ammonia synthesis? 12 MR. COLLARD: Object to form. 13 A. Yeah. Price, as I mentioned, 14 the hydrogen required for Fischer-Tropsch is -- 15 the amount of hydrogen you make in steam 16 reforming is much more than you need for 17 Fischer-Tropsch. 18 So he suggests a way to improve 19 the efficiency and use that excess hydrogen in 20 an ammonia plant. Yes. 21 BY MR. PHILLIPS: 22 Q. So my understanding is	348 1 hydrogen-rich stream. Is that accurate? 2 A. Yes. 3 As I said, you produce much 4 more -- yeah, you produce a higher 5 hydrogen-to-CO ratio than is necessary. 6 So, yes, he's suggesting 7 diverting part of that hydrogen to ammonia 8 to -- since you don't need it for the 9 Fischer-Tropsch process. 10 Q. Is there an overlap in the 11 knowledge of a POSA between Fischer-Tropsch and 12 ammonia synthesis? 13 MR. COLLARD: Object to form. 14 A. Again, they are very different 15 processes. An expert -- we're talking POSA. 16 That's ordinary. 17 So someone working on a 18 methanol plant probably doesn't appreciate 19 what's in an ammonia plant and vice versa. 20 BY MR. PHILLIPS: 21 Q. What's your basis for saying 22 that?

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Page 88 of 147

349 1 A. They're completely different 2 reactors. They have different constraints. 3 One's a high-pressure, hundred-bar operation; 4 the others are at modest pressures, completely 5 different temperatures, completely different 6 feedstocks, different catalysts. All those 7 things. 8 Q. But both utilize steam 9 reforming of methane in the front end. Is that 10 right? 11 MR. COLLARD: Object to form. 12 A. They both rely on steam 13 reforming of methane to produce the raw 14 materials. 15 But, again, they're different 16 raw materials that go into the two different 17 processes. 18 BY MR. PHILLIPS: 19 Q. Of course. 20 Both utilize a water-gas shift 21 reactor; right? 22 And by "both," I mean	351 1 Q. Again, the front end, both 2 isolate a hydrogen-rich stream? 3 A. They can. 4 Again, the separation isn't 5 necessary for Fischer-Tropsch, where it's 6 necessary – you need to separate the hydrogen 7 for ammonia, but you could just put the 8 reformer directly into the Fischer-Tropsch 9 process. 10 Q. But they may need to remove 11 hydrogen to get that 2-to-1 ratio you were 12 talking about; right? 13 A. Yes. There may be an 14 operational consideration that they want to 15 remove hydrogen for other things, yes. 16 Q. And that's what they did in 17 Price; right? 18 A. Yes, that's part of what they 19 do. 20 Q. That could be a relatively 21 significant reduction in hydrogen. Isn't that 22 right?
350 1 Fischer-Tropsch and ammonia synthesis front 2 ends. They both use water-gas shift reactors; 3 right? 4 A. The Fischer-Tropsch doesn't 5 necessarily need to use a water-gas shift 6 because you just get H₂ and CO off of the 7 reforming. You don't need to shift it because 8 that's what you want. 9 In fact, you usually don't want 10 a water-gas shift to send in a Fischer-Tropsch. 11 I think it's only included in Price because 12 they need to purify it up for the ammonia 13 caliber hydrogen. 14 Q. So both Fischer-Tropsch and 15 ammonia synthesis processes both isolate a 16 hydrogen-rich stream? 17 A. Sorry. It's getting late. I 18 want to make sure. I didn't follow – or miss 19 what you said. 20 Q. So, again, we're comparing 21 Fischer-Tropsch and ammonia synthesis. 22 A. Yeah.	352 1 MR. COLLARD: Object to form. 2 A. Significant reduction in 3 hydrogen for – with respect to what? 4 BY MR. PHILLIPS: 5 Q. From the Price process. 6 Removing -- the removal of 7 hydrogen needed to be fairly significant to get 8 down to a 2-to-1 ratio. 9 Would you agree with that? 10 MR. COLLARD: Object to form. 11 A. You're removing less than – 12 typically less than 50 percent of the 13 hydrogens. You're removing not an 14 insignificant amount, but it's not the majority 15 of the amount of hydrogen. 16 BY MR. PHILLIPS: 17 Q. Have you ever heard of a 18 company called Sasol? 19 A. I have. 20 Q. Are you aware that they offer 21 both gas to liquids and ammonia synthesis 22 processes?

Conducted on July 23, 2026

353 1 MR. COLLARD: Object to form 2 and scope. 3 A. I know of Sasol as a major 4 chemical company. I don't know their exact 5 plants or processes. 6 BY MR. PHILLIPS: 7 Q. Would it surprise you to know 8 that a company like Sasol offers both 9 technologies -- 10 MR. COLLARD: Object to form. 11 BY MR. PHILLIPS: 12 Q. -- to customers? 13 MR. COLLARD: Sorry. 14 Object to form and scope. 15 A. It would not surprise me. 16 BY MR. PHILLIPS: 17 Q. Okay. Last few questions. 18 Do you have any opinions not 19 stated in Exhibit 2007? 20 A. No, I don't think so. 21 Q. Is there anything you would 22 change in Exhibit 2007?	355 1 THE STENOGRAPHER: Counsel, can 2 you place on the stenographic record your 3 transcript orders, please. 4 MR. PHILLIPS: I think we had 5 ordered a rough. And we would like a rush, 6 three-day. 7 MR. COLLARD: I don't know. 8 Can I e-mail you? 9 MR. PHILLIPS: In terms of 10 video, I think we want whatever he gets. 11 MR. COLLARD: I'm going to 12 watch it tonight -- no. We don't normally 13 order the video until much later. 14 MR. PHILLIPS: So we'll hold 15 off too. 16 MR. COLLARD: Let's take the 17 rough tonight. 18 THE STENOGRAPHER: Thank you. 19 (Time noted: 3:26 p.m.) 20 21 22
354 1 A. I don't think so. 2 Q. And just to confirm: You did 3 not perform any calculations, experiments, or 4 simulations to reach your opinions? 5 A. I did make some calculations. 6 Q. What calculations did you make? 7 A. So, for example, I guess -- 8 maybe it's not -- there's -- certain claims are 9 very specific to the amount of hydrogen that is 10 recycled to the auxiliary. They talk about 11 between 10 and 40 percent and 20 and 12 30 percent. And so I did some calculations 13 relative to that. 14 Q. Those are in the dependent 15 claims; is that right? 16 A. Yes, I believe so. 17 MR. PHILLIPS: I have no 18 further questions. Pass the witness. 19 MR. COLLARD: Nothing from me. 20 THE VIDEOGRAPHER: This marks 21 the end of the deposition of Colin A. Wolden, 22 Ph.D. We are going off the record at 3:25 p.m.	356 1 CERTIFICATE OF SHORTHAND REPORTER 2 I, LISA A. KNIGHT, Registered Diplomat 3 Reporter, Certified Realtime Reporter, and Notary 4 Public within and for the State of Colorado do 5 hereby certify: 6 That COLIN A. WOLDEN, Ph.D., the 7 witness whose deposition is hereinbefore set forth, 8 was duly sworn by me before the commencement of 9 such deposition and that such deposition was taken 10 before me and is a true record of the testimony 11 given by such witness. 12 I further certify that the adverse party, 13 CASALE, was represented by counsel at the 14 deposition. 15 I further certify that the deposition of 16 COLIN A. WOLDEN, Ph.D., occurred at the offices of 17 Dorsey & Whitney, located at 1400 Wewatta Street, 18 Suite 400, Denver, Colorado, on Thursday, July 23, 19 2026, commencing at 8:59 a.m. to 3:26 p.m. 20 I further certify that inspection, reading 21 and signing of said deposition was not requested on 22 the record.

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Page 90 of 147

Transcript of Colin A. Wolden, Ph.D.
Conducted on July 23, 2026

90 (357 to 360)

357

1 I further certify that I am not related to
2 any of the parties to this action by blood or
3 marriage; I am not employed by or an attorney to
4 any of the parties to this action; and that I am in
5 no way interested, financially or otherwise, in the
6 outcome of this matter.

7 IN WITNESS WHEREOF, I have hereunto set my
8 hand this 28th day of July, 2026.

9 My commission expires April 23, 2029.

10 LBA Knight
11

LISA A. KNIGHT

12 NCRA Certified Realtime Reporter
NCRA Registered Diplomate Reporter
13 NCRA Realtime Systems Administrator
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A			
ability	130:8, 173:20	338:1	ago
172:7, 330:1	achieve	adding	332:5
able	50:1	291:21, 339:7,	agreed
136:10, 254:6,	acid	339:10	80:21, 114:2,
344:14	19:2, 262:12,	additional	226:2, 243:10
above	263:6, 263:9	74:9, 120:17,	agreement
272:3, 273:6,	acknowledging	167:5, 200:13,	267:17
274:1, 276:9,	139:19	245:11, 245:12	agrees
279:20, 283:14,	acronym	address	321:21
305:7, 338:19	145:19, 208:16	75:8, 242:17,	ah
absolutely	action	298:18, 299:2	342:15
146:14, 279:18,	357:2, 357:4	addressing	ahead
340:7, 343:18	active	341:4	36:12, 37:12,
absorbed	105:3, 119:17	adds	48:3, 48:9,
97:12	actively	129:1	55:4, 61:10,
absorber	70:17, 71:6	adhesive	66:21, 72:10,
251:17, 252:2,	actual	32:20	121:4, 152:21,
328:2	54:2, 72:12,	adjust	164:18, 172:11,
absorption	196:19, 260:14,	45:10, 47:3,	180:2, 211:8,
24:21, 39:1,	287:21, 300:5,	47:10	212:1, 215:21,
97:2, 97:10,	326:20	administrator	218:2, 224:6,
98:9, 129:19	actually	2:11, 357:15	236:3, 279:17,
absorption-based	20:20, 31:4,	admit	283:11, 296:21,
25:2	44:10, 47:14,	138:20	323:7, 323:9,
absorptions	55:1, 63:2,	adopted	324:13, 325:5,
25:2	69:18, 119:16,	235:1, 236:11	328:20
academia	133:19, 149:16,	advanced	air
73:9	185:16, 188:11,	55:22, 56:15	90:13, 90:14,
accept	210:19, 222:16,	advantages	92:6, 120:14,
118:20, 343:16	241:21, 252:21,	291:17	129:1, 130:11,
acceptable	279:3, 282:11,	adverse	188:14, 192:17,
336:13	284:12, 284:14,	131:15, 356:12	224:11, 228:22,
accepted	285:5, 285:18,	advise	291:14, 310:4,
40:22, 342:11	287:11, 288:2,	118:2, 136:19	313:18, 314:6,
accompanied	288:8, 290:17,	affect	317:8, 318:6,
339:17	292:16, 297:16,	159:12, 159:18,	328:8, 335:5,
accompanying	297:20, 297:21,	165:9, 165:10	335:11, 335:17,
13:7	298:8, 300:13,	after	335:20, 336:21,
account	318:15, 321:5,	38:18, 45:8,	337:5, 337:22,
61:22, 146:16	324:6, 329:4,	52:19, 53:2,	338:6, 338:15,
accurate	330:21	76:3, 128:18,	338:18, 339:7,
23:16, 56:2,	add	132:19, 159:7,	339:9
59:7, 77:6,	49:8, 49:9,	179:9, 212:9,	air-fuel
81:3, 187:12,	254:19, 339:14	213:9, 213:14,	336:4, 336:13
238:11, 347:13,	added	229:3, 252:16,	al
348:1	141:21, 252:22,	269:14, 293:14,	5:5, 5:12,
	254:15, 254:16,	307:10	5:14, 301:22
		agnostic	al-ansari
		210:11, 210:15	302:3

ali 302:1 all 4:21, 10:13, 12:11, 12:12, 16:22, 27:7, 28:22, 30:5, 42:4, 49:9, 50:15, 50:16, 61:4, 68:1, 68:7, 69:6, 75:15, 82:4, 104:2, 104:5, 106:11, 123:19, 126:21, 130:20, 146:19, 167:10, 173:13, 178:9, 178:21, 180:8, 181:18, 185:14, 186:2, 186:6, 186:12, 189:21, 198:21, 204:18, 211:1, 213:17, 213:21, 221:13, 222:18, 228:11, 229:17, 233:7, 235:21, 242:1, 250:9, 255:17, 265:14, 272:1, 278:3, 292:11, 310:21, 315:18, 317:7, 321:4, 321:6, 327:14, 341:16, 343:16, 344:4, 349:6 allow 25:7, 213:21 allowing 138:9 allows 109:18, 137:11, 168:6 alluding 90:9 almost 26:9 along 33:3, 229:13,	255:5 already 9:10, 15:16, 16:6, 123:15, 123:16, 152:13, 153:7, 170:21, 171:14, 198:9, 296:8 also 3:18, 14:5, 16:8, 21:11, 24:14, 32:11, 34:11, 34:15, 41:10, 43:5, 43:12, 46:13, 63:12, 77:12, 80:14, 91:17, 93:18, 109:18, 129:8, 133:9, 135:7, 137:22, 143:13, 143:14, 151:5, 152:15, 152:17, 153:7, 153:10, 153:11, 184:2, 188:9, 200:21, 203:20, 205:14, 210:2, 210:15, 214:8, 249:3, 251:15, 254:17, 256:19, 263:5, 275:20, 283:1, 284:3, 285:14, 287:2, 300:8, 307:8, 310:4, 320:9, 341:19, 343:21 alternative 35:7 alternatives 334:3, 334:6, 344:21 although 198:9, 199:7, 326:14 alumni 31:3 always 84:22, 85:8,	228:2, 228:7 ammonia-hydrogen 23:13 among 174:3, 177:13, 178:2, 232:21 amount 66:7, 99:20, 148:5, 150:13, 166:2, 167:6, 242:21, 338:10, 339:18, 346:15, 352:14, 352:15, 354:9 amounts 328:3, 335:4 analogous 194:4, 214:19 analysis 70:13, 233:10, 235:2, 235:5, 236:12, 273:5 analyze 60:3 ancillary 51:8 another 24:12, 49:4, 89:3, 91:14, 129:19, 129:21, 159:5, 182:2, 186:1, 187:6, 187:15, 189:6, 209:12, 209:22, 258:13, 265:17, 309:6, 316:8, 330:22, 345:11 ansari 301:22, 302:1 answer 46:5, 48:9, 48:12, 61:2, 71:14, 96:19, 113:3, 173:10, 207:20, 235:21, 236:1 answerable 244:20	answered 72:9, 96:16, 158:21, 179:22 answers 84:4 any 9:18, 10:14, 10:17, 10:22, 11:3, 11:11, 11:17, 13:2, 13:6, 13:10, 13:19, 14:9, 14:13, 25:17, 33:16, 33:17, 34:18, 34:20, 35:18, 36:4, 36:21, 37:7, 37:15, 38:2, 45:1, 61:4, 68:21, 69:18, 75:2, 82:21, 85:18, 102:19, 103:7, 106:5, 112:1, 124:5, 124:10, 128:22, 137:5, 143:15, 143:18, 144:21, 187:20, 192:4, 194:15, 195:16, 195:17, 196:22, 198:18, 203:3, 213:22, 239:3, 245:1, 248:3, 250:8, 294:13, 302:10, 302:17, 303:6, 304:22, 307:20, 317:16, 319:5, 323:22, 326:8, 353:18, 354:3, 357:2, 357:4 anybody 14:19, 14:21, 241:10, 248:18 anymore 159:3 anyone 189:19, 280:13,
---	--	---	--

284:8, 322:22 anything 14:10, 33:18, 68:13, 163:4, 176:18, 184:6, 198:17, 198:19, 208:12, 231:20, 259:14, 263:17, 280:13, 280:15, 282:7, 286:19, 305:15, 308:1, 308:19, 338:19, 338:20, 353:21 anyway 10:13 anywhere 69:17 apologize 150:8, 177:20 apparatus 142:4, 174:3, 175:4, 176:11, 177:13, 178:1, 178:4, 179:15, 187:20, 206:5, 217:11, 225:10, 228:12, 232:21, 233:16, 234:17 apparatuses 229:14 appeal 1:2 appear 200:1, 316:20 appears 70:14, 220:9, 255:4, 329:9, 329:11, 332:2 application 173:5 applications 23:21, 218:19 applied 46:13, 233:7 apply 53:7, 183:21 appreciate 145:4, 169:12,	219:9, 241:11, 348:18 appreciated 105:12 approaches 47:17, 130:2 appropriate 137:3, 143:18 approximate 41:11 approximately 10:3, 15:2, 21:9, 164:7, 293:22 april 357:9 archive 298:2, 298:14, 298:17, 298:18, 299:1, 299:4 archived 299:2, 299:9 area 24:2, 26:11 areas 36:22 aren't 189:22, 211:1, 326:9 argonne 58:21, 59:17 arguing 323:22 argument 185:4 around 71:19, 109:12, 159:2, 193:1, 206:14, 269:20, 337:9 arrangement 238:13, 238:18, 242:5, 267:21 art 13:20, 13:21, 14:6, 40:18, 41:1, 47:13, 49:17, 49:21,	54:7, 65:2, 65:4, 77:1, 114:1, 136:19, 138:21, 139:16, 139:20, 142:7, 144:3, 153:21, 158:19, 225:16, 233:7, 326:19 article 300:14, 300:20 articles 301:21 aside 303:20 asked 28:14, 72:9, 90:19, 94:2, 96:3, 179:22, 187:17, 231:11, 236:10, 236:14 asking 9:10, 61:20, 91:4, 96:12, 96:13, 104:11, 150:6, 207:18, 282:14, 317:4, 320:17, 321:9, 332:6 aspect 195:17, 227:14 aspen 28:20, 29:1, 29:8 aspirin 19:3, 19:6 associated 60:18, 61:13, 62:1, 62:22, 63:18, 64:21, 77:13, 83:4, 83:12, 83:19, 110:15, 202:5 association 299:21 assume 21:16, 84:14, 253:17, 258:19, 258:21, 265:12,	275:5, 307:12 assumed 197:1 assuming 28:17, 84:8, 258:12, 269:16 assumption 82:6 assumptions 153:2 asu 129:2 atmosphere 76:22, 78:21, 86:7, 86:13, 91:2, 91:8, 91:19, 113:22, 114:6, 167:17, 194:11 atr 43:3, 81:20, 88:4, 88:13, 88:17, 88:19, 120:13, 121:13, 121:14, 121:16, 121:17, 122:2, 124:13, 126:4, 126:16, 130:12, 238:8, 239:1, 242:5, 242:11, 242:17, 244:12, 291:5, 291:17, 291:22, 292:9, 305:1, 307:22, 308:7, 308:11 atr-based 250:17 atrs 41:20, 238:1, 238:2 attached 4:6, 197:8, 198:6 attempted 219:5 attempting 219:6 attended 302:11, 303:17
--	--	--	--

attendees 296:11	aware 60:15, 61:15, 61:21, 72:11, 73:13, 73:22, 74:12, 74:18, 75:1, 75:11, 79:5, 79:9, 79:15, 157:2, 195:20, 196:2, 196:6, 232:2, 232:6, 298:5, 352:20	bad 32:1	230:22, 234:14, 235:9, 235:11, 235:16, 236:18, 236:20, 237:7, 237:16, 251:16, 257:4, 264:6, 281:18, 285:5, 285:11, 290:9, 290:16, 308:2, 320:19, 329:7, 339:17, 341:10, 344:20, 345:16, 350:6, 350:7, 350:11
attorney 9:11, 13:5, 357:3	away 162:7, 342:5, 344:6	balances 26:14, 30:5	become 79:22
attorneys 66:19	B	balken 300:18	bed 20:14, 20:18, 122:17
attributed 115:4	bachelor 18:1, 55:20	baratto 5:5	been 8:9, 9:3, 10:21, 11:12, 11:16, 11:22, 12:2, 13:16, 14:1, 17:1, 22:16, 25:15, 31:7, 39:14, 65:17, 69:10, 73:8, 74:9, 74:22, 93:16, 123:16, 151:19, 154:8, 159:2, 216:13, 222:12, 246:15, 290:14, 297:11, 303:14, 327:15
audience 248:5	back 14:2, 18:22, 42:18, 44:18, 45:11, 51:14, 57:4, 61:7, 66:11, 75:20, 98:19, 119:22, 126:7, 128:19, 131:3, 132:21, 143:4, 157:5, 157:19, 172:4, 188:11, 220:13, 223:1, 223:3, 230:9, 232:18, 240:11, 257:12, 259:8, 260:17, 260:20, 267:14, 270:12, 281:1, 283:5, 289:17, 297:7, 298:15, 313:14, 336:9	based 189:3, 217:15, 253:11, 265:11, 269:18	before 1:2, 2:9, 9:4, 28:15, 39:6, 65:15, 70:19, 71:9, 78:9, 86:12, 87:4, 91:19, 92:21, 93:8, 93:19, 95:5, 95:14, 96:4, 96:14, 99:4, 99:14, 103:17, 104:6,
authenticating 298:13	back-end 43:5, 45:22, 53:9, 54:9	basic 160:20, 182:4	
author 248:4, 248:11, 263:20, 267:19, 286:3	backed 167:3	basically 23:11, 181:21, 189:15, 209:3, 298:5, 299:3, 342:1	
authors 112:12, 174:9, 180:14, 233:5	background 17:22	basis 164:5, 323:22, 337:14, 337:15, 348:21	
authorship 66:22	backwards 11:15	batteries 26:2	
autothermal 120:13, 250:22		baytown 152:4	
autothermic 304:17, 305:8, 306:16, 307:5		bears 299:8	
aux 120:10, 120:22, 128:20, 137:20		became 298:5	
auxiliary 123:16, 127:12, 132:22, 137:19, 138:17, 261:18, 263:5, 263:21, 264:5, 264:10, 264:16, 265:6, 265:12, 266:9, 275:20, 281:4, 281:9, 284:4, 288:22, 354:10		because 9:16, 17:18, 30:13, 31:10, 50:16, 64:9, 64:10, 75:10, 91:13, 116:20, 117:14, 117:18, 121:8, 122:21, 123:14, 133:12, 150:5, 162:5, 181:4, 181:7, 183:7, 183:10, 185:3, 187:18, 197:11, 205:4, 205:9, 207:22, 209:16, 215:1, 215:13, 230:14,	
available 49:13, 81:7, 128:1, 128:10, 128:14, 270:9, 294:14, 300:21, 334:10			
average 347:19			

104:15, 120:5, 120:11, 122:6, 122:14, 124:13, 124:14, 124:17, 124:18, 124:21, 125:16, 126:5, 134:1, 143:7, 156:6, 156:14, 158:4, 160:12, 204:15, 211:11, 223:6, 224:3, 224:14, 224:20, 225:3, 238:22, 243:21, 244:1, 247:2, 251:4, 253:18, 255:21, 270:3, 279:20, 281:19, 291:18, 301:17, 330:10, 343:7, 344:3, 356:8, 356:10 beginning 90:19 begins 7:2 behalf 3:2, 3:10, 9:2, 12:3 being 11:5, 46:19, 49:14, 73:18, 85:16, 99:19, 120:11, 123:15, 131:6, 131:7, 134:17, 135:16, 137:20, 172:14, 184:20, 195:9, 210:6, 210:15, 210:19, 236:19, 257:11, 260:13, 269:6, 277:14, 277:16, 277:17, 277:19, 280:8, 288:8, 292:8, 308:20, 317:13, 319:4, 319:21, 328:15, 335:4, 338:10	belief 111:1, 111:16 believe 32:11, 59:8, 69:22, 70:15, 73:17, 96:20, 112:8, 181:16, 187:9, 191:9, 194:10, 198:11, 206:21, 249:8, 254:2, 273:17, 301:16, 319:6, 326:9, 340:15, 354:16 believes 184:11 below 137:8, 176:4, 276:13, 285:12, 338:20 bench 35:12, 36:2 benchmarking 302:5 beneath 342:11 beneficial 108:21, 292:3, 316:10 beneficially 304:19 benefits 243:6 besides 308:20 best 33:2, 49:22, 92:19, 118:18, 119:15, 271:12, 300:20 better 27:13 between 13:18, 33:7, 34:12, 34:14, 43:16, 115:17, 116:15, 139:8, 193:18, 211:11,	294:3, 294:6, 294:10, 294:15, 305:1, 306:15, 307:22, 308:12, 314:13, 316:11, 319:3, 321:22, 322:14, 344:16, 347:2, 347:9, 348:11, 354:11 beyond 55:8 big 61:6, 136:6, 224:8, 347:10 biggest 35:17, 152:10 bingo 59:1 biological 30:21 bit 21:20, 31:21, 53:2, 76:8, 292:17 bite-sized 324:18 blades 229:3 blood 357:2 blow 117:3, 118:4 blower 206:22 blue 58:14, 59:11, 60:19, 61:13, 78:5, 78:8, 78:13, 78:16, 78:17, 78:18, 78:22, 80:12, 80:17, 81:2, 110:12, 110:17, 110:18, 168:16, 239:10 board 1:2 boardrooms 73:10	boiler 115:18, 116:16, 207:2, 230:13, 261:18, 263:21, 264:5, 264:10, 264:16, 265:6, 265:12, 266:9, 284:4 boilers 82:7, 106:4, 226:22 boring 19:9 boss 79:14, 79:18, 169:13, 239:8 bosses 239:14 both 28:3, 57:5, 57:7, 170:16, 176:19, 273:5, 278:1, 286:10, 289:4, 332:16, 333:19, 334:5, 334:14, 334:17, 342:16, 349:8, 349:12, 349:20, 349:22, 350:2, 350:14, 350:15, 351:1, 352:21, 353:8 bottom 250:14, 251:14, 261:17, 265:16, 267:14, 268:3, 270:14, 274:9, 274:14, 277:22, 279:8, 279:10, 280:18, 282:1, 282:17, 283:10, 283:16, 286:2, 286:17, 287:11, 287:22, 288:15, 288:17, 288:22, 290:3, 290:5, 291:9, 292:7, 300:6, 301:5,
---	--	---	---

341:20 boulevard 3:5 box 130:14, 261:12, 264:14, 319:21, 325:12, 325:22, 326:1 boxes 109:12, 146:15, 197:1, 206:14, 258:1 break 10:2, 10:4, 10:5, 10:11, 76:3, 142:18, 143:7, 222:14, 223:6, 292:20, 296:22, 324:17 breaking 75:13 bring 108:11, 108:22 brings 185:6 broadly 22:22, 87:14, 87:15 broke 20:18 broken 284:1 bucket 172:18 build 51:6 builds 131:16 built 35:5, 38:1 bullet 265:20, 266:8, 266:21, 270:17, 272:22, 273:9, 285:11 bullets 271:9, 273:18 bunch 202:22	burger 30:22 burn 39:7, 39:13, 105:4, 140:18, 143:11, 143:14, 152:14, 152:16, 153:8, 153:10, 166:16, 170:20, 171:13, 173:3, 206:6, 224:14, 227:3, 254:6, 340:9 burned 63:11, 154:8, 157:18, 159:11, 268:9, 268:11, 268:13 burner 101:20, 203:21, 205:5, 205:15, 205:20, 205:22, 207:11, 208:4, 263:5, 281:4, 281:9 burners 101:15, 144:10, 224:2, 224:11, 224:13, 231:13, 232:4 burning 39:10, 39:20, 40:3, 62:20, 101:6, 101:11, 101:20, 112:4, 112:9, 140:10, 155:12, 156:11, 156:12, 156:18, 223:17, 245:3, 271:5, 271:15, 322:15 burns 103:20, 121:8, 166:1, 187:20 businessperson 136:15 butchering 327:19	byproduct 141:14, 318:2, 323:19 byproducts 133:17 C calculated 148:9 calculation 257:19 calculations 163:15, 354:3, 354:5, 354:6, 354:12 caliber 350:13 call 27:13, 190:18, 190:22, 191:3, 201:5, 207:4, 327:20 called 18:10, 72:1, 176:1, 220:8, 275:17, 312:13, 329:22, 352:18 calls 273:8, 273:9, 343:9 calorific 164:19, 194:19 came 12:22 can't 10:18, 11:13, 20:20, 34:11, 59:8, 61:16, 73:6, 79:17, 83:15, 88:10, 89:9, 94:12, 94:16, 98:20, 106:14, 119:11, 147:17, 152:8, 163:12, 169:7, 169:8, 170:1, 172:12, 173:11, 173:15, 199:1,	215:1, 215:10, 243:3, 254:11, 293:13, 308:1, 340:9, 344:7 cannot 59:13, 119:7, 172:17, 253:9 capabilities 244:8 capable 224:2 capacity 162:11 capex 162:21, 166:8, 167:11, 260:7 capital 167:22 capstone 27:22, 28:4 capstone-type 27:18 capture 71:22, 73:19, 80:18, 93:4, 239:19, 240:2, 240:6, 267:1, 271:13 captured 78:20, 110:18, 263:11 capturing 92:18, 266:16, 271:16 car 103:6, 189:18, 189:19 carbon 48:16, 58:14, 59:11, 60:3, 60:7, 60:13, 61:17, 73:19, 79:21, 80:13, 80:18, 109:1, 109:5, 126:11, 156:18, 159:19, 239:19, 240:2, 257:19, 342:18
---	---	--	--

carbon-based 168:8 carbon-free 257:11 casale 1:7, 7:5, 8:2, 9:2, 11:16, 11:19, 12:1, 12:4, 13:18, 14:4, 14:19, 17:12, 35:10, 54:16, 60:17, 66:19, 73:22, 74:4, 74:10, 74:18, 190:22, 356:13 casale's 12:3, 69:8 case 3:12, 8:1, 9:2, 11:8, 11:10, 12:1, 14:1, 15:6, 17:12, 25:6, 39:19, 44:6, 45:2, 49:6, 64:14, 65:2, 67:18, 89:3, 122:5, 179:3, 179:13, 210:18, 233:10, 293:16, 298:6 case@dorsey 3:17 cases 10:22, 11:3, 45:14, 45:15, 45:16 catalyst 44:21, 46:18, 290:11 catalysts 57:11, 349:6 catalytic 24:9, 103:6 ccus 71:22 cdr 126:10, 132:19	cells 26:2 celsius 86:4, 86:5 center 33:12 certain 67:20, 150:13, 166:2, 166:3, 354:8 certainly 30:2, 30:4, 31:7, 71:18, 83:3, 94:1, 101:10, 106:9, 132:11, 191:12, 193:9, 212:15, 230:5, 245:5, 253:19, 292:1, 308:14, 309:19, 319:19 certificate 356:1 certified 2:10, 356:3, 357:13 certify 356:5, 356:12, 356:15, 356:20, 357:1 cetera 108:12, 108:16, 112:17, 144:10, 154:8 challenges 253:6 chamber 119:9, 194:5, 227:11, 228:9, 230:2, 230:3 change 49:2, 86:13, 160:18, 254:12, 339:14, 353:22 changes 117:10 changing 125:17, 254:5	characteristic 339:13 characteristics 254:13 characterization 154:2 characterize 39:20 charge 88:3, 88:6, 88:12, 89:4, 89:6, 92:16, 120:22, 122:2, 124:12, 126:15, 174:4, 178:2, 232:22, 238:22, 239:11, 240:12, 244:11, 245:17 charged 122:6 cheaper 136:2, 167:17, 214:5 cheapest 93:13 chemical 18:2, 18:6, 18:11, 18:15, 19:11, 21:12, 22:1, 25:19, 26:17, 31:12, 38:8, 43:6, 55:20, 56:1, 56:14, 56:15, 107:12, 151:16, 152:3, 194:15, 195:18, 225:16, 353:4 chemically 336:21 chemicals 139:2, 139:22, 140:15 china 93:15 ching 5:15, 297:22 choice 95:19, 136:4,	239:11, 240:11, 240:20, 241:2, 242:16, 244:10, 245:19 choices 243:8 chosen 174:3, 177:13, 178:1, 232:21 chronological 281:18 circular 244:19 cite 272:16 cited 13:20, 67:21, 68:8, 68:9, 315:5, 321:21, 345:15 cities 33:12 civil 29:18 claim 60:17, 111:3, 111:19, 232:18 claims 74:1, 74:9, 75:4, 75:9, 111:10, 111:13, 112:3, 113:15, 354:8, 354:15 clarify 9:20, 13:21, 46:4, 46:8, 48:4, 58:16, 181:4, 217:13 clarifying 36:15 class 27:1, 27:16, 27:18, 28:16, 29:22, 169:7, 195:6 classes 26:6, 26:8, 27:4
---	---	---	--

classic 31:10 classify 217:10 clean 13:3, 13:4, 143:12, 152:14, 152:15, 153:9, 167:18, 262:16 cleanup 344:2 clear 9:22, 37:4, 41:16, 64:19, 105:1, 121:12, 181:10, 183:20, 207:8, 223:8, 236:8, 241:10, 241:11, 252:18, 252:20, 259:3, 317:7, 332:20, 345:14 clearly 112:14, 276:5, 277:12 closely 85:7 closer 61:3, 171:4, 331:13 co-generating 332:17, 333:20 co-op 33:17 co-pending 13:17, 157:1 co-product 63:16 co2-depleted 39:21, 109:21, 110:7, 111:2, 111:18, 112:4, 112:10, 115:17, 115:19, 128:19, 143:12, 143:14, 152:14, 152:16, 153:8, 153:10, 154:9, 154:14,	154:18, 155:8, 157:5, 157:18, 158:7, 160:17, 170:20, 171:13, 171:22, 172:2, 172:16, 173:3, 240:10, 241:16, 244:4, 245:3, 251:11, 252:8, 280:9, 287:4, 329:8, 341:17 coal 39:16, 93:14 coated 20:16 coating 20:18, 32:22 coatings 20:16 code 59:18, 61:15, 163:19 coder 32:20 cogeneration 38:4, 200:21, 201:17 coil 228:18 colder 91:16 colin 1:15, 2:1, 4:2, 5:20, 6:4, 7:4, 8:8, 8:18, 16:2, 354:21, 356:6, 356:16 collaboratively 67:9 collection 250:1 colorado 1:16, 2:7, 2:12, 3:15, 7:16, 22:14, 22:21, 25:15, 26:6, 29:1, 29:16, 30:14,	356:4, 356:18, 357:16 column 19:1, 19:6, 76:17, 97:10, 97:14, 98:9, 107:19, 109:16, 113:19, 176:10, 177:9, 225:8, 234:15, 304:13, 304:15, 305:18, 306:12, 307:8, 309:9, 309:21, 309:22, 311:18, 312:6, 313:3, 315:1, 315:6, 316:9, 317:14, 318:21, 321:14, 321:21, 328:1, 330:5, 341:15, 341:20, 341:21 com 3:9, 3:17 combination 288:2, 306:20 combined 4:8, 4:10, 4:12, 4:14, 198:12, 198:15, 199:20, 200:2, 200:4, 200:6, 200:20, 201:6, 305:9, 307:5, 328:7, 328:15, 334:14, 334:16 combining 200:14 combust 118:7, 140:21, 141:13, 230:22, 318:10 combusted 85:4, 91:22, 188:15, 191:21, 210:19, 227:12, 231:13, 232:4, 255:4, 288:8, 314:7	combusting 205:16, 212:22, 213:1, 256:13, 333:3, 345:17 combustion-fired 218:17 combusts 101:2 come 64:15, 64:16, 64:21, 193:20, 212:20, 243:5, 317:9 comes 44:4, 45:17, 90:16, 131:9, 150:18, 192:1, 202:7, 259:7, 273:5, 281:19, 287:10 coming 44:8, 80:10, 103:8, 103:22, 130:11, 155:6, 210:12, 212:9, 212:21, 220:3, 220:13, 228:16, 262:11, 263:3, 263:6, 263:9, 263:15, 267:11, 276:12, 278:8 command 168:17 commencement 356:8 commencing 356:19 comment 170:1, 173:11, 173:15, 173:21, 294:8, 335:1 comments 138:6 commercial 34:22, 35:1, 35:3, 35:9, 35:20, 36:2, 70:2
---	---	--	--

commercially 336:13	349:1, 349:4, 349:5	concept 323:11	confirm 75:7, 125:2,
commission 357:9	completion 84:20, 85:1	concerned 342:2	159:10, 160:16,
commissioning 34:21, 35:19, 37:16, 38:3	complex 49:11, 53:11, 59:16, 104:10,	concerning 69:19	255:3, 295:11,
committee 300:22, 301:13, 302:7	135:18, 152:3, 165:17, 188:13, 210:6, 219:14	concerns 102:14, 102:18, 102:22	296:7, 354:2
common 24:15, 43:5, 96:7, 96:12, 99:4, 153:15	component 25:4, 53:2, 84:15, 89:2, 208:10, 227:5, 231:3, 251:21, 269:18	conclude 323:1	conjunction 22:6
community 31:2	components 88:22, 200:3, 200:5, 202:5, 202:20, 251:3	conclusion 317:5	connected 196:10, 203:1, 208:4
companies 54:21, 60:16, 145:12, 145:17, 145:20, 145:21, 145:22, 146:1, 146:3, 146:4, 146:12, 147:2, 147:10	composition 99:17, 100:11, 116:15, 117:11, 133:6, 133:8, 134:12, 135:3, 137:4, 154:22, 155:16, 156:3, 252:7, 326:10, 326:14, 337:13, 340:8	conclusions 40:22	connecting 268:2, 316:16
company 20:13, 34:12, 168:6, 169:22, 352:18, 353:4, 353:8	compositions 208:3	condensed 27:6	consequently 50:15
compare 81:7	compound 43:12	conditions 51:18, 85:16, 101:13, 342:11	conservation 5:17, 299:14
compared 77:1, 114:1, 115:12	compressed 188:15	conduct 84:9	consider 42:17, 62:11, 62:20, 99:22, 118:15, 131:22, 133:21, 134:1, 134:4, 189:19, 194:2, 202:21, 202:22, 206:2, 206:9, 216:22, 223:16, 229:10, 229:21, 230:20, 232:8, 237:4, 272:1, 305:12, 330:15
comparing 350:20	compresses 97:8	conducted 115:22	considerably 91:16, 311:16
compensate 162:18	compressor 97:8, 144:22	conducting 76:20, 77:9, 113:20	consideration 351:14
compensated 11:5	compressors 64:6, 83:6, 83:20, 107:14, 259:10, 259:17, 260:2	confidential 296:14	considerations 45:21, 101:8
compensation 154:17	comprised 83:9	confidentiality 296:12	considered 42:15, 67:20, 68:21, 96:21, 198:12, 205:19, 218:6, 220:16, 221:5, 221:22, 223:10, 226:9, 227:1, 263:8, 263:10, 263:11
competitive 35:8	computer 146:14	configurations 87:19, 90:7, 106:12, 127:4, 224:13, 230:6, 243:16, 245:6, 245:10, 265:3, 308:17	considering 235:14, 237:5, 271:20
complete 10:18, 85:8, 296:18		configured 88:8	
completely 118:7, 280:11,			

consistent 286:8 consists 181:21, 258:5, 305:8, 307:5, 328:2 constraint 98:16 constraints 334:9, 349:2 construction 145:17, 176:15, 232:19, 232:20, 233:6, 233:11, 233:18, 234:5, 234:13 construed 174:2, 174:12, 176:7 consult 14:21, 341:5 consumed 62:1, 338:10 consumers 168:8, 168:12 contain 264:5 contained 94:14 contains 69:6, 97:9, 162:5 content 339:4 contentions 14:4, 156:22 context 32:16, 42:5, 104:17, 185:10 continuous 249:20 contradicting 296:17 contrast 139:8 contributes 60:11 contribution 125:10	control 28:8 controlling 103:17 convection 87:13, 87:20, 87:21, 214:19, 215:8 conveniently 108:4 convention 87:16 conventional 18:12, 23:11, 40:2, 63:6, 82:3, 95:18, 96:3, 138:12, 160:7, 165:22, 252:1 conventionally 78:19, 82:4 conversations 14:17 conversion 41:22, 342:7 convert 50:8, 51:1, 52:9, 227:4, 229:14, 231:10, 290:9 converted 116:11, 120:11, 120:12, 130:21, 133:13, 188:17, 290:15 converter 103:7 converts 120:17, 174:21, 227:5 cool 190:21 cooled 90:13 cooler 192:7 cooling 36:21	copies 321:13 copy 12:22, 13:3, 13:4, 15:21, 17:2, 17:10, 76:11, 197:15 copying 70:8 core 28:12 corporate 33:11, 34:4 correct 11:1, 18:4, 21:13, 21:15, 22:15, 34:7, 41:8, 41:9, 42:1, 42:6, 42:7, 50:9, 50:11, 51:2, 52:1, 52:21, 69:9, 69:21, 69:22, 75:9, 79:3, 80:22, 95:10, 112:6, 120:7, 121:11, 121:21, 126:19, 136:13, 160:1, 161:8, 164:2, 208:18, 209:18, 211:19, 212:22, 215:17, 223:11, 223:13, 226:5, 226:21, 229:4, 229:11, 235:10, 235:13, 236:13, 236:18, 237:2, 237:19, 239:1, 239:2, 244:6, 245:18, 247:12, 261:20, 272:20, 300:10, 329:21, 337:21 correlation 321:8, 321:10 corroborate 110:11	cost 35:8, 163:4, 166:1, 166:3 costs 165:6 couldn't 249:5, 287:5, 294:8, 343:4 counsel 7:17, 14:16, 340:19, 355:1, 356:13 count 109:4 counted 257:18 couple 10:11, 22:10, 84:17, 175:18 coupled 88:14, 88:15, 242:2 course 12:9, 13:8, 14:16, 21:5, 27:6, 27:22, 28:7, 28:9, 29:4, 29:5, 29:8, 29:13, 29:15, 31:9, 44:9, 44:22, 60:10, 66:9, 67:4, 75:5, 85:2, 91:10, 91:12, 93:13, 145:19, 148:14, 293:14, 344:2, 349:19 courses 29:11, 29:16, 30:15 coursework 21:9, 29:20 court 8:3, 9:13 cover 68:2, 68:5, 68:11, 298:15,
--	--	---	---

299:8 covered 309:8 create 63:12, 66:3, 129:2, 134:7, 191:13, 206:6, 209:6, 331:1 created 212:6 creates 101:7, 131:14, 142:4, 181:22, 206:7, 222:11 creating 23:12, 72:19, 317:18, 317:19, 323:5 credit 79:2 credits 60:16, 61:13, 61:17, 78:10, 239:10 critical 70:19, 71:9, 195:17 cross-reference 301:18 crosstalk 121:2, 235:17 crr 1:25 cryogenic 129:20 cs 193:19 curious 258:19 current 23:10, 26:4, 28:18, 119:14 currently 22:13 curriculum 5:20, 26:10, 27:9, 27:11, 28:9, 28:12,	28:13, 29:7 customary 189:3 customers 353:12 cv 17:2, 21:11, 32:11, 34:17, 67:4 cycle 4:8, 4:10, 4:12, 4:14, 198:12, 199:21, 200:2, 200:4, 200:6, 200:20, 201:6, 289:8, 328:7, 328:15, 334:15, 334:16 cyclic 97:13 D dangled 309:15, 309:19 daniel 145:21 date 7:8, 11:12, 36:5, 37:8, 70:19, 71:9, 198:18, 199:12, 293:14, 294:1, 299:1 dates 71:19 dawson 3:19, 7:12 day 357:8 deal 29:22, 104:18 deals 40:17 decade 70:19, 71:9 decarbonation 128:18 december 293:18	decision 136:9, 242:1 deck 247:9, 247:14, 248:5, 249:18, 253:8, 256:11, 295:13, 295:15, 296:18 declaration 5:15, 6:4, 13:7, 15:21, 16:1, 16:2, 40:7, 40:17, 55:11, 55:15, 66:13, 66:16, 67:12, 67:22, 68:7, 68:14, 68:22, 119:21, 119:22, 120:2, 137:8, 138:20, 143:9, 159:8, 184:10, 209:9, 225:6, 225:8, 233:8, 247:6, 269:3, 272:8, 292:12, 293:9, 293:15, 297:22, 298:12, 298:14, 299:5, 309:2, 334:18, 346:5 declaring 299:4, 299:5 deficient 337:20, 338:1, 338:7, 338:21, 339:13, 339:15 define 36:9, 112:15, 289:21, 337:13 defined 37:3, 37:10, 60:8, 63:7, 80:4, 80:6, 109:14, 112:14, 114:12, 132:20, 154:18, 155:7, 174:9, 186:16, 189:2, 208:11,	234:12, 235:5, 237:12, 258:1, 267:7, 275:20, 283:19, 284:8 defines 62:17, 179:4, 217:14 defining 337:12 definitely 192:7 definition 41:4, 41:11, 55:15, 56:11, 64:20, 69:13, 112:9, 142:1, 172:15, 174:8, 175:22, 176:20, 178:17, 178:19, 180:12, 180:15, 180:19, 182:4, 183:22, 184:19, 206:10, 208:15, 229:21, 230:17, 230:18, 232:11, 233:4, 233:9, 233:15, 234:1, 234:2, 234:5, 234:9, 266:22, 312:4, 318:11 definitional 132:13 definitions 59:18, 62:18, 180:6 definitive 219:16 definitively 119:11 degree 21:10, 56:1, 256:9 degrees 56:15, 85:22, 90:22, 91:8, 192:19, 193:1, 193:19 deliver 164:12, 215:14
---	---	---	---

delivered 123:15, 249:20, 328:15 delivering 271:16 delivers 214:3, 215:17 delivery 144:10 demand 137:12, 137:17, 137:19, 138:10, 138:11, 138:12, 138:16, 168:9, 316:13 demonstratives 199:17 denver 1:16, 2:7, 3:15, 7:16, 356:18 department 29:19 depend 49:12, 83:8, 83:22, 99:20, 132:6, 167:20 dependent 354:14 depending 45:3, 46:17, 97:22, 100:10, 137:3, 148:15, 192:16, 292:4, 316:13, 319:1 depends 30:8, 31:1, 44:20, 45:13, 62:16, 64:10, 66:9, 86:9, 93:13, 97:20, 99:18, 100:15, 102:4, 103:5, 106:10, 109:9, 109:13, 135:20, 135:21, 135:22, 151:3, 192:9, 258:1, 289:21	depict 130:8, 206:3 depicted 159:7 depicting 206:5 depleted 133:10, 143:21, 154:16 deponent 36:11, 46:3, 55:2, 55:5, 73:3, 121:3, 177:16, 177:20, 180:3, 191:3, 191:7, 199:6, 207:13, 211:9, 211:21, 212:17, 224:6, 240:16, 249:12, 249:15, 293:5, 302:14, 323:7, 324:8, 325:4 depos 7:12, 8:5 deposed 9:4, 10:22 deposition 1:15, 2:1, 4:7, 5:1, 6:1, 7:3, 7:15, 12:6, 13:11, 14:14, 15:3, 15:5, 15:7, 15:8, 22:1, 76:14, 184:7, 184:10, 197:6, 198:4, 247:3, 249:8, 298:6, 354:21, 356:7, 356:9, 356:14, 356:15, 356:21 derivatives 109:20 derived 78:17 describe 24:7, 37:13,	59:10, 87:7, 89:22, 98:15, 120:21, 123:19, 124:1, 124:5, 173:20, 282:20, 283:1, 334:1, 334:2 described 58:6, 104:3, 125:6, 130:9, 138:5, 141:20, 167:12, 173:17, 180:19, 200:19, 258:10, 274:17, 308:2, 315:4, 320:15, 325:18, 326:22, 330:20, 332:3, 338:17 describes 125:15, 308:3, 308:4, 309:22, 310:13, 310:18, 310:22, 315:2, 317:12, 322:21, 342:21 describing 108:10, 201:14, 311:20, 338:15, 343:2 description 33:2, 182:17, 219:13, 232:15, 246:2, 313:15, 330:16 design 26:11, 27:14, 27:21, 28:4, 28:16, 29:5, 29:22, 30:11, 92:9, 93:4, 98:11, 98:16, 101:7, 103:11, 144:4, 144:8, 147:13, 195:6, 243:8 designated 202:18 designed 19:10, 35:5,	38:1, 91:7, 143:20 designing 34:21, 35:19, 37:16, 38:3, 92:10, 92:20, 98:12, 146:8, 147:4 designs 79:20 desired 45:5, 49:14, 50:1, 92:15, 92:16 destroy 19:11 destroying 170:7 desulfurization 122:17, 123:3, 123:8, 123:11, 123:17, 123:19, 124:10, 251:21, 252:5 desulfurized 120:9, 122:13, 124:2 detail 57:16, 110:22 detailed 232:15 details 61:15, 62:6, 88:9, 144:11, 173:14 determines 100:16, 135:15 detrimental 290:17 develop 24:18 developed 57:11, 58:21, 59:17, 60:2 developing 24:9, 32:22 device 188:14
--	--	---	--

devoted 256:11 diagram 83:16, 172:22, 173:15, 196:16, 196:21, 196:22, 205:7, 206:3, 219:15, 221:9, 255:8, 259:4, 259:21, 263:3, 263:15, 264:14, 267:8, 272:3, 276:12, 281:1, 291:6, 324:22, 331:1, 332:13 diagrams 14:7, 157:4, 158:6, 173:13 diamond-thin 22:2, 22:5 diego 34:12, 34:14 difference 115:16, 116:14, 200:16 differences 44:11 different 13:22, 22:4, 24:22, 29:4, 29:8, 29:9, 43:16, 43:21, 47:15, 47:17, 47:18, 48:15, 49:9, 53:12, 53:17, 54:12, 64:9, 80:7, 86:22, 87:18, 87:19, 90:6, 96:1, 101:1, 101:13, 101:15, 101:16, 101:19, 102:11, 103:14, 106:12, 109:12, 116:2, 116:6, 116:8, 127:3, 127:11, 128:7, 129:17, 146:12,	151:12, 154:5, 154:11, 154:17, 155:5, 161:2, 166:8, 168:7, 171:21, 172:16, 173:13, 191:10, 196:13, 203:19, 203:20, 205:2, 217:16, 223:14, 223:21, 225:22, 227:21, 239:19, 252:17, 268:21, 277:20, 286:7, 292:14, 314:19, 319:15, 326:15, 328:21, 329:6, 341:12, 341:21, 342:19, 342:22, 343:9, 344:22, 348:14, 349:1, 349:2, 349:5, 349:6, 349:15, 349:16 differently 115:22, 327:2, 343:15 differs 251:15 difficult 67:13, 203:17, 207:22, 208:12, 219:15 diffused 224:12 diffusion 102:8, 117:12 diluent 254:3 diluents 192:17 dilute 117:8, 117:9, 340:9 diluted 253:21, 256:9, 256:10 dimethyl 316:13	dioxins 19:5, 19:7 diplomate 2:10, 356:2, 357:14 direct 12:4, 40:9, 107:18, 299:12, 300:1 directed 50:22, 255:10, 256:16, 257:12 direction 51:1 directly 44:5, 45:17, 90:8, 99:10, 121:18, 194:11, 195:2, 196:5, 253:20, 273:22, 329:12, 330:2, 343:4, 351:8 disagree 57:18, 71:16, 200:17, 219:9, 279:18, 292:2, 324:21 disagreed 333:14 disagrees 185:4 disclosed 14:1, 162:16 disclosure 244:17, 321:17, 322:14 disclosures 12:8, 12:9 discuss 57:15, 124:9, 305:19, 306:15, 311:3, 323:11, 335:1 discussed 142:14, 238:3, 262:20, 265:2, 281:1 discusses 249:9	discussing 17:21, 156:4, 269:5 discussion 16:19, 189:10, 227:8, 304:11 dispute 296:10 disregard 112:21, 113:7 distinct 63:14, 197:1, 197:2, 310:19, 332:1 distinction 224:8, 314:13 distinguish 154:4, 171:18, 216:12, 277:15, 277:17, 287:12 distinguishing 277:21, 278:3 distributed 316:11 district 11:21 diverse 84:14, 147:9 diversity 25:20 divert 327:22 diverted 161:20 diverting 348:7 document 4:24, 108:2, 177:8, 249:19, 292:14, 297:15, 297:17, 298:18, 300:13, 303:19, 311:11, 311:13, 316:4, 316:7 documents 67:21, 68:2, 68:4, 68:21, 106:11
---	--	---	--

doing 18:15, 18:19, 21:4, 48:13, 67:16, 91:15, 94:4, 119:17, 127:4, 127:21, 131:1, 167:17, 183:10, 183:11, 239:19, 267:9, 293:15 dominant 269:18 done 12:5, 21:10, 23:8, 25:22, 34:18, 35:10, 36:1, 36:5, 47:15, 47:19, 77:20, 123:9, 225:3, 327:4, 327:5, 340:13, 340:19 dorsey 2:4, 3:11, 12:2, 13:17, 14:18, 67:5, 356:17 doubt 321:16 doubted 332:12 dow 18:15, 18:17, 18:19, 20:3, 32:10, 33:21, 34:2, 34:5, 94:3, 94:12 down 20:3, 176:4, 324:18, 330:5, 352:8 downstream 190:13, 216:20, 217:8, 217:10, 324:2 dr 8:13, 9:3, 13:7, 40:22,	41:4, 68:6, 68:7, 76:2, 143:7, 190:2, 199:21, 223:3, 246:7, 262:20, 268:9, 297:10, 298:2, 298:9, 315:8, 322:8 draft 67:2 dramatically 86:13 draw 199:1 drawing 197:12, 207:17 drawn 324:22, 325:6, 325:10, 327:1 drew 199:1 drive 7:13, 50:15 driven 50:8 driver 279:15, 280:5 drives 226:20 drop-in 23:11 drugs 20:15 drum 207:2 dry 337:14 drying 20:17, 129:20 duct 205:19, 231:13, 232:4 duct-fired 231:12, 232:3 due 19:15, 270:8 duly 8:9, 356:8	dumping 167:16 during 18:8, 21:17, 213:18 durrell 3:19, 7:12 duty 161:3 E e-mail 3:9, 3:17, 299:1, 355:8 each 144:20, 198:11, 273:13 earlier 50:6, 65:21, 66:15, 78:3, 80:21, 84:4, 86:16, 108:10, 113:18, 134:21, 142:14, 153:19, 154:21, 187:17, 188:12, 226:3, 227:9, 231:11, 234:16, 238:4, 243:11, 276:22, 311:12, 330:2 early 33:5, 72:6 easiest 300:6 ecn 299:18 economic 136:4, 170:11 economically 163:11, 170:19, 171:12, 194:12, 194:17 economics 97:22, 162:21, 163:6, 163:15, 165:3, 165:9, 165:17, 167:21, 168:21, 169:12,	170:17, 342:3 economizer 207:1 education 41:12 effect 331:2 efficiency 5:7, 92:17, 295:18, 301:11, 302:5, 346:19 efficient 138:21 efficiently 92:13 effluent 212:13 either 84:8, 96:11, 303:4, 338:16 elaboration 271:9 electives 28:11 electric 319:3 electrical 185:20, 188:18, 210:5, 211:14, 213:10, 216:3, 228:16, 310:6, 310:10, 311:17, 312:22, 313:20, 314:1, 316:15, 317:16, 317:18, 317:19, 318:4, 318:18, 323:15 electricity 61:22, 64:15, 64:21, 65:6, 65:13, 65:18, 106:19, 108:5, 108:11, 108:14, 108:18, 109:1, 109:4, 109:18, 110:14, 115:5, 139:1, 139:21, 140:15, 141:18,
---	---	--	--

142:4, 142:12, 151:11, 152:6, 168:6, 168:8, 185:21, 189:1, 191:13, 191:17, 200:9, 200:13, 202:9, 206:7, 212:10, 218:14, 220:10, 228:19, 229:15, 256:17, 258:2, 258:8, 259:9, 259:13, 260:3, 260:8, 260:10, 260:13, 260:17, 268:14, 289:1, 312:2, 316:18, 317:9, 317:10, 319:5, 319:20, 322:19, 334:11 electrochromics 26:2 elements 306:21 elevated 122:22, 123:9, 188:15 eliminate 19:7 eliminated 320:18 else 48:7, 130:13, 202:8, 258:21, 268:8, 271:17, 281:10, 303:14, 308:8 elsewhere 141:20, 245:9 embodiment 241:1, 246:3, 308:21, 322:1 embodiments 305:11, 305:13, 319:15 emission 62:21, 84:7, 86:12, 256:12,	262:3, 262:10, 262:11, 262:12, 263:10, 265:8, 265:21, 267:4, 270:22, 271:21, 311:16 emissions 30:1, 30:5, 39:7, 40:4, 56:6, 56:22, 57:22, 58:7, 58:9, 59:6, 60:9, 60:12, 60:14, 61:22, 62:10, 62:12, 62:20, 62:22, 63:5, 63:17, 64:15, 64:21, 66:4, 71:7, 73:14, 73:18, 76:21, 77:5, 77:9, 77:13, 77:18, 78:4, 81:1, 81:8, 81:11, 81:17, 81:20, 82:8, 82:15, 82:22, 83:12, 83:19, 85:3, 103:12, 106:6, 108:6, 108:18, 108:22, 109:4, 109:21, 110:14, 112:22, 113:8, 113:16, 113:21, 114:4, 114:6, 115:4, 115:6, 143:15, 152:17, 153:11, 155:12, 167:12, 169:14, 170:4, 170:6, 171:19, 239:9, 240:13, 241:15, 241:20, 242:20, 243:7, 244:3, 245:21, 246:13, 247:15, 256:14, 256:17, 257:13, 257:17,	257:18, 261:7, 262:22, 265:1, 267:20, 268:14, 268:19, 268:22, 284:15, 285:1, 285:6, 285:16, 296:1 emit 91:7, 263:17 emitted 66:8, 78:21, 86:7, 91:2 emitter 239:16 emphasis 23:10, 30:9 employ 44:3, 139:12 employed 85:16, 160:21, 357:3 enables 79:1 encompassed 228:11, 229:18 encompasses 180:16 encompassing 233:16 encounter 29:10 encourage 320:22 end 42:12, 42:18, 44:18, 45:11, 57:4, 57:5, 99:2, 162:12, 238:4, 238:7, 239:4, 245:2, 316:9, 341:5, 349:9, 351:1, 354:21 endothermic 226:17, 226:21 ends 32:2, 98:9, 290:2, 350:2	energy 5:7, 5:16, 23:1, 26:13, 30:4, 59:6, 108:3, 115:11, 115:12, 148:1, 148:5, 148:17, 148:19, 148:22, 149:3, 149:8, 149:15, 150:2, 150:13, 150:16, 150:17, 151:1, 151:6, 151:8, 151:13, 151:17, 187:5, 187:11, 188:17, 188:18, 191:22, 205:6, 209:5, 209:12, 209:21, 210:3, 210:4, 210:5, 211:13, 211:15, 212:10, 213:9, 213:12, 213:14, 213:17, 214:4, 214:9, 215:14, 216:1, 216:2, 216:3, 229:15, 231:9, 257:10, 257:11, 295:18, 299:14, 299:20, 301:11, 302:5, 309:5, 318:4, 318:5, 319:2 engaged 11:16, 293:14 engine 110:7 engineer 25:20, 56:14, 79:20, 136:10, 144:15 engineering 18:2, 18:6, 18:11, 21:12, 26:17, 29:13, 29:16, 29:19, 31:9, 31:13, 55:21, 56:1,
---	--	---	--

56:15, 145:16, 145:20, 225:17 engineers 54:15, 54:16, 146:5, 147:3, 147:4 enough 173:20, 192:12, 193:7, 213:3 enriched 118:13, 291:22, 338:20 entering 122:2, 124:18, 220:7, 269:13 entire 162:12, 268:17 entitled 5:6, 5:16, 266:4 entropy 213:20 entry 301:5, 301:10 environment 170:16, 195:3 environmental 29:12, 29:16, 29:18, 85:5, 135:21 envisioned 202:14 epc 145:11, 147:2 equally 172:18, 278:12 equals 183:18 equate 178:17, 179:19, 180:4 equated 189:14 equating 177:2, 178:13 equilibrium 50:21, 51:16, 51:19	equipment 37:17, 38:4, 116:2, 116:5, 147:5, 191:11, 195:22, 196:11, 196:19, 197:2, 228:8, 229:18, 239:4 equipped 53:16 equivalent 182:11, 234:21 erik 5:9, 248:14 especially 50:13, 67:3, 114:12 esquire 3:4, 3:12 essentially 23:3, 89:19, 278:9 established 238:6 et 5:5, 5:12, 5:14, 108:12, 108:16, 112:17, 144:10, 154:8, 301:22 ether 316:14 ethylene 85:9 evaluation 49:22 evaporator 207:2 even 44:3, 155:10, 189:20, 218:13, 235:15, 237:6, 339:2, 339:10, 343:2 ever 9:3, 11:2, 33:22, 34:18, 87:3, 151:15,	352:17 every 10:3, 31:9, 106:15, 134:6, 277:1, 279:20, 343:18 everybody 327:9 everything 9:14, 26:10, 130:13, 228:15, 274:15, 284:5, 344:10 evidence 70:2, 70:4, 70:6, 70:8, 70:10, 248:3, 250:4, 250:8, 294:13, 296:16, 302:10, 302:17, 303:3, 303:4, 303:6 ex-parte 74:22 exact 4:24, 11:15, 43:15, 45:4, 79:5, 98:7, 135:2, 164:8, 192:9, 264:4, 275:18, 293:22, 311:10, 342:15, 353:4 exactly 51:12, 59:9, 68:17, 77:19, 80:3, 88:7, 90:5, 94:12, 96:10, 103:19, 104:11, 108:13, 111:7, 127:14, 141:7, 144:9, 145:2, 145:9, 151:2, 162:15, 171:9, 175:10, 177:11, 190:16, 203:18, 204:2, 207:22, 249:2,	265:14, 272:3, 282:14, 288:13, 303:12, 305:4, 306:7, 307:15, 320:5, 337:15 examination 4:2, 8:11 example 20:15, 24:11, 31:8, 37:19, 39:11, 43:10, 44:2, 50:4, 90:12, 92:3, 107:3, 109:20, 109:22, 131:13, 133:3, 135:7, 141:16, 148:18, 148:20, 152:2, 159:6, 168:5, 182:16, 219:7, 316:6, 316:8, 343:15, 354:7 examples 134:17, 140:14 excel 168:5 except 268:5 exceptions 186:7 excess 117:20, 118:6, 138:22, 139:13, 139:17, 139:20, 140:2, 140:6, 140:8, 141:17, 335:5, 335:11, 335:20, 337:4, 337:5, 338:1, 346:19 exchanged 330:8, 330:19 exchanger 89:2, 90:11, 90:15, 182:1, 183:18, 205:6, 208:20, 209:3, 209:7, 210:10,
---	---	---	---

210:11, 211:20, 212:3, 215:5, 215:9, 216:11, 216:19, 217:17, 227:5, 231:4, 231:9, 330:10, 330:20, 331:4, 331:12, 332:2 exchangers 214:15, 330:21, 331:9, 331:20, 332:1 exclude 112:9 excluded 64:19, 111:2, 111:18 excluding 235:11, 236:19 exclusively 168:11, 215:11, 272:12, 273:8, 279:21, 280:1, 283:2, 287:18, 310:18, 310:22, 314:4, 317:12, 320:19 executed 227:20 exercise 112:13 exhaust 191:18, 192:22, 193:21, 194:11, 194:19, 195:13, 196:4, 196:8, 200:10, 201:8, 203:22, 211:18, 213:6, 214:13, 229:3, 229:6, 231:14, 232:5, 318:2, 318:5, 318:9, 318:12, 320:8, 330:7, 330:18, 333:6, 335:2, 337:8, 337:13, 337:20, 338:4, 339:3,	339:5 exhibit 4:7, 4:8, 4:9, 4:11, 4:13, 4:15, 5:3, 5:4, 5:6, 5:11, 5:13, 5:15, 5:20, 6:3, 6:4, 15:16, 15:18, 16:1, 16:10, 16:12, 17:1, 17:5, 17:10, 17:15, 40:7, 66:12, 68:15, 69:1, 69:6, 69:18, 70:14, 75:8, 76:10, 107:20, 120:2, 138:20, 174:1, 177:7, 187:2, 197:4, 198:3, 198:4, 199:8, 200:1, 201:21, 202:12, 203:9, 210:22, 211:1, 218:21, 233:8, 235:3, 236:12, 246:15, 246:17, 247:6, 250:13, 270:11, 272:19, 295:12, 297:11, 297:13, 298:15, 301:17, 304:3, 304:4, 304:6, 327:15, 327:17, 353:19, 353:22 exhibits 4:21, 5:1, 6:1, 13:7, 13:11, 16:13, 197:4, 197:6, 198:10 exist 205:7, 232:7 existed 126:21, 224:3, 231:16 existence 125:11, 125:20	existing 138:12 exists 64:11, 158:20, 270:20 exothermic 84:22, 212:13, 212:21, 213:2 expand 189:21 expander 228:9 expect 92:9, 94:17, 95:2, 101:18, 101:21, 146:20, 147:8, 147:12, 280:13, 287:15, 326:13 expectation 228:14 expectations 169:9 expected 29:22, 269:17 expense 167:11 expensive 166:17 experience 13:9, 34:15, 34:20, 35:18, 35:22, 37:15, 38:2, 41:6, 41:13, 55:21 experiments 354:3 expert 9:1, 12:1, 12:9, 13:1, 53:14, 163:11, 163:19, 168:22, 189:13, 348:15 expires 357:9 explain 83:11, 83:18, 253:8, 317:21	explained 288:1 explicit 184:19, 305:15, 308:5, 319:19, 321:10, 322:13 explicitly 138:5, 205:14, 208:12, 210:20, 211:15, 283:15, 284:2, 285:11, 306:17, 308:18, 316:16, 322:20, 341:20, 342:9, 342:21, 343:9 explore 185:9 explored 22:2 exploring 185:2 exposed 118:12 extensive 68:12 extent 124:10, 157:14, 289:22, 298:10 external 230:3, 258:8, 288:5 externally 278:11 extra 167:10 extract 38:17, 39:6, 91:21 extracting 24:16 extracts 92:4, 126:10 extreme 319:4 exxonmobil 152:2 F facilities 34:1
--	--	--	---

fact 54:15, 94:2, 272:2, 282:10, 350:9 factor 164:9 factors 137:5 fair 197:13, 213:3, 230:18, 249:10, 249:14, 326:17 fairly 352:7 fake 30:20, 30:21 familiar 38:10, 49:21, 53:7, 54:12, 57:7, 57:8, 57:10, 58:13, 59:2, 59:14, 61:14, 62:5, 74:21, 78:12, 87:12, 88:4, 97:1, 145:11, 145:18, 145:22, 146:2, 198:14, 199:20, 298:1, 298:11, 299:18, 304:2 familiarity 56:5, 56:18, 56:21, 57:3 fane 3:3 far 126:14, 258:4, 284:8, 290:8 fast 177:19 faster 118:4, 118:10 fault 150:4 feasible 136:20, 334:5 feature 27:9	fed 88:19, 110:7, 273:19, 291:11, 304:17, 324:1, 341:17 feed 45:1, 45:11, 52:1, 81:20, 106:5, 121:9, 122:9, 122:16, 273:1, 273:20, 274:22, 275:4, 275:9, 277:13, 277:17, 278:2, 278:9, 283:6, 283:15, 284:2, 286:5, 286:11, 286:16, 287:21 feeds 276:6 feedstock 44:10, 54:8, 58:2 feedstocks 349:6 feedwater 207:1 feel 158:11, 313:10 fertiliser 5:18, 299:15 few 9:7, 15:10, 16:12, 81:14, 237:22, 271:8, 290:2, 297:20, 305:6, 340:18, 353:17 fields 56:16, 225:21, 225:22 fight 61:7 figure 120:5, 130:5, 130:8, 137:8, 138:5, 138:7, 159:6, 161:16,	204:3, 238:16, 238:19, 238:20, 239:7, 240:20, 241:22, 243:12, 244:10, 244:17, 244:22, 245:17, 246:2, 250:20, 251:15, 257:10, 258:10, 260:16, 281:2, 283:14, 289:2, 307:17, 307:21, 308:2, 312:3, 312:7, 312:12, 319:11, 322:3, 324:21, 327:1, 331:6 filament 22:3 filed 329:17, 329:18, 329:20 films 22:2, 22:5 final 129:2 financially 357:5 find 115:16, 219:6, 249:4, 249:5, 274:12, 291:20, 292:2, 303:22, 316:5, 321:1, 342:15 fine 16:14, 121:5, 199:10, 199:13, 199:18, 234:7, 292:18, 293:6, 322:5 finish 10:7, 236:4, 328:19 fire 90:8, 138:13, 153:21, 226:13, 286:3 fired 82:5, 121:18,	125:8, 149:10, 149:11, 150:19, 150:20, 157:7, 158:8, 175:5, 176:2, 176:13, 176:19, 177:3, 178:5, 178:7, 178:13, 178:18, 178:21, 179:17, 179:20, 180:5, 180:9, 180:16, 182:6, 182:8, 182:11, 182:15, 182:21, 183:8, 183:16, 183:17, 183:18, 186:2, 186:8, 205:3, 225:12, 225:15, 226:3, 226:6, 226:9, 226:14, 227:1, 227:16, 230:13, 233:13, 233:15, 233:17, 234:18, 234:20, 238:21, 239:3, 245:16, 318:12 fires 19:16 firing 111:2, 111:18, 183:11, 223:9, 224:2, 242:5, 242:21 firms 147:17 first 8:9, 17:19, 120:8, 120:10, 137:16, 179:9, 188:17, 200:8, 210:4, 216:1, 242:1, 246:3, 253:21, 272:22, 273:9, 297:21, 297:22, 298:14, 329:20, 332:8, 332:14, 333:8, 333:15
--	--	--	--

fischer-tropsch 45:21, 46:14, 46:16, 46:21, 48:6, 48:13, 48:19, 50:21, 51:4, 51:8, 51:10, 51:21, 52:3, 52:5, 53:13, 54:2, 346:14, 346:17, 347:16, 348:9, 348:11, 350:1, 350:4, 350:10, 350:14, 350:21, 351:5, 351:8 fits 182:16 five 197:17 fjellhaug 5:14, 12:18, 327:20, 327:21, 333:1, 337:20, 340:13 flame 85:22, 87:9, 101:11, 101:22, 102:9, 102:11, 104:3, 104:4, 104:19, 117:12, 117:16, 117:19, 254:8, 254:9 flare 136:2 flared 135:12, 135:16 flow 83:16, 126:14, 126:21, 127:7, 127:15, 127:16, 129:8, 159:6, 159:13, 164:12, 172:21, 243:11, 244:10, 250:17, 250:19, 252:2, 264:17, 290:8, 291:6, 308:11, 322:3, 326:15,	328:12, 332:13 flows 208:2 flue 19:20, 38:17, 77:6, 77:13, 81:11, 81:17, 81:20, 82:8, 82:15, 82:22, 86:7, 89:1, 91:1, 91:7, 91:15, 91:18, 91:22, 92:19, 106:6, 112:21, 113:8, 116:15, 205:6, 240:6, 261:13, 261:19, 262:21, 263:4, 263:21, 265:7, 266:9, 266:14, 266:16, 266:21, 267:4, 267:12, 267:20 fluid 26:13, 89:3, 91:15, 92:15, 182:2, 186:1, 187:6, 187:15, 189:6, 209:4, 209:13, 209:22, 210:12, 309:6 fluidized 20:13, 20:17 fluor 145:21 focus 18:7, 21:17, 22:20, 25:18, 26:4, 57:19, 58:1, 58:2, 58:5, 71:20, 77:4, 310:9 focused 13:13, 138:21, 189:16 focuses 139:16 focusing 54:3	follow 171:9, 281:18, 350:18 followed 120:12, 173:1, 173:2, 187:5, 207:1, 209:11, 209:21, 238:8, 238:9, 251:1, 251:2, 309:4 following 109:22, 130:6, 279:22, 347:1 follows 8:10, 190:12, 260:12, 281:19, 307:10 forget 190:16 formation 103:22, 104:3, 104:20 formed 75:2 forth 356:7 fortunately 213:20 fossil 84:9 fossil-fuel 82:12, 82:19, 137:13 found 19:15, 158:6, 193:11, 250:20, 298:19, 303:8 foundation 22:12, 203:15, 205:1, 207:16, 207:19, 211:7, 219:11, 220:6 four 112:15, 176:1, 176:8, 176:9, 178:8, 180:5, 184:20, 186:11, 186:17, 233:16,	234:21, 340:22 four-month 21:7 fourth 300:17 fraction 119:18, 161:10, 240:10, 241:16 freepoint 20:3 front 15:13, 15:20, 16:7, 32:2, 42:12, 57:4, 76:11, 162:12, 238:4, 238:7, 239:4, 245:1, 298:22, 341:5, 349:9, 350:1, 351:1 front-end 43:4, 44:13, 52:8, 53:8 fuel-firing 244:7 fuels 23:12, 39:6, 39:17, 84:9, 223:14 full 8:17, 144:17, 149:5, 294:22, 295:7, 295:13, 295:15, 342:7 fully 71:2, 168:14 function 321:12 functional 187:10, 237:17 functionality 294:6 furnace's 91:13, 187:14 furnace-fired 4:16, 219:7 furnaces 63:18, 81:19,
---	---	--	---

82:5, 85:15, 86:22, 87:19, 91:7, 92:11, 93:9, 95:20, 106:5, 125:6, 125:7, 125:11, 138:13, 143:20, 144:4, 147:5, 152:16, 153:11, 153:21, 178:21, 180:9, 185:14, 185:21, 186:12, 189:22, 219:18, 223:7, 223:15 further 49:5, 316:9, 330:5, 342:13, 342:14, 342:16, 354:18, 356:12, 356:15, 356:20, 357:1 fusion 23:2 future 5:6, 265:21, 301:11	266:14, 266:16, 266:21, 267:4, 267:12, 314:7, 334:10 gave 17:17, 61:5, 197:19, 197:20, 327:8 gears 76:6, 119:20 general 22:22, 53:20, 59:14, 62:7, 65:10, 65:12, 69:3, 72:19, 87:8, 92:13, 93:3, 94:17, 102:18, 110:17, 115:2, 118:3, 129:12, 145:8, 162:4, 167:16, 170:6, 179:2, 180:11, 181:20, 182:4, 182:17, 183:3, 183:6, 191:20, 194:15, 195:15, 209:1, 221:9, 221:11, 223:13, 229:20, 242:6, 242:22, 320:13, 334:11, 335:14, 335:22, 347:15 generally 87:6, 90:1, 121:14, 124:16, 160:4, 185:10, 186:8, 229:10, 342:11 generate 65:5, 66:2, 94:5, 189:1, 189:5, 191:17, 192:19, 193:7, 211:19, 212:12, 218:5, 218:14, 220:4, 230:15, 231:6, 235:16,	237:11, 260:7, 333:7, 333:18 generated 121:14, 204:20, 213:17, 217:9, 312:12, 319:21, 320:3 generates 200:11, 228:18, 235:15, 237:6, 237:13 generating 102:15, 213:6, 220:10, 221:2, 221:19, 260:10, 315:10, 315:11, 315:13, 315:15, 316:12, 316:20, 332:8, 332:15, 333:7, 333:15 generation 36:20, 36:21, 37:17, 138:1, 138:6, 191:1, 201:9, 208:17, 221:4, 221:21, 245:8, 257:17, 268:15, 315:17, 315:18, 316:17, 316:18, 316:22, 319:9 generator 4:17, 112:16, 174:5, 174:17, 174:19, 178:3, 187:18, 187:22, 188:4, 190:4, 202:4, 202:9, 202:19, 204:13, 204:16, 205:4, 206:8, 216:7, 216:9, 216:13, 216:17, 217:1, 217:9, 217:11, 217:15, 217:21, 217:22, 218:7, 218:14, 218:18, 219:7, 220:9,	221:5, 221:22, 222:3, 230:14, 230:18, 230:21, 230:22, 233:1, 235:15, 237:6, 237:12, 330:8, 330:11, 332:8, 333:17 generators 37:22, 230:10 generic 77:18, 127:18, 127:21 generically 52:3, 88:21, 130:1 germane 13:15 getting 169:11, 171:5, 347:11, 350:17 give 9:6, 16:8, 30:11, 85:10, 149:4, 198:2, 198:3, 293:13, 311:9, 324:5 given 166:7, 184:11, 184:15, 356:11 glad 252:20 global 302:5 go 10:9, 36:12, 37:12, 40:13, 44:5, 48:3, 48:9, 55:4, 61:10, 66:21, 72:10, 84:19, 84:22, 118:10, 121:4, 122:14, 150:7, 152:21, 162:6, 164:18, 172:11, 177:19, 180:2, 191:2, 202:7, 211:8,
---	--	--	--

212:1, 215:21, 218:2, 224:6, 236:3, 242:16, 259:8, 269:2, 279:17, 280:22, 283:5, 283:11, 296:21, 311:7, 311:9, 317:8, 323:7, 323:9, 324:13, 325:5, 328:20, 343:3, 343:4, 343:11, 343:17, 349:16 goal 50:1, 91:20, 92:3, 108:22, 213:22, 241:19 goes 63:13, 85:5, 85:7, 88:17, 90:14, 91:19, 97:10, 132:21, 144:19, 163:7, 184:17, 184:18, 191:21, 196:5, 196:8, 200:10, 238:19, 254:16, 254:17, 273:20, 275:9, 275:10, 278:9, 307:13, 326:1, 326:5, 344:3 good 8:13, 10:16, 63:2, 75:13, 222:13, 222:17, 252:20, 316:5 gotten 119:13 government 60:18, 167:21, 168:11, 299:21 grade 80:7, 80:8 grades 80:7 graduate 27:17	great 118:11, 297:1 greater 155:1 greatly 76:22, 113:22 green 58:18 greenhouse 59:5, 60:9, 60:11 greet 58:13, 58:17, 58:19, 58:20, 59:5, 59:10, 59:14, 61:21, 62:6, 80:22, 81:6, 109:11 ground 9:7 group 30:17, 296:5 growing 30:20 gt 118:18, 253:16, 269:8, 269:13 guess 28:14, 28:19, 33:1, 36:20, 40:14, 177:10, 179:13, 197:21, 271:12, 272:21, 289:16, 289:22, 291:4, 331:12, 354:7 gum 34:13 guys 27:12, 30:11 H h2 52:4, 52:16, 53:4, 251:5, 251:9, 251:12, 252:6, 252:14, 252:15, 253:14,	255:8, 276:7, 279:4, 279:13, 282:2, 284:13, 287:12, 287:15, 287:16, 287:22, 288:3, 288:4, 350:6 hand 15:10, 16:22, 17:9, 179:13, 197:3, 246:14, 303:21, 357:8 hanging 297:10, 327:14 hang 55:12 happened 74:12 happening 73:10 happens 90:13, 118:12, 191:17 hard 254:12 harmful 19:11 headaches 327:9 headquartered 7:13 heard 87:3, 352:17 heartbeat 31:12 heat-generating 315:2 heat-generation 311:15 heater 127:12, 175:6, 176:2, 176:13, 176:19, 177:3, 178:6, 178:7, 178:14, 178:18, 179:17, 179:20, 182:7, 182:9, 182:11, 182:15,	182:21, 183:8, 183:16, 183:18, 225:12, 225:15, 226:14, 227:16, 233:13, 233:15, 233:17, 234:19, 234:21, 238:21, 245:16 heaters 148:20, 149:10, 149:11, 150:19, 150:20, 178:22, 180:5, 180:9, 180:16, 186:2, 226:3, 226:9, 227:1, 231:20 heating 93:16, 164:4, 164:20, 174:20, 183:11, 187:15 heightened 103:1 held 2:2 help 117:21, 167:21, 242:17 here 7:2, 8:14, 8:19, 8:22, 9:1, 9:21, 10:19, 123:4, 123:12, 140:13, 171:10, 171:22, 173:5, 175:18, 202:20, 205:15, 206:15, 208:3, 219:13, 219:16, 241:19, 252:13, 253:13, 260:14, 265:5, 271:11, 272:1, 274:7, 278:7, 283:20, 286:14, 287:16, 321:12, 327:5, 343:15 here's 56:10, 112:20 hereby 356:5
--	--	---	--

hereinbefore 356:7	hot 22:3, 89:1,	212:2, 212:20, 213:7, 214:8,	hydrogen-rich 72:5, 73:14,
hereunto 357:7	187:6, 192:12,	214:18, 216:9,	94:20, 95:6,
hey 342:4	196:4, 196:8,	216:11, 217:15,	95:14, 96:4,
high 25:10, 97:21,	209:12, 209:22,	230:21, 231:3,	100:1, 100:19,
209:5	210:12, 309:5,	237:4, 237:13,	101:7, 101:22,
high-efficiency 92:4, 214:3	333:6	267:21, 330:16,	102:15, 103:1,
high-pressure 349:3	hotter 193:20	330:20, 331:4,	104:21, 105:4,
high-purity 97:16	hottest 87:11, 207:3,	331:20, 332:1	118:15, 125:18,
higher 44:7, 44:13,	207:6	hrsgs 231:12, 232:3,	132:1, 132:9,
51:6, 101:11,	hour 10:3, 11:10,	235:11, 236:19	132:15, 132:20,
101:21, 104:3,	17:19, 222:13	hru 130:14, 134:10	133:3, 137:21,
104:4, 104:19,	hourly 11:9	huge 19:22, 29:8	140:18, 153:20,
117:15, 117:16,	hours 10:11, 11:15,	huh 340:16	154:4, 154:9,
117:18, 164:11,	15:9, 67:11,	hundred 192:19	172:7, 223:18,
168:17, 321:13,	67:14, 340:22	hundred-bar 349:3	224:2, 244:4,
347:22, 348:4	house 90:13, 90:14,	hungerford 7:13	287:4, 328:13,
highest 119:12	92:3, 214:6	hydro 64:13	328:14, 333:2,
highlight 48:15	housed 29:20	hydrocarbon 23:12, 139:9,	333:4, 345:17,
highly 30:12, 99:21,	houston 3:7	139:15, 140:5,	345:18, 346:10,
118:13	however 10:4, 16:15	272:13, 273:1,	348:1, 350:16,
hit 162:21, 165:3	hrsg 190:6, 190:19,	273:7, 273:8,	351:2
hold 37:1, 60:20,	190:20, 191:2,	273:10, 274:17,	hydrogen-to-carb-
73:2, 93:1,	191:4, 191:10,	275:9, 283:16,	on 46:12, 47:11,
144:5, 152:19,	191:13, 191:14,	283:19, 283:20,	49:2
198:16, 207:12,	192:13, 195:21,	285:12, 285:13,	hydrogen-to-co
235:19, 355:14	196:5, 196:9,	285:17, 286:4,	44:17, 347:2,
honestly 305:16	200:11, 202:7,	286:10, 286:16,	348:5
hopefully 35:8, 59:4,	202:10, 202:15,	286:21, 304:18,	hydrogenator
230:12, 293:1,	202:19, 203:12,	341:11	251:17, 252:1
324:18	203:16, 204:21,	hydrocarbons 51:6, 94:14,	hydrogens
host 100:14, 146:12,	205:5, 205:20,	94:18, 255:17,	352:13
168:12	205:22, 207:4,	273:19, 283:6	hypothetical
	207:5, 207:9,	hydrogen-carbon 48:20	150:11
	208:14, 209:15,	hydrogen-depleted 116:21, 153:15	hysys
	209:20, 210:10,	hydrogen-enriched 143:21	28:19
	210:11, 211:11,		
	211:19, 211:20,		

identification 197:8, 198:5 identified 68:15, 69:1, 175:5, 176:12, 178:5, 179:16, 225:11, 234:18 identifies 186:12 identify 7:18 ifa 5:9, 12:10, 68:7, 157:15, 190:8, 196:12, 196:15, 202:13, 202:17, 246:19, 247:8, 247:13, 247:14, 269:5, 272:11, 272:18, 292:14, 292:16, 293:10, 294:2, 294:7, 294:10, 294:14, 294:15, 294:18, 294:22, 295:4, 295:7, 295:12, 296:18, 300:22, 301:12, 302:4, 302:6, 302:11, 302:19, 303:9, 308:17, 328:12, 328:22, 329:7, 332:14, 333:2 ii 28:20 illustrative 331:7 imagine 253:10 immaterial 339:14 impact 103:21, 163:5 impacted 160:21 implications 79:6, 163:20,	165:8, 165:13, 167:9 implies 186:8 imply 80:18 important 9:14, 48:15, 48:21, 85:5, 108:17, 165:13, 167:10, 170:4, 170:8, 194:16, 228:5, 338:13 imported 108:4 impossible 30:22 improve 346:18 improvements 343:7 impurities 97:10, 97:11, 99:21, 131:20, 135:4, 256:8 inc 1:4, 7:5, 7:22, 17:15, 246:17, 297:13, 304:6, 327:17 incentives 163:8, 163:9 include 12:13, 41:18, 45:9, 133:18, 137:22, 179:10, 189:17, 233:12, 237:7, 259:5, 259:6, 328:22 included 109:12, 109:13, 112:17, 233:15, 233:17, 236:15, 238:8, 308:8, 350:11 includes 41:16, 228:16, 306:20, 308:11	including 41:6, 235:6 inclusion 110:13 inconsistencies 345:8 inconsistent 305:16 incorporated 237:16 increase 119:18, 162:17 independent 206:7 independently 200:9, 205:3 indexing 294:10 indicate 4:23, 260:16, 293:9, 337:5 indicated 196:12, 259:21, 265:14, 292:9 indicates 181:6, 226:6, 255:8 indicating 263:20, 299:9 indicia 69:13, 69:19 individual 53:16, 146:17, 253:10 induced 87:20 industrial 18:13, 18:16, 21:7, 73:10, 80:8, 85:12, 85:14, 93:9, 93:21, 94:11, 95:7, 95:15, 95:20, 96:5, 96:22, 99:6 industry 5:18, 22:7, 30:18, 41:5,	41:12, 70:6, 70:11, 70:17, 71:6, 71:18, 71:21, 72:4, 72:18, 72:21, 73:5, 73:7, 73:13, 172:13, 239:15, 296:11, 299:15, 299:20, 342:12 industry-supplied 30:15 inerts 339:18, 340:4 inflames 105:5 information 253:12 informed 279:13 initial 67:2 injection 272:4 innovation 170:11, 170:12, 285:19, 285:21 innovations 170:16 innovative 243:8 input 52:4, 52:5, 117:11, 164:13, 228:21 inputs 188:4, 259:4 inside 89:7, 121:14 insight 73:9 insignificant 352:14 inspection 356:20 instance 201:18 instead 188:16, 286:16,
---	---	---	---

291:14 intake 228:9 integral 228:8, 229:11, 230:6 integrate 270:20 integrated 20:1, 195:22 integrating 280:4 integration 165:18, 194:16, 195:17, 264:8, 279:14, 280:5, 280:7, 280:20, 281:22, 282:1, 289:5, 289:14, 289:19, 289:22 intend 69:7 intended 189:1, 189:5 intends 305:19 intensity 58:14, 59:11, 60:4, 60:7, 60:13, 79:21, 80:13, 109:1, 109:5 intensive 27:7 intentionally 69:11, 111:2, 111:17, 260:6 interchangeable 333:20, 334:2 interchangeably 284:6 interconnected 211:1 interested 51:22, 295:22, 303:7, 357:5 intern 33:6	internal 88:9, 137:10, 147:17 internet 197:11, 219:4, 298:2, 298:14, 298:17, 299:4, 299:10 internship 33:17 interpret 323:16, 323:19 interpretation 275:12 interpreted 181:8 interpreting 184:16 interrupt 34:10 interrupted 262:15 intimate 144:20 intricacies 146:17 invalidity 14:4, 156:22 invention 76:20, 109:17, 113:20, 246:3, 246:4, 246:12 inventors 111:1, 111:17, 112:8, 244:3 investing 169:2, 260:7 investor 169:7 involve 36:5, 43:14, 141:9, 151:4, 151:5, 151:9, 209:16, 209:20 involved 11:20, 14:22, 37:8, 78:10, 80:19, 141:15,	148:15, 151:3 involvement 24:5 involves 37:21, 97:7, 174:20, 187:4, 209:10, 210:2, 228:15, 309:3 involving 35:20, 211:12 ipr 1:11, 7:6, 11:12, 11:17, 14:1, 14:12, 16:12, 69:8, 74:2, 74:8, 297:19, 345:15 isolate 350:15, 351:2 issue 17:12, 61:17, 117:22, 179:7, 179:12 issues 67:3, 104:2, 104:5, 145:5 items 178:9, 184:21, 295:13 iterated 67:8 iterative 67:1 itself 127:15, 249:1, 258:7, 296:8	judgment 253:12 july 1:17, 7:8, 299:3, 299:9, 356:18, 357:8 jumped 31:4 junk 131:12, 133:22 junky 344:6 justify 167:10 jvp 301:6
		J	K
		jeff 7:20, 8:14, 61:1 jeffrey 3:4, 16:9 job 1:23 jphillips@spence- rfane 3:9	kbr 145:22 kept 19:14 key 48:18 kilogram 147:20, 147:22, 148:18, 149:8, 149:19, 150:3, 150:12, 150:18 kilojoules 148:1 kind 27:8, 31:12, 67:6, 90:9, 123:3, 144:19, 182:4, 225:3, 232:15, 233:16, 264:6, 298:6, 309:15, 319:18, 344:6 kinetics 22:1, 26:11 knew 139:20, 140:17, 143:11, 156:14, 170:21, 171:14 knight 1:25, 2:9, 8:4,

356:2, 357:12 knocks 102:15, 102:19, 103:8, 103:12, 103:22, 104:3, 104:20 knowing 146:19, 165:7 knowledge 119:12, 172:6, 348:11 knowledgeable 54:7 known 92:19, 93:8, 93:19, 95:5, 95:13, 96:3, 96:13, 104:18, 108:15, 124:13, 124:17, 129:13, 140:7, 142:7, 142:10, 156:6, 156:9, 172:13, 291:18, 292:1 knows 61:2, 117:6, 152:13, 153:4, 153:7	299:13, 302:11, 302:18, 303:7 laminar 101:11 language 9:19, 154:11, 317:14 large 269:1 larger 180:12, 180:19, 181:5 largest 239:16 last 40:14, 42:9, 128:17, 188:9, 188:21, 269:15, 270:13, 270:17, 293:17, 300:18, 301:4, 301:10, 301:21, 323:21, 353:17 late 350:17 later 31:21, 65:3, 110:22, 280:14, 355:13 latter 269:16 laws 79:6 lay 146:13 layout 203:11, 294:3 lead 282:6, 287:8 leads 252:21 lean 102:7, 338:16, 339:6, 339:8 learn 29:3 least 64:9, 70:18,	71:8, 71:21, 77:20, 118:15, 243:8, 257:9, 258:9, 265:4, 280:8, 299:10, 332:2, 340:19 left 206:19, 216:4, 261:12, 274:21, 276:5, 326:5 legal 67:6, 67:7, 69:13 less 100:5, 100:8, 133:3, 155:11, 155:22, 156:11, 162:1, 162:8, 242:11, 250:2, 293:2, 338:7, 352:11, 352:12 let's 17:21, 40:13, 58:9, 66:11, 76:17, 81:10, 88:2, 88:3, 99:1, 109:16, 119:20, 137:7, 161:15, 161:19, 232:18, 235:20, 241:12, 250:13, 261:3, 274:18, 290:2, 292:19, 296:21, 303:22, 304:13, 327:3, 342:14, 355:16 level 40:17, 41:1, 56:5, 291:3 lexicographers 112:13 lexicography 179:4, 179:8, 179:11, 183:21, 185:4, 185:11 liberal 172:15 licensing 70:4	licht 12:16, 12:17 lieu 18:12 likely 53:1, 132:3, 260:20, 274:1, 279:12, 283:18 limit 189:9 limited 51:19, 112:7, 112:8, 253:12 limiting 184:20 line 76:17, 90:19, 107:19, 107:22, 108:1, 110:5, 113:19, 225:8, 304:13, 304:15, 305:18, 306:12, 307:8, 309:22, 313:5, 315:6, 316:9, 318:22, 321:14, 328:1, 330:6, 341:16, 347:11 lines 177:11, 305:7, 309:9, 311:18, 315:1, 326:20 liquid 188:4, 262:13 liquids 45:22, 347:12, 352:21 lisa 1:25, 2:9, 8:4, 356:2, 357:12 list 81:14, 112:18, 149:5, 149:6, 186:11, 187:18, 300:15 listed 69:5, 218:22, 260:14, 279:11,
L			
lab 35:6, 35:12, 36:1, 37:18, 37:20, 37:22, 38:8 label 252:15, 286:19, 288:7 labeled 203:16, 251:5, 263:15, 288:18 laboratory-scale 35:6 labs 58:22 lack 27:13 lako 5:19, 299:7,			

279:19, 319:11 literal 323:16, 326:20 literally 228:21 literature 291:21 litigation 11:21, 13:18, 13:20, 14:3, 157:1 little 19:4, 19:5, 19:8, 21:20, 31:21, 53:1, 64:9, 76:7, 95:22, 110:22, 203:18, 222:13, 321:13, 342:13 llp 3:11 local 168:6 locally 49:13 located 33:10, 356:17 location 125:6, 126:2 long 15:2, 21:1, 22:18, 34:8, 65:18, 93:17, 159:2, 327:11 long-felt 70:10 longer 327:12 look 11:14, 40:6, 109:16, 137:7, 151:20, 161:15, 177:9, 201:20, 203:9, 218:21, 219:8, 219:22, 243:3, 249:3, 250:13, 252:2, 252:14, 253:14,	261:3, 270:10, 272:2, 273:6, 274:18, 276:2, 290:3, 304:13, 311:7, 311:9, 320:22, 321:12, 327:3, 330:22, 341:10, 344:20, 344:21 looked 69:2, 294:10 looking 66:15, 94:9, 143:8, 202:12, 273:5, 280:17, 301:17, 306:11, 329:2, 330:5, 334:18 looks 22:17, 196:19, 197:20, 200:3, 280:22, 299:20, 331:16 loop 42:16, 42:18, 45:6, 48:17, 256:21 lose 198:8 loses 191:22 lost 98:8, 198:9 lot 12:7, 19:22, 23:2, 25:22, 33:19, 67:5, 93:14, 130:22, 167:17 lots 29:9, 100:12, 151:12, 225:21, 319:15 love 98:18 low 97:21, 109:20, 110:14, 342:16	low-carbon 137:11, 138:1 lower 25:8, 133:5, 133:7, 135:4, 192:2, 193:15, 276:2, 304:18, 339:16, 342:2 lumped 176:1, 315:20, 317:3 lumps 315:17, 316:3 lunch 10:10, 223:4 M made 46:19, 149:10, 149:11, 150:19, 150:20, 180:15, 317:11, 331:14, 343:11 main 106:16 mainly 328:2 maintain 162:10 major 146:11, 353:3 majority 126:10, 352:14 make 9:21, 32:18, 35:6, 50:15, 71:1, 84:10, 95:10, 97:21, 101:3, 118:3, 136:10, 137:1, 143:12, 148:18, 149:8, 149:19, 150:2, 150:17, 151:2, 152:14, 153:3, 153:8, 160:4, 162:1, 162:8, 163:9, 167:21, 173:20,	194:22, 201:8, 212:3, 223:7, 231:10, 241:10, 244:19, 254:6, 254:21, 276:19, 285:3, 318:11, 332:19, 344:14, 345:18, 346:15, 350:18, 354:5, 354:6 makes 112:1, 165:12, 222:9, 284:11, 285:20, 308:5 making 9:12, 22:4, 34:13, 101:3, 102:19, 141:16, 147:20, 150:11, 153:1, 194:17, 258:8, 289:1, 318:3 managed 104:5 manner 4:22, 167:12, 170:21, 171:14 many 31:22, 39:1, 62:17, 67:11, 81:6, 85:14, 87:18, 87:19, 90:6, 102:11, 106:12, 127:3, 127:22, 128:7, 160:13, 182:18, 194:21, 210:3, 211:4, 217:18, 237:10, 238:14, 239:19, 243:15, 265:3, 295:9, 311:7, 321:2, 340:10, 345:7 march 5:19, 294:22, 295:7, 295:14, 296:8, 299:8 mark 16:10
--	---	---	--

marked 5:2, 6:2, 15:17, 17:1, 17:4, 17:14, 197:4, 197:7, 198:5, 246:15, 246:16, 297:11, 297:12, 304:3, 304:5, 327:15, 327:16 market 168:18 marks 354:20 marriage 357:3 maryland 7:14 mass 26:13, 336:6, 336:8, 336:14 massive 152:3 master's 18:5, 18:8, 18:9, 21:2 match 178:18 material 14:11, 67:17 materials 23:1, 32:21, 67:17, 67:21, 68:10, 346:2, 349:14, 349:16 math 11:15, 148:8 matter 7:4, 11:17, 220:15, 223:9, 340:9, 357:6 matters 338:9, 340:2, 340:8 maximize 92:3 maybe 27:16, 35:16,	51:13, 118:19, 119:13, 119:14, 140:22, 163:10, 293:18, 303:16, 324:20, 354:8 mean 15:4, 25:19, 28:22, 29:22, 31:20, 31:21, 33:16, 36:7, 48:14, 51:4, 53:15, 55:6, 60:21, 63:20, 64:8, 68:17, 69:2, 82:1, 84:7, 86:21, 94:2, 98:18, 132:4, 132:18, 134:6, 137:17, 139:5, 149:13, 153:13, 161:22, 169:16, 181:17, 182:8, 189:17, 196:18, 225:20, 234:2, 235:9, 242:4, 245:5, 246:10, 254:5, 266:13, 267:17, 269:17, 270:7, 278:17, 282:11, 284:14, 285:18, 290:22, 291:20, 317:6, 318:17, 328:18, 335:17, 339:22, 340:7, 342:9, 345:14, 345:21, 347:10, 349:22 meaning 177:12, 178:1, 180:22, 182:12, 184:12, 184:16, 185:3, 188:1, 217:22, 218:1, 221:6, 222:1, 320:10 means 132:17, 175:4,	176:12, 176:18, 178:4, 179:16, 182:7, 185:14, 186:3, 225:11, 226:3, 233:12, 233:19, 234:10, 234:17, 267:19, 275:11, 305:15 meant 64:1, 87:16, 89:17, 277:2 measuring 58:14, 59:11 meat 30:21 mechanical 142:3, 188:17, 210:4, 210:5, 211:13, 212:10, 213:10, 216:2, 229:15, 318:4 mechanics 26:13 media 7:3 medium 93:13 meeting 250:10, 295:1, 295:8, 295:14, 296:8, 301:1, 301:13, 302:7, 302:11, 303:9, 303:17 members 14:18 membrane 24:9, 24:18, 25:4, 25:13 membranes 24:9, 24:15, 25:3, 129:21 mention 277:7, 304:22, 310:20, 312:8 mentioned 20:9, 24:4, 31:14, 32:9,	78:2, 78:8, 78:9, 86:16, 90:20, 103:16, 130:5, 134:20, 151:4, 190:12, 255:2, 270:3, 313:16, 323:17, 346:13 mentions 130:13 mentor 30:18 merck 18:15, 18:17, 20:10, 20:11, 32:10, 33:22 messed 150:5 met 128:22 methanated 290:20 methanation 44:9, 83:6, 83:12, 128:22, 129:8, 129:16, 129:18, 130:2, 131:14, 133:14, 342:6 methanator 157:7, 251:2, 251:5, 252:9, 252:12, 290:7, 290:16 methane 24:12, 31:6, 32:3, 35:20, 52:15, 54:4, 62:20, 63:10, 81:16, 84:15, 88:16, 100:12, 117:9, 121:18, 131:15, 131:19, 132:5, 133:13, 133:16, 135:4, 155:18, 155:21, 156:1, 157:8, 158:9, 164:3,
--	--	---	---

164:13, 164:21, 166:1, 167:3, 172:3, 172:22, 173:4, 226:7, 226:8, 226:16, 255:17, 256:5, 269:11, 270:8, 290:16, 328:4, 342:8, 343:16, 343:17, 343:19, 349:9, 349:13 methane-powered 314:10 methanization 342:17 methanol 24:12, 31:16, 31:17, 32:6, 37:20, 43:9, 43:14, 43:17, 43:18, 43:22, 44:2, 44:10, 44:14, 44:17, 44:18, 45:2, 45:11, 45:18, 46:11, 48:13, 48:19, 53:13, 54:2, 54:18, 139:9, 139:14, 140:5, 141:1, 143:13, 316:11, 316:13, 326:6, 341:6, 341:11, 341:22, 342:3, 344:5, 344:7, 344:16, 344:20, 348:18 method 76:20, 113:20, 347:1 methods 333:20 microelectronics 26:1 middle 206:22, 291:6, 309:20, 330:6 midland 20:5, 20:6,	20:7, 34:6 might 51:8, 85:19, 145:8, 223:21, 245:9, 253:11, 303:13 mina 5:15, 297:22 mind 116:20, 150:6, 262:16, 313:9 mine 316:1 mines 22:14, 22:21, 25:16, 26:6, 29:2, 29:17, 30:14 minimizing 242:13 minnesota 18:3, 33:9, 34:14 minor 53:2, 115:5, 115:8, 115:12, 256:7, 328:3, 335:3 minute 332:5 minutes 10:3, 293:2 miss 350:18 missing 108:3 misstates 104:8, 205:12 mit 18:6, 18:10, 21:9, 21:14, 22:8, 34:14 mitigate 103:12, 117:4, 117:21 mix 224:9, 288:4 mixed 99:11, 103:18,	133:1, 253:15, 255:10, 255:16, 269:7, 269:10, 276:7, 282:2 mixes 255:21 mixing 227:20, 252:16, 288:12, 329:1 mixture 24:17, 49:5, 52:16, 120:15, 131:19, 132:5, 155:21, 155:22, 254:13, 255:9, 278:13, 279:3, 279:12, 284:12, 285:4, 287:2, 287:3, 336:1 mixtures 23:13 model 58:14, 58:17, 59:11, 59:14, 59:16, 60:2, 61:21, 62:6, 80:22, 81:6, 109:11 models 81:6, 109:10 modern 28:21 modest 349:4 modifications 343:10, 344:15 modified 111:10 molecule 84:16, 343:19 molecules 84:17 moles 336:8, 338:10, 339:11, 340:3, 340:4, 340:10 moment 311:9	money 165:6 monitor 7:9 monoxide 342:18 more 19:8, 26:4, 34:3, 35:8, 35:11, 41:12, 50:16, 54:3, 56:17, 87:1, 100:4, 110:22, 119:7, 136:15, 155:17, 163:3, 163:4, 164:20, 165:5, 165:6, 167:2, 182:3, 188:13, 208:19, 210:6, 214:2, 221:16, 250:2, 253:7, 260:19, 284:11, 285:3, 336:1, 336:21, 339:10, 346:16, 348:4 morning 8:13 most 13:14, 17:19, 29:19, 84:14, 107:11, 118:20, 132:3, 137:2, 182:3, 183:9, 225:21, 230:6, 239:20, 242:15, 243:16, 270:4, 274:1, 283:18, 341:9 mostly 13:13, 14:6, 29:17, 117:8 motivated 170:20, 171:13 motivations 169:8 move 344:16
---	--	---	--

moving 292:13, 347:21 much 9:17, 11:12, 34:5, 44:7, 44:12, 66:18, 86:9, 87:1, 91:21, 92:14, 93:4, 98:4, 99:18, 101:10, 102:4, 117:18, 118:10, 130:13, 139:14, 155:17, 158:4, 159:3, 164:11, 180:12, 188:13, 192:2, 192:17, 193:19, 210:6, 213:9, 214:9, 214:16, 219:16, 238:2, 265:20, 317:7, 339:13, 340:9, 343:22, 346:16, 348:3, 355:13 multiple 20:1, 29:10, 50:14, 223:13, 287:17, 343:21 multitude 218:19 must 41:5, 122:3, 233:19, 234:9, 273:7 N name 8:14, 8:17, 248:16, 300:18, 327:20 names 219:13, 219:14 national 22:11, 58:21 ncra 357:13, 357:14, 357:15 near 265:21	necessarily 4:23, 39:15, 53:15, 53:21, 79:12, 105:16, 114:11, 114:15, 141:8, 141:9, 225:19, 257:22, 264:20, 312:6, 331:19, 337:19, 350:5 necessary 54:9, 109:19, 318:18, 348:5, 351:5, 351:6 need 10:4, 50:16, 61:7, 70:10, 121:17, 122:17, 125:22, 139:14, 150:2, 162:11, 164:11, 164:20, 167:2, 167:5, 181:4, 181:9, 191:12, 191:14, 192:18, 239:9, 254:21, 260:2, 319:9, 342:5, 342:6, 343:6, 343:11, 344:2, 345:12, 346:16, 348:8, 350:5, 350:7, 350:12, 351:6, 351:10 needed 64:5, 289:18, 352:7 needing 46:11 needs 122:9, 124:6, 126:5, 134:7, 169:13, 226:19, 226:20, 245:12 nervous 186:7 netherlands 299:22 never 38:6, 151:19	new 14:5, 75:4, 125:21, 126:1, 126:3, 126:20, 127:8, 127:16, 128:4, 129:8, 134:1, 134:5, 150:6, 243:13, 270:8, 311:14 next 126:8, 128:16, 175:2, 175:13, 176:10, 179:14, 252:22, 258:13, 258:16, 275:19, 285:15, 301:21, 329:4 nh3 129:3 nielsen 5:9, 248:15, 263:20, 296:17, 301:11 nitrogen 5:18, 100:12, 117:10, 129:1, 130:20, 131:20, 133:18, 252:16, 252:22, 253:21, 254:2, 254:15, 254:16, 254:19, 254:22, 255:9, 256:2, 256:9, 259:6, 269:11, 287:3, 299:14, 318:6, 328:3, 329:1, 335:3, 338:19, 339:21 nondefinitive 88:1 none 10:20, 70:13, 257:10 nonobviousness 69:14, 69:20 nope 294:12 normal 337:22, 338:6	normally 264:16, 355:12 notary 2:12, 356:3, 357:16 note 4:21, 41:10, 256:19, 305:6 noted 73:8, 355:19 notes 13:2 nothing 69:10, 126:20, 127:8, 127:16, 159:3, 208:19, 248:21, 250:2, 253:7, 256:20, 268:1, 281:10, 282:5, 287:7, 289:16, 308:8, 354:19 notice 2:9, 23:20 novel 243:5 november 293:18 nozzles 88:8 nsf-sponsored 22:11 nuclear 64:15, 108:15, 151:12, 151:17 number 28:10, 47:14, 97:20, 98:7, 102:5, 164:8, 193:5, 243:7, 343:14, 345:8 numbers 16:12, 16:17, 300:5, 347:7 O oak 3:5
---	---	---	--

oath 76:4, 223:5 objection 48:8, 96:15, 159:1, 214:21, 215:19, 222:2, 236:1, 244:15, 246:1, 344:11 objections 9:12, 167:4 objective 69:13, 69:19, 91:13, 165:16, 169:21, 187:15 obtained 302:18, 303:13 obvious 152:15, 153:10, 239:11, 240:11, 240:19, 244:10, 244:18 obviously 33:16, 48:18, 267:10, 347:10 occur 227:16 occurred 356:16 occurring 213:4 occurs 252:15 odd 264:6 oddly 324:21 odds 290:2 off-site 271:14 off-sites 36:19, 270:21 off-stream 257:8 offer 69:7, 352:20 offered 69:18	offers 353:8 office 1:1, 7:6 offices 356:16 offset 163:10 often 45:3, 50:13, 91:18, 135:12, 215:8, 305:16, 336:14, 337:13 oftentimes 43:15, 44:3, 86:11, 107:15 oh 17:3, 58:19, 119:22, 175:12, 177:16, 180:3, 197:18, 197:19, 204:13, 225:5, 270:12, 327:5, 341:1 okay 9:6, 10:6, 16:18, 17:17, 26:15, 32:9, 43:11, 61:9, 76:9, 78:2, 81:15, 91:4, 96:10, 104:16, 111:15, 120:5, 126:14, 131:11, 144:2, 149:21, 150:16, 171:7, 173:17, 173:22, 175:19, 181:14, 183:7, 185:12, 185:19, 186:2, 190:10, 198:10, 198:21, 199:5, 199:6, 199:18, 204:14, 204:19, 207:10, 208:8, 220:2, 221:13, 228:4, 230:11, 232:2, 236:6,	238:20, 241:5, 249:6, 249:11, 256:4, 262:18, 277:4, 283:11, 284:21, 293:2, 293:3, 295:5, 297:2, 298:4, 298:20, 300:8, 300:11, 306:5, 321:19, 322:4, 324:12, 324:16, 325:9, 327:7, 328:5, 328:11, 334:21, 334:22, 340:14, 353:17 omit 176:18 omitted 176:10, 176:14 once 171:3, 310:21 one 15:15, 15:20, 19:1, 19:5, 20:13, 21:5, 25:4, 25:8, 26:20, 31:4, 31:10, 33:16, 47:22, 49:2, 49:6, 53:14, 58:22, 62:16, 78:3, 81:6, 90:18, 116:20, 117:6, 119:16, 127:5, 127:22, 128:8, 129:18, 130:2, 146:19, 147:2, 147:7, 152:9, 160:9, 160:13, 182:17, 188:4, 188:5, 194:19, 195:15, 196:10, 197:20, 202:21, 203:4, 205:13, 211:2, 217:15, 221:15, 228:8, 228:12, 229:10, 229:18,	238:16, 238:18, 239:17, 242:19, 243:3, 243:15, 246:11, 248:4, 248:5, 250:10, 253:5, 274:2, 274:7, 278:8, 280:17, 287:8, 295:6, 295:9, 295:12, 307:12, 307:17, 307:19, 308:3, 308:16, 312:11, 324:6, 327:11, 327:12, 330:21, 332:2, 345:9, 345:14 one's 349:3 one-month 18:21 ones 26:3, 106:16 only 9:16, 10:7, 61:19, 85:4, 117:7, 157:14, 190:14, 192:18, 220:12, 238:21, 245:15, 245:16, 245:19, 245:20, 266:17, 287:10, 307:17, 307:19, 312:2, 312:8, 312:11, 313:16, 319:8, 319:10, 319:12, 319:20, 321:22, 322:20, 335:4, 340:21, 350:11 operate 49:3, 62:13, 64:6, 103:15, 117:20, 128:8, 166:2, 175:4, 176:11, 178:4, 179:15, 185:14, 186:3, 186:12, 186:17, 225:10,
--	---	--	--

226:3, 233:12, 233:19, 234:10, 234:17, 259:10, 270:4, 343:13, 343:14 operated 148:16, 192:16, 214:16, 335:10 operates 89:13, 89:20, 90:1, 117:15, 122:21, 193:1, 215:8 operating 33:22, 34:21, 35:19, 37:16, 38:3 operation 107:3, 132:7, 144:20, 186:19, 192:9, 205:3, 243:4, 246:11, 291:17, 349:3 operational 351:14 operations 26:18, 27:8, 28:4, 42:4, 42:12, 43:2, 43:5, 45:9, 52:8, 53:8, 81:21, 82:2, 128:4, 146:18, 147:17, 148:15, 181:21, 196:13, 202:18, 211:5, 211:10, 215:3, 243:12 operator 79:1 opex 165:2, 166:3, 166:8, 167:11, 260:7 opinion 171:4, 172:19, 189:16, 204:3, 206:4, 226:12	opinions 10:1, 61:5, 61:8, 69:7, 69:19, 75:3, 353:18, 354:4 opposed 68:4, 101:3, 117:12, 211:14 optimal 45:4, 45:10, 46:11, 46:20 optimization 28:7 optimization-type 28:11 optimize 50:1 optimum 45:1 option 113:14, 129:18, 129:20, 129:21, 129:22 optionally 133:1 options 182:18, 332:17 order 11:14, 45:10, 54:8, 62:13, 65:5, 128:3, 162:10, 162:17, 167:21, 169:14, 281:18, 355:13 ordered 355:5 ordering 243:12 orders 355:3 ordinary 40:17, 47:12, 49:16, 49:20, 54:6, 136:18, 182:12, 184:11, 184:16, 185:3, 189:3, 189:4, 348:16	org 299:1 orient 300:12 other 11:17, 13:6, 16:13, 19:8, 20:21, 25:13, 25:17, 25:18, 29:4, 34:2, 39:11, 39:16, 39:17, 43:5, 43:13, 51:1, 68:10, 68:21, 69:4, 82:21, 83:5, 83:6, 90:16, 91:18, 93:15, 93:20, 94:5, 97:9, 97:11, 99:11, 99:20, 102:5, 106:6, 131:20, 132:5, 137:5, 139:1, 139:11, 139:22, 140:15, 140:22, 141:1, 151:5, 151:8, 152:16, 153:11, 155:18, 165:8, 165:18, 168:12, 189:17, 189:21, 192:17, 194:21, 201:9, 201:22, 210:3, 211:4, 211:10, 215:15, 215:16, 224:12, 224:13, 238:15, 239:3, 244:2, 245:1, 245:6, 245:10, 248:22, 273:13, 275:9, 278:10, 281:21, 282:10, 302:18, 317:16, 317:17, 326:19, 351:15 others 23:4, 25:5, 60:3, 349:4	otherwise 357:5 out 19:14, 19:15, 19:16, 34:13, 39:8, 80:10, 90:16, 100:17, 103:9, 103:22, 131:9, 144:20, 146:13, 158:6, 167:3, 176:21, 192:1, 202:7, 228:16, 240:11, 246:11, 249:4, 259:7, 284:9, 309:15, 317:9, 343:9, 343:19 outcome 357:6 outlet 331:13 outlined 247:14 outside 14:15, 33:12, 108:4, 181:13, 184:6, 185:10, 244:22, 248:16, 267:11, 308:6 over 9:15, 9:16, 13:8, 21:5, 21:7, 55:6, 92:5, 210:8, 214:4, 216:4, 222:13 overall 165:9, 227:22 overlap 348:10 overlapping 102:12 own 55:15, 56:11, 112:13, 137:12, 138:10 owner 1:8, 3:10, 8:2,
--	---	--	---

15:18, 17:5, 176:6 owner's 6:6, 16:3, 175:22, 178:16 owners 180:4 oxidation 121:15, 316:14 oxidizers 224:9 oxygen 84:16, 84:17, 101:2, 102:8, 103:18, 117:21, 118:6, 118:13, 130:11, 231:14, 232:5, 259:5, 276:13, 291:11, 291:22, 292:7, 292:8, 335:4, 337:7, 337:9, 337:19, 337:22, 338:1, 338:3, 338:7, 338:10, 338:12, 338:16, 338:18, 338:20, 339:3, 339:4, 339:6, 339:11, 339:12, 340:3 oxygen-deficient 339:9 oxygen-enriched 120:14, 291:17 oxygenates 290:10 P pads 32:19 page 4:2, 4:7, 5:3, 6:3, 175:14, 250:14, 251:15, 261:3, 265:16, 266:3, 267:15, 268:2, 268:3, 270:10, 270:12,	272:16, 273:13, 274:10, 274:14, 274:18, 276:3, 277:22, 279:10, 280:18, 281:22, 282:8, 282:16, 282:17, 283:9, 284:11, 284:18, 284:19, 285:15, 286:2, 286:17, 287:22, 288:15, 288:18, 288:22, 290:3, 290:4, 290:5, 291:8, 292:7, 297:22, 298:15, 298:16, 300:1, 300:3, 300:5, 300:6, 300:9, 300:15, 300:17, 301:4, 301:5, 301:20, 329:20, 342:10 pages 1:24, 297:21 paid 11:12, 214:2 paired 195:21, 202:14, 209:19, 212:19 paper 5:16, 299:6, 299:13, 300:14, 321:13 paragraph 40:14, 40:15, 40:21, 55:10, 55:12, 55:14, 67:19, 67:20, 69:12, 119:21, 120:9, 126:7, 126:9, 128:17, 130:6, 130:9, 137:7, 138:19, 143:8, 159:8, 173:22, 175:3, 175:9, 175:11, 175:14, 175:15, 175:20, 178:10,	186:21, 188:9, 188:12, 188:22, 209:8, 225:2, 225:7, 247:5, 269:2, 269:15, 272:8, 272:10, 292:11, 293:8, 294:20, 309:1, 330:7, 334:19, 334:21, 337:18, 346:4 paragraphs 40:10 parameter 98:11, 98:16 parameters 102:6 part 28:9, 28:12, 30:3, 30:5, 37:21, 38:1, 38:7, 48:16, 48:22, 51:7, 51:8, 51:9, 113:13, 113:15, 114:5, 114:11, 114:19, 114:21, 115:5, 115:9, 128:18, 138:4, 141:21, 142:11, 186:18, 189:20, 194:17, 208:5, 210:20, 226:5, 226:6, 230:6, 231:7, 241:22, 242:14, 242:16, 243:4, 246:11, 252:5, 263:21, 264:7, 264:17, 265:6, 267:9, 267:12, 271:21, 305:17, 305:22, 307:7, 315:12, 322:3, 323:11, 341:16, 348:7, 351:18 partial 121:15	partially 256:16, 268:12, 268:13, 280:8 particular 42:12, 127:7, 272:21 particularly 304:16, 305:7, 307:4, 307:9, 308:21 parties 357:2, 357:4 partners 31:3 parts 109:12, 291:2, 313:11 party 356:12 pass 25:7, 354:18 passes 25:12, 97:12 past 32:14 patent's 125:10, 241:14 patentability 75:3 patents 12:11, 12:13, 13:14, 23:20, 68:8, 184:16, 346:1 pathways 47:15, 47:21 paul 33:11 pause 55:13, 120:4, 180:1, 304:1 pay 168:6 pct 329:20 peak 101:21, 104:4, 104:19
--	--	--	--

pedantic 149:14 pending 10:8, 11:20 people 14:13, 62:19, 84:14, 146:13, 146:16, 147:9, 169:2, 183:9, 190:22, 229:21, 239:20, 292:2, 341:10 percent 92:5, 98:7, 98:19, 99:1, 100:5, 100:6, 100:9, 118:19, 119:8, 119:14, 155:1, 155:6, 155:11, 161:20, 161:21, 162:1, 162:7, 162:8, 166:15, 214:1, 214:4, 221:3, 221:20, 266:10, 270:5, 270:8, 272:22, 273:1, 273:20, 273:21, 275:8, 275:10, 283:5, 283:6, 329:7, 337:9, 338:4, 338:6, 338:8, 338:18, 338:19, 339:3, 339:4, 352:12, 354:11, 354:12 percentage 338:12, 339:17 percentages 338:17 perfect 291:1 perfectly 293:5 perform 354:3 period 21:8	periodically 97:14 person 47:10, 47:12, 49:16, 49:20, 54:6, 136:18, 144:3, 146:19, 156:17, 189:4, 248:13, 282:7 personally 18:14, 67:12 perspective 115:15 pertains 170:15 pertinent 296:2, 296:5 petition 297:19 petitioner 1:5, 3:2, 7:21 petitions 12:8, 13:14, 68:6 ph 1:15, 2:1, 4:2, 6:5, 7:4, 8:8, 16:3, 21:12, 21:17, 354:22, 356:6, 356:16 pharmaceutical 18:15, 20:12 pharmaceuticals 20:22 phenomena 26:12 phone 3:8, 3:16 phrase 67:7 pick 50:3, 88:2, 144:22, 284:9 piece 195:22, 196:10, 196:19, 201:1, 228:5, 228:8, 229:18	pieces 147:4, 191:10, 197:2, 324:18 piggyback 85:22 pilot 35:14, 35:16 place 7:15, 87:10, 175:17, 242:1, 245:1, 307:20, 312:2, 312:12, 319:8, 319:10, 319:12, 319:20, 342:15, 345:10, 345:11, 355:2 places 34:3, 64:12, 93:15, 134:18, 175:18, 279:12, 311:7 plan 322:3 planet 7:12, 8:5, 170:7 plant's 166:1 plants 28:17, 58:10, 64:17, 72:6, 85:3, 85:9, 106:13, 125:5, 151:12, 151:20, 165:18, 169:3, 169:21, 261:8, 265:1, 265:3, 269:1, 285:1, 353:5 plasma 26:1 plausible 278:12, 279:2 played 271:20 please 7:17, 8:16, 36:9, 70:22,	113:5, 355:3 plenty 333:11 plus 55:21, 210:10, 314:11, 318:6 point 61:2, 65:10, 74:14, 75:13, 161:9, 161:11, 161:16, 199:3, 252:17, 265:8, 275:14, 281:7, 281:11, 285:7, 285:11, 299:11, 307:20, 308:1, 321:22 pointing 190:2 points 262:3, 262:22 poison 50:18, 290:10 pollutants 19:11, 167:16 polymer-coating 33:1 poorly 308:2, 325:10 popular 243:16 port 228:22 portion 118:16, 207:3, 207:7, 208:9, 269:15, 275:3, 275:4, 276:7, 276:11 posa 41:5, 42:5, 47:2, 47:17, 53:7, 54:11, 55:16, 55:19, 56:11, 62:11, 79:9, 92:20, 93:8, 93:19, 95:5, 95:14,
--	--	--	---

96:4, 96:14, 96:20, 99:5, 104:5, 104:14, 104:18, 105:12, 112:21, 113:7, 113:11, 115:16, 118:14, 124:14, 134:2, 137:1, 140:17, 142:7, 143:11, 143:13, 144:12, 144:14, 144:18, 145:2, 145:4, 145:7, 152:13, 153:2, 153:4, 153:7, 153:16, 156:14, 158:15, 158:18, 169:12, 170:19, 171:10, 171:12, 172:6, 180:22, 181:6, 181:16, 194:9, 195:11, 239:10, 245:20, 249:17, 269:20, 295:22, 308:10, 336:3, 341:4, 344:9, 344:14, 344:19, 348:11, 348:15 posa's 79:14, 239:8 posas 146:8 position 183:21, 194:9 positively 165:10 possibility 201:7, 291:21, 320:18 possible 49:3, 49:4, 91:21, 92:16, 93:5, 106:15, 145:8, 214:16, 259:20, 308:10, 308:15, 311:14 possibly 79:17, 101:16,	103:4, 152:10, 264:20, 344:1 post 3:5, 86:11, 111:13, 240:3 post-combustion 38:11, 38:14, 38:16, 266:18, 266:22 post-it 32:19 potential 5:8, 5:17, 83:19, 243:17, 243:20, 243:22, 247:9, 262:3, 262:21, 265:7, 265:17, 266:5, 299:14, 301:12 potentially 122:19, 135:13, 138:3, 139:1, 139:21, 192:15, 192:18, 245:11 power 36:21, 38:5, 38:6, 38:7, 62:1, 62:12, 63:11, 63:18, 63:21, 64:5, 64:11, 64:12, 64:13, 64:16, 66:2, 85:3, 106:19, 107:7, 108:12, 110:13, 140:11, 143:12, 149:10, 150:20, 152:15, 153:9, 200:12, 200:21, 201:9, 201:17, 211:12, 218:5, 220:4, 221:4, 221:21, 228:16, 245:7, 245:8, 257:17, 268:22, 275:21, 289:8, 310:1, 310:6, 310:10, 310:15,	311:4, 311:17, 311:20, 311:21, 312:1, 312:12, 312:13, 312:15, 312:22, 313:15, 313:20, 314:1, 315:14, 315:18, 316:15, 317:1, 317:16, 317:18, 317:19, 318:15, 318:18, 319:3, 319:7, 319:9, 321:8, 322:1, 322:2, 322:16, 322:18, 323:3, 323:5, 323:15, 324:1, 326:3, 330:11, 332:7, 332:9, 332:17, 333:7, 333:18, 333:21, 345:18 powered 82:11, 82:18, 84:1 powering 220:9 powerpoint 5:6, 268:18, 284:16, 285:7 ppm 291:3 practice 18:10, 18:11, 92:20, 96:8, 96:13, 123:19 praise 70:6 pre 120:12 pre-formed 305:5 precedes 42:16, 280:12 precise 293:13 precombustion 38:11, 39:4, 39:5, 39:21,	267:4 precursor 19:3 predating 158:7 predominant 60:11 predominantly 24:8, 73:18, 256:3 preferentially 25:12, 97:11 preferred 305:7, 306:20, 307:2, 307:4, 308:21 preheat 88:16, 88:18, 124:17 preheated 120:10, 122:3, 122:14 preheater 88:3, 88:7, 88:12, 112:16, 120:22, 124:12, 125:17, 126:16, 166:13, 174:4, 178:2, 232:22, 238:22, 239:11, 240:12, 244:12, 245:17 preheating 81:19, 106:5, 122:9, 122:17, 124:6 preliminary 293:16 premises 153:14 premixed 102:8, 119:13, 224:11, 330:3 preparation 13:11, 76:14, 247:2 prepare 12:6, 14:14
---	--	---	---

prepared 15:3 preparing 58:2 prereformed 304:19, 307:16 prereformer 120:12, 121:10, 122:7, 122:8, 122:14, 124:13, 124:18, 126:1, 126:3, 126:6, 126:16, 238:8, 238:22, 242:5, 242:10, 244:12, 250:22, 251:18, 286:4, 286:13, 305:2, 305:10, 306:15, 307:6, 307:13, 307:22, 308:11 prereformers 41:18, 159:18 prereforming 43:3 presence 251:16 present 3:18, 23:8, 335:4 presentation 5:10, 202:13, 246:20, 247:19, 248:19, 248:22, 249:1, 249:9, 249:18, 253:6, 267:18, 268:6, 272:12, 274:3, 274:6, 274:8, 274:16, 277:11, 278:22, 279:21, 281:11, 282:6, 283:21, 284:6, 284:8, 284:9, 287:8, 287:19, 312:10 presentations 302:18, 303:9	presented 248:1, 248:8, 250:5, 250:9, 296:11, 296:15, 296:17 presenting 70:1, 248:4, 253:10, 265:5 pressure 24:21, 25:1, 25:7, 25:9, 25:10, 97:2, 129:18, 188:16, 192:2 pressures 349:4 pressurized 191:21 presumably 169:3, 202:7, 264:5 presume 200:22, 272:5 presuming 153:4 pretend 168:13 pretreatment 308:4 pretty 130:13, 222:17 prevent 103:8 previous 307:11, 332:3 previously 5:2, 6:2, 15:17, 17:4, 17:14, 246:15, 246:16, 297:12, 304:5, 327:16 price 12:20, 168:18, 346:6, 346:7, 346:9, 346:13, 347:21, 350:11, 351:17, 352:5 primarily 23:7, 26:10,	29:1, 53:3, 115:7, 120:15, 133:16, 137:18, 154:19, 191:22, 215:18, 215:22, 256:8, 271:5, 329:11, 335:3 primary 52:4, 62:21, 68:8, 71:20, 72:2, 80:9, 84:15, 93:16, 218:13, 305:1, 305:19, 306:2, 306:4, 307:21, 308:12 principal 187:15 principally 186:17 principle 62:19 printed 303:14 prior 10:22, 11:17, 13:20, 13:21, 14:5, 37:8, 39:8, 65:1, 65:4, 71:18, 77:1, 99:7, 105:20, 114:1, 119:3, 125:4, 125:7, 125:22, 126:21, 126:22, 127:8, 128:11, 128:14, 129:13, 134:15, 135:9, 138:21, 139:16, 139:20, 142:7, 153:21, 154:2, 158:3, 158:19, 170:22, 171:15, 172:6, 233:7, 269:13, 294:18, 308:9, 326:19 pro 28:20	probably 9:9, 10:10, 11:13, 15:8, 26:9, 30:7, 32:1, 52:13, 68:11, 79:11, 99:10, 131:19, 136:15, 147:8, 151:5, 168:12, 197:19, 222:16, 239:20, 242:14, 256:1, 290:22, 293:17, 293:21, 321:4, 327:12, 327:19, 331:6, 344:19, 348:18 problem 19:4, 19:13, 19:17 problems 105:11, 105:16 proceed 8:7 proceeding 74:2 proceedings 295:17, 303:13 proceeds 128:21, 227:21 process-fired 148:19, 149:9 process-flow 14:6, 157:4, 158:6, 196:16, 196:21, 196:22, 267:8, 276:11, 324:22 processed 212:8, 259:6 processes 23:1, 23:4, 31:13, 33:1, 36:1, 43:14, 43:15, 45:22, 46:14, 46:16, 47:19, 48:21, 49:10, 49:12, 49:21, 50:21,
---	--	--	---

53:9, 53:12, 53:17, 54:3, 54:9, 56:7, 56:22, 57:9, 60:4, 64:3, 76:21, 77:10, 77:14, 81:8, 83:5, 83:7, 86:12, 91:18, 94:6, 94:11, 107:12, 113:21, 115:21, 127:22, 138:21, 139:12, 140:6, 140:22, 141:1, 201:10, 281:9, 344:15, 348:15, 349:17, 350:15, 352:22, 353:5 processing 24:5, 26:1, 38:8, 324:6 procurement 145:16 produce 24:13, 49:14, 57:10, 65:13, 65:18, 84:16, 84:18, 109:18, 138:22, 139:12, 141:12, 141:18, 142:12, 200:13, 212:10, 218:18, 310:15, 314:1, 318:18, 334:11, 348:3, 348:4, 349:13 produced 19:2, 63:15, 78:19, 156:18, 216:18, 312:3, 320:6, 320:10, 320:14, 322:19 produces 89:1, 97:16, 120:17, 200:9, 216:12, 216:22, 217:17, 273:6,	314:14, 323:18, 331:3 producing 310:6, 310:10, 310:13, 312:21, 313:20, 313:22, 317:15, 319:4, 323:15 product 78:4, 79:22, 80:4, 80:14, 97:17, 109:6, 129:3, 257:20 production 20:22, 24:10, 31:18, 41:6, 42:15, 43:6, 43:9, 50:13, 53:9, 54:17, 54:18, 55:22, 56:6, 56:19, 57:3, 60:19, 62:13, 62:22, 63:17, 69:4, 140:5, 256:18, 258:6, 275:21, 295:19, 300:21, 302:6, 311:17, 316:18, 341:12, 341:13, 342:3, 342:20, 344:17 products 46:19, 91:22, 314:9, 316:14 professional 17:22, 33:4 professor 22:8, 22:9, 22:13, 186:6 professors 22:10 profitable 136:17 program 18:8, 18:10, 21:2, 21:17, 29:9 programs 33:18	progress 224:16, 224:19 project 20:21, 22:11, 23:17, 24:13, 30:3, 30:8, 94:3, 169:15 project's 162:21, 165:3 projects 18:16, 18:21, 20:13, 21:5, 21:7, 25:21, 30:10, 31:2, 167:22 prominent 242:15 pronounce 299:7 proper 67:7 proportions 288:12 proposal 74:17, 308:19 proposed 74:1, 74:8, 74:10, 75:4 prospects 295:18 protective 20:16 prove 199:3 provide 10:18, 54:8, 55:15, 60:2, 64:2, 76:20, 113:20, 149:15, 152:6, 161:3, 185:22, 188:5, 288:7 provided 13:4, 14:4, 14:5, 64:13, 67:5, 67:18, 69:12, 75:1, 127:12, 149:3,	149:9, 151:2, 157:4, 157:15, 208:21, 210:16, 258:2 provides 243:6 providing 213:5 psa 97:16, 98:4, 98:12, 99:2, 99:5, 99:17, 99:19, 100:12, 134:21, 153:20, 154:7, 154:13, 154:22, 171:20 public 2:12, 356:4 publication 296:18 published 299:10, 303:14 pulled 197:10, 219:3 pulling 176:21 pumps 64:6, 107:3, 107:5, 107:11, 115:11, 259:10, 259:17, 260:2 punch 347:11 pure 131:9, 142:15, 155:22, 291:11, 292:7, 292:8 purged 134:7, 134:10 purification 23:9, 24:15, 41:7, 41:15, 97:3, 343:7 purified 98:8 purify 49:7, 350:12 purifying 100:14, 131:2
---	--	--	---

purity 80:6, 97:22, 100:16, 100:17 purpose 88:7, 185:11, 201:22, 218:13, 220:14, 221:3, 221:20, 256:13, 262:2, 290:8 purposes 24:19, 62:7, 78:3, 132:13, 174:12, 174:14, 180:13, 265:4 pursuant 2:9 pursued 73:18 pursuing 70:17, 71:7, 72:21, 73:13 put 32:20, 45:16, 109:11, 116:20, 206:14, 295:4, 303:20, 351:7 puts 19:16 putting 19:15 Q qualification 80:9 qualifications 67:4 qualified 84:3 qualify 78:4 qualifying 78:22 quality 44:7, 44:13, 135:4, 135:20, 342:2, 345:11 quantified 81:1	quantify 81:7 quantitatively 106:22 question 10:8, 33:14, 37:2, 42:9, 46:8, 47:7, 56:10, 63:3, 71:2, 71:5, 71:15, 89:15, 89:17, 89:18, 90:22, 91:6, 95:9, 95:22, 96:11, 96:16, 102:3, 111:7, 112:20, 113:4, 135:19, 137:16, 149:17, 150:5, 150:7, 152:22, 155:20, 158:22, 159:5, 163:6, 165:17, 168:11, 173:8, 174:16, 181:4, 207:15, 217:5, 220:14, 220:17, 220:19, 221:10, 221:12, 235:20, 236:1, 236:4, 240:18, 241:4, 241:7, 244:9, 244:15, 244:20, 246:6, 252:19, 252:22, 262:15, 262:16, 293:11, 306:6, 309:18, 309:20, 313:10, 324:7, 324:15, 325:11, 329:5, 329:22, 332:20 questions 9:11, 9:19, 10:14, 31:5, 61:20, 90:18, 90:20, 163:7, 199:2, 199:3, 238:1, 297:20,	332:10, 340:20, 353:17, 354:18 quick 340:16 quite 18:22, 43:16, 53:12, 305:16, 334:20 quotations 4:21 quote 4:24, 225:3, 225:8, 278:14, 278:18 R r-y-t-t-e-r 304:10 radiant 85:11, 86:17, 86:19, 87:4, 87:7, 87:8, 87:9, 90:21, 194:3 raise 139:21, 140:11, 187:21, 192:12 ran 32:19, 293:9 random 94:4, 94:8 randomly 219:3 range 85:19, 193:4, 338:4, 347:10, 347:18 ranged 30:19 rate 11:9, 164:12 rate-limiting 139:11 rated 118:19, 119:7 rates 168:7, 326:15 ratio 44:18, 45:4,	45:10, 46:12, 46:20, 47:3, 47:11, 48:20, 49:2, 102:6, 319:2, 336:4, 336:10, 347:2, 347:12, 347:16, 347:22, 348:5, 351:11, 352:8 ratios 336:14 raw 349:13, 349:16 rd 7:8 rdr 1:25 re-ask 37:2, 324:9 reach 354:4 reactant 46:20 reaction 44:4, 51:15, 51:16, 52:9, 84:11, 84:19, 100:20, 101:1, 116:8, 116:10, 116:11, 118:10, 121:15, 212:21, 213:2, 226:17, 226:21, 227:19, 227:22, 338:11 reactor 26:11, 31:8, 120:16, 126:17, 129:4, 159:19, 173:2, 212:13, 251:1, 316:12, 326:7, 339:11, 342:6, 349:21 reactors 24:10, 50:14, 343:22, 349:2, 350:2 reacts 84:16
--	--	--	--

read 4:22, 68:1, 68:5, 68:11, 113:18, 175:3, 177:18, 178:19, 249:7, 249:18, 293:15, 298:8, 298:22, 299:1, 305:17, 309:17, 312:5, 321:2 reading 175:19, 299:19, 311:18, 313:2, 313:21, 317:17, 318:20, 323:14, 333:13, 356:20 reagent 139:11 real 253:6 really 9:14, 14:15, 31:1, 49:12, 54:3, 59:13, 73:1, 83:15, 100:15, 117:17, 136:3, 153:17, 157:11, 157:14, 158:11, 168:4, 170:1, 173:15, 179:12, 194:16, 215:1, 228:5, 240:21, 261:1, 268:1, 273:4, 303:16, 317:7, 340:2 realtime 2:10, 2:11, 356:3, 357:13, 357:15 reasking 313:9 reason 61:19, 185:2, 220:12, 280:13, 326:8 reasonable 282:6	reasons 10:17, 205:13, 344:22, 345:15 rebutting 189:15 recall 59:8, 67:13, 94:10, 95:1, 199:9, 225:13, 231:19, 332:10 receive 79:2 recess 75:19, 143:3, 222:21, 297:6 recognize 17:7, 246:21, 296:1, 297:15 recommendations 137:2 recommended 342:12 record 4:23, 8:17, 9:12, 10:1, 10:9, 16:20, 37:4, 59:3, 75:17, 75:21, 89:19, 143:1, 143:5, 183:20, 222:20, 223:1, 223:8, 241:11, 297:4, 297:8, 304:12, 354:22, 355:2, 356:10, 356:22 recover 195:12, 195:16, 213:17, 214:1, 214:9, 214:16, 216:5 recovered 98:4, 99:1 recovering 205:6, 213:21 recovery 98:12, 130:17, 131:10, 154:7,	171:21, 190:4, 190:15, 191:1, 208:16, 216:16, 230:21 recycle 133:21, 136:20 recycled 131:6, 131:8, 134:14, 340:3, 354:10 recycling 131:2, 137:11 redefined 275:19 redesigned 19:1, 19:6 reduce 77:5, 77:8, 108:22, 143:15, 152:17, 153:11, 239:9, 241:20, 246:13, 254:8, 256:14, 257:13, 268:13, 270:21, 285:15 reduced 57:22, 58:7, 76:22, 108:5, 108:18, 109:1, 113:22, 244:3, 265:21 reduces 242:5, 242:20 reducing 77:12, 77:18, 78:3, 113:15, 167:12, 240:12, 241:14, 242:21, 243:7, 245:20, 247:15, 256:17, 267:20, 268:18, 268:22, 271:21, 311:16 reduction 5:8, 56:6, 56:22, 58:10, 70:17, 71:7, 71:17, 247:9,	256:12, 265:17, 266:4, 284:15, 285:6, 295:18, 296:1, 301:12, 341:4, 351:21, 352:2 reductions 73:14 reexamination 74:22, 111:10, 111:14 reexamined 74:4 ref 275:3, 275:4, 275:5, 275:11 refer 36:6, 37:9, 42:11, 272:12, 300:7 reference 300:9, 300:17, 301:22, 302:1, 302:3, 304:3, 304:8, 307:18, 317:3, 327:4, 327:8, 329:15, 341:6 referenced 301:21, 315:1 references 15:11, 17:18, 69:3, 69:4, 300:15 referencing 283:14 referred 133:22 referring 36:20, 57:4, 74:15, 119:3, 138:7, 138:11, 190:3, 190:7, 190:8, 242:7, 255:20, 275:7 refers 279:21, 314:4 refines 19:2
--	--	---	--

refining 152:3 reflected 4:22 reflects 56:5 reform 39:6 reformed 39:14 reformer 44:5, 66:1, 120:13, 121:19, 144:22, 157:8, 157:19, 158:9, 172:3, 173:1, 173:4, 174:4, 178:2, 226:7, 226:8, 232:22, 242:12, 245:7, 250:22, 261:13, 263:4, 266:9, 273:19, 275:5, 277:18, 278:2, 278:9, 286:14, 304:17, 305:1, 305:9, 305:19, 306:15, 306:16, 307:5, 307:6, 307:14, 307:21, 308:12, 316:11, 343:15, 351:8 reformer-based 273:2 reformers 45:17, 106:4, 166:13, 276:6 reforming 24:12, 30:20, 31:6, 31:11, 32:3, 32:7, 35:21, 37:20, 41:7, 41:15, 41:16, 43:3, 43:14, 45:8, 49:4, 52:15, 52:19, 53:3, 54:4, 54:11,	54:13, 57:8, 81:16, 113:16, 115:7, 115:13, 121:13, 127:4, 127:22, 128:8, 160:13, 226:16, 242:14, 242:15, 258:6, 305:8, 306:20, 307:4, 308:5, 308:6, 343:16, 346:16, 347:1, 349:9, 349:13, 350:7 refrigerant 80:7 regard 67:3, 256:17 regarding 75:3, 163:15 regardless 66:7, 222:7, 338:1 regenerate 97:14 registered 2:10, 356:2, 357:14 regulated 59:5 regulation 85:5 regulations 135:22 reiterated 14:16 rejected 25:14 relate 112:4, 258:20, 284:15, 289:4, 312:6 related 12:11, 12:13, 281:8, 281:9, 357:1 relates 258:21, 273:22, 319:6, 325:11	relating 62:10, 62:12, 257:17 relationship 12:4, 289:2 relative 25:5, 337:21, 338:8, 354:13 relatively 187:3, 209:10, 219:20, 309:3, 351:20 release 20:17, 195:3 releases 156:11 relevant 216:21, 217:10 rely 349:12 relying 137:12 remainder 128:20 remaining 25:9, 231:14, 232:5 remember 20:20, 34:12, 61:16, 94:16, 153:22, 155:2, 155:4, 238:3, 293:22 remind 76:3, 223:4 removal 38:11, 38:12, 38:15, 38:17, 39:4, 39:22, 42:2, 43:4, 54:5, 126:10, 126:17, 129:17, 159:19, 166:14, 173:2, 238:10, 240:5, 240:7, 251:2, 262:12, 263:6, 263:9, 266:18, 267:5,	290:14, 324:3, 325:14, 325:19, 352:6 remove 44:9, 128:22, 129:13, 130:2, 266:8, 267:3, 351:10, 351:15 removed 133:13, 213:10, 266:10, 290:14, 290:21 removes 25:4 removing 266:14, 346:10, 347:22, 352:6, 352:11, 352:13 rendering 4:9, 4:11, 4:13, 4:15 renderings 198:11 renewable 108:16, 168:7, 258:2 renewables 64:13 renewal 151:11 repeat 95:9, 177:21, 217:3 repeating 174:7, 177:11 rephrase 68:16, 220:21, 221:15, 236:7, 241:7 replace 100:18, 244:7, 285:20 report 13:1, 174:1, 175:15, 186:22 reported 1:25 reporter 2:10, 2:11,
--	---	---	---

8:4, 9:13, 356:1, 356:3, 357:13, 357:14 represent 7:19, 7:21, 8:2, 157:3, 170:10, 219:2, 298:21, 339:6 represented 356:13 representing 7:12, 8:4, 8:14, 66:19 requested 356:21 require 44:7, 46:17, 101:12, 147:22, 148:4, 150:12, 164:14, 213:16 required 28:9, 115:11, 115:12, 124:2, 124:3, 138:16, 139:13, 148:17, 150:17, 151:1, 164:15, 336:21, 344:5, 346:14 requirement 107:8, 107:11, 187:10, 235:2, 235:7, 236:11, 236:15, 237:17 requirements 43:17, 43:18, 43:22, 106:19, 269:19, 319:2, 341:11, 341:13, 341:21, 345:1 requires 44:8, 110:12, 110:13, 128:21, 149:20, 242:11, 322:19 research 18:7, 18:13, 21:16, 22:20, 25:17, 33:11,	33:20, 34:4, 67:16, 105:4, 119:18, 293:16 researcher 303:7 residual 129:1, 136:7, 213:14, 216:3, 290:9, 290:15, 291:2, 342:18 resource 60:3 resources 49:13 respect 14:11, 46:11, 49:1, 67:6, 74:3, 77:9, 77:19, 81:1, 84:4, 161:16, 266:20, 311:4, 328:13, 352:3 respectfully 270:1 respectively 316:15 respond 111:8 responding 189:12 response 6:6, 16:4, 69:8 rest 66:9, 270:7 restate 46:8, 70:22, 111:6, 113:4, 140:2, 152:18, 152:22, 171:8, 216:10, 332:19 restrictions 296:12 restroom 10:4 result 285:5 resulting 128:18	retained 11:22, 12:2, 13:16 returned 294:21, 295:3, 295:10 revamp 20:19 review 13:6, 13:10 reviewed 13:19, 68:14, 76:13, 108:2, 156:21, 177:8, 202:13, 247:1, 248:21, 311:11, 311:13, 316:4, 316:7 reviewing 12:8, 67:16 rich 102:7, 132:14, 338:16, 339:15 ritter 189:13, 190:2 ritter's 12:9, 13:7, 40:22, 41:4, 68:6, 68:7, 184:6, 184:10, 249:7, 293:15, 298:6, 298:9, 298:11 road 33:4 rockville 7:14 rotate 228:18 rough 355:5, 355:17 round 226:13 routed 128:19 row 109:16, 317:15 rsa 1:25	rules 9:7 run 62:1, 90:10, 115:3, 117:8, 166:12, 214:5, 259:16, 293:12, 342:10 running 136:16 rush 355:5 rytter 5:11, 12:13, 304:8, 307:18, 309:9, 317:2, 318:15, 323:21, 327:11, 332:6, 333:14, 341:6, 341:15, 344:20, 345:3, 345:8, 345:16 S s 172:13 sa 1:7 safely 254:6 said 10:21, 13:16, 15:15, 18:17, 21:1, 32:11, 50:6, 55:4, 76:13, 90:3, 91:17, 114:15, 133:15, 138:15, 139:17, 156:21, 160:12, 163:18, 165:5, 181:6, 183:10, 209:9, 212:2, 216:1, 218:17, 219:18, 227:4, 234:1, 236:16, 236:18, 237:2, 238:14, 247:1, 250:11,
---	---	--	--

253:11, 253:18, 267:11, 269:10, 275:8, 276:22, 277:1, 281:21, 283:22, 287:17, 307:2, 309:2, 317:2, 319:18, 331:22, 332:12, 343:14, 344:10, 348:3, 350:19, 356:21 salicylic 19:2 same 66:3, 66:7, 100:20, 115:18, 116:11, 122:8, 125:6, 138:13, 160:6, 160:8, 164:13, 164:19, 167:4, 167:6, 170:21, 171:14, 172:18, 173:4, 204:2, 222:2, 227:15, 227:20, 227:22, 244:15, 246:1, 251:3, 252:7, 252:18, 268:5, 288:17, 291:5, 305:11, 315:18, 315:21, 316:3, 326:10, 326:14 san 34:12, 34:14 sasol 352:18, 353:3, 353:8 saturated 331:14 save 298:16 saw 234:16, 311:12 say 9:14, 12:12, 13:13, 15:3, 22:20, 34:3,	34:8, 35:3, 35:10, 35:11, 43:16, 43:17, 45:20, 53:22, 57:2, 60:13, 66:18, 67:15, 67:20, 73:6, 86:3, 87:15, 88:3, 91:12, 99:1, 115:8, 119:2, 123:11, 132:13, 132:14, 136:16, 138:9, 161:19, 171:20, 178:9, 183:9, 185:16, 186:5, 186:7, 189:18, 207:16, 207:22, 208:12, 214:18, 215:1, 219:15, 234:14, 240:2, 242:10, 246:9, 272:10, 277:7, 277:12, 282:11, 283:15, 283:17, 286:15, 292:22, 305:4, 306:2, 306:3, 307:3, 307:15, 308:7, 308:18, 312:22, 335:12, 341:16, 345:3, 347:19 saying 51:13, 109:17, 118:14, 125:4, 141:6, 142:6, 149:14, 154:13, 171:10, 178:8, 181:5, 183:12, 199:11, 199:15, 209:15, 240:19, 240:22, 241:2, 244:17, 273:20, 274:9, 306:11, 308:6, 309:15, 318:8, 320:5, 335:22, 339:2, 348:21	says 21:11, 41:11, 56:3, 76:19, 77:18, 108:3, 112:14, 122:12, 124:2, 184:5, 239:8, 247:18, 280:4, 284:1, 285:11, 300:8, 304:16, 305:19, 306:16, 306:19, 307:8, 308:8, 311:8, 318:17, 328:1, 329:19, 329:21, 330:19, 331:11, 341:19, 342:1, 342:4, 342:9, 343:3 scale 35:12, 36:1, 36:2, 36:3, 37:18, 37:22, 162:12 schematic 4:8, 4:9, 4:11, 4:13, 4:15, 232:15 schematics 198:11 scheme 127:17, 308:11 school 18:10, 18:11, 22:14, 22:21, 25:16, 26:6, 29:2, 29:17, 30:14 science 18:2, 22:11, 55:20 scope 54:22, 55:4, 60:21, 61:3, 61:7, 62:3, 62:17, 111:3, 111:19, 112:22, 113:8, 163:2, 165:14, 166:6,	166:20, 167:15, 168:3, 168:20, 169:5, 169:19, 170:14, 171:2, 171:17, 194:14, 203:6, 239:13, 249:22, 302:15, 302:21, 303:11, 336:16, 337:3, 337:11, 345:21, 353:2, 353:14 scores 67:14 scratch 188:11, 191:15 screwed 262:15 scrubber 38:20 scrubbing 266:15, 285:16 se 301:10 search 294:5, 295:10, 321:12 searched 294:21, 303:8 searches 293:10, 293:12 second 23:19, 55:12, 58:11, 110:4, 126:8, 179:10, 234:15, 266:8, 266:20, 310:10, 324:6 secondary 200:12 secondly 188:18 section 40:15, 40:16, 85:12, 86:17, 86:19, 87:4, 87:7, 87:9, 87:13, 87:16, 87:21, 88:22,
--	---	---	--

90:4, 90:5, 90:6, 90:21, 109:17, 113:16, 194:3, 214:19, 215:8 see 18:1, 40:19, 41:2, 55:17, 56:8, 69:15, 69:17, 77:2, 106:11, 108:7, 110:2, 110:9, 120:19, 126:12, 129:5, 137:14, 139:3, 175:8, 187:7, 188:19, 189:7, 197:18, 203:13, 232:14, 247:11, 251:6, 261:10, 261:15, 261:21, 265:18, 266:1, 266:2, 266:6, 266:11, 269:21, 270:17, 271:2, 272:14, 275:1, 276:8, 276:14, 291:5, 291:12, 295:20, 299:16, 299:17, 300:18, 301:2, 301:14, 302:4, 302:8, 303:22, 304:20, 310:2, 310:7, 317:16, 317:18, 321:1, 321:7, 328:9, 330:13, 335:6, 342:14 seeing 173:12, 173:14 seems 10:11, 24:1, 258:8, 277:6, 331:14 seen 14:9, 14:10, 14:11, 65:1, 151:15, 173:12,	326:18, 334:14 segment 292:20 segregate 246:10 selected 346:1, 346:2 selection 241:21 selectively 25:4 self-consistent 286:20 send 340:10, 350:10 senior 27:21, 92:9 senior-level 27:22 seniors 27:16 sense 40:3, 59:15, 85:10, 85:18, 89:12, 98:3, 98:6, 99:16, 106:18, 192:4, 233:17, 284:11, 285:3 sensitivity 257:19 sent 278:10 sentence 120:8, 126:8, 128:16, 128:17, 175:2, 175:13, 176:10, 176:14, 179:9, 179:10, 179:14, 188:10, 188:21, 225:10, 225:13, 234:15, 335:9 sentences 126:15, 176:5 separate 29:18, 181:11, 203:21, 289:8,	305:12, 331:20, 351:6 separated 324:2 separately 250:5, 314:14 separation 25:3, 129:2, 129:20, 129:22, 130:12, 291:1, 351:4 sequester 271:17 sequestered 78:20, 262:13 sequestration 71:22, 73:19, 263:12, 271:14 series 293:9 set 147:9, 294:22, 295:7, 356:7, 357:7 set-of-ways 281:4 sets 300:4 several 14:17 sheet 126:14, 126:21, 127:7, 127:15, 129:9, 159:6, 159:13, 243:11, 244:10, 250:17, 250:19, 252:3, 298:15, 329:2 shf 120:16 shift 31:11, 41:7, 41:15, 41:22, 43:4, 44:4, 49:5, 50:4, 50:7, 50:12, 50:14, 50:22, 51:7, 51:15,	51:19, 52:9, 52:14, 54:4, 54:13, 57:9, 120:16, 126:17, 159:19, 166:14, 173:1, 238:9, 251:1, 342:5, 342:17, 343:22, 347:1, 349:20, 350:2, 350:5, 350:7, 350:10 shifts 49:5 shock 158:19 shorthand 356:1 should 28:14, 76:11, 77:20, 174:2, 174:12, 176:6, 183:21, 184:11, 184:15, 290:13, 303:22, 304:2, 326:11 show 74:16, 158:7, 204:5, 204:8, 204:17, 205:9, 205:14, 219:6, 262:2, 264:3, 278:7, 283:14, 288:11, 288:16, 326:19, 332:14 showed 172:21, 175:17, 281:2, 281:3 showing 220:12 shown 206:15, 239:7, 241:22, 267:8, 288:21, 292:6 shows 203:11, 250:16, 251:4, 261:12, 261:13, 261:18, 262:7, 263:3,
---	---	---	---

263:5, 272:3, 274:21, 275:3, 276:6, 276:12, 292:7, 292:8, 298:17, 317:7 side 90:16, 159:21, 189:14, 264:7 siemens 199:8 signature-plkal 357:10 significant 44:11, 80:18, 117:10, 139:8, 162:20, 165:2, 314:13, 335:10, 343:6, 351:21, 352:2, 352:7 significantly 117:8, 193:15 signing 356:21 similar 24:20, 31:22, 32:2, 45:20, 134:12, 134:22, 193:10, 250:19, 250:21, 251:11, 328:12, 344:15 simple 187:4, 209:10, 210:9, 219:18, 219:21, 219:22, 309:3 simplified 178:8 simply 165:19, 174:7, 205:5, 215:4, 222:4, 306:19 simulating 28:17 simulations 354:4 since 15:5, 22:16, 25:16, 75:5,	93:11, 274:2, 348:8 single 195:22, 243:3, 249:20 sir 76:2 sit 321:12 site 135:22 sites 36:6, 37:9 sitting 264:6 situation 98:1 six 27:8 six-week 27:7 size 35:9, 137:3, 166:7 sized 167:22 skill 40:18, 41:1, 47:13, 49:16, 49:20, 54:7, 56:4, 136:19, 144:3, 189:4 slack 32:19 slide 247:9, 247:14, 248:5, 249:18, 251:14, 253:7, 256:11, 261:5, 262:2, 263:19, 264:22, 265:17, 266:3, 266:4, 267:15, 268:2, 270:14, 270:16, 272:6, 273:6, 274:1, 274:10, 274:13, 274:14, 274:19, 276:1,	276:2, 276:11, 278:1, 279:6, 279:8, 279:11, 279:14, 279:20, 279:21, 279:22, 280:3, 280:12, 280:14, 280:15, 280:18, 281:4, 281:16, 282:1, 282:16, 282:17, 283:5, 283:10, 283:16, 284:1, 284:11, 284:20, 285:1, 286:3, 286:9, 287:11, 289:9, 290:3, 290:5, 291:5, 291:9, 296:18 slides 248:8, 250:1, 250:9, 273:5, 273:13, 276:19, 280:14, 281:13, 281:15, 289:4, 294:14, 294:22, 295:7, 295:13, 295:16, 296:5, 296:10 slow 177:15 slower 177:15, 177:19 small 208:5, 208:9, 291:2 smaller 35:14, 35:16 smog 85:6 solar 26:1, 64:14, 108:12, 108:15 sold 203:4 solenoid 228:18 solicited 31:2	solid-state 26:2 solution 136:20 solutions 105:17, 105:20 solved 19:18, 105:5, 105:7 some 23:4, 23:20, 24:4, 38:19, 45:14, 45:16, 47:20, 61:2, 64:12, 65:1, 68:10, 69:2, 69:3, 83:5, 87:20, 110:19, 118:11, 131:14, 131:19, 135:3, 135:4, 146:13, 148:4, 166:11, 173:2, 197:3, 201:22, 208:22, 209:4, 226:6, 240:11, 256:6, 256:7, 265:13, 290:22, 291:1, 326:19, 340:20, 343:17, 354:5, 354:12 someone 274:5, 348:17 something 20:21, 27:19, 39:11, 39:13, 48:7, 59:9, 92:8, 144:12, 154:11, 181:11, 202:8, 217:16, 220:16, 223:10, 223:16, 257:2, 258:21 sometimes 32:6, 32:7, 168:9 somewhere 271:17, 303:14
--	--	--	---

soon 171:4 sorry 30:22, 34:10, 36:11, 46:3, 48:1, 55:3, 55:5, 55:11, 58:16, 71:12, 73:3, 74:6, 83:16, 107:21, 111:6, 114:8, 120:1, 120:3, 121:3, 127:19, 141:4, 148:22, 154:10, 160:10, 175:11, 175:12, 175:16, 177:16, 177:17, 180:3, 181:3, 184:3, 206:8, 207:13, 211:6, 211:9, 211:21, 212:17, 219:10, 221:8, 221:15, 224:5, 233:22, 240:15, 245:22, 249:12, 262:8, 262:14, 274:12, 278:17, 283:8, 283:10, 284:17, 288:19, 301:8, 302:14, 306:1, 306:8, 308:20, 309:13, 309:17, 309:22, 313:7, 315:3, 318:21, 324:5, 325:4, 328:18, 329:3, 334:20, 345:21, 347:6, 350:17, 353:13 sort 38:19, 330:6 sound 59:7 sounds 166:17 source 64:17, 81:17,	81:20, 82:6, 82:7, 82:14, 93:16, 108:14, 188:5, 198:18, 199:15, 208:22, 209:2, 270:5 sources 63:4, 63:15, 64:11, 81:10, 82:21, 106:6, 151:5, 151:8, 258:3 southeast 151:16, 151:20 southern 11:21 space 23:6 speak 79:17, 88:10, 89:9, 94:12, 106:14, 119:11, 147:18, 151:21, 163:12, 169:8, 172:12 speaking 54:1, 219:20 special 18:9, 101:7 specialize 147:4 specialized 144:9, 144:14, 145:1, 146:16 specially 143:19 species 25:13, 45:5 specific 44:21, 46:18, 46:19, 48:12, 53:21, 68:4, 80:17, 83:15, 85:15, 86:20, 87:1, 88:9, 89:10, 140:4, 146:3, 148:13, 151:3, 173:14,	180:5, 180:15, 182:16, 186:11, 195:8, 238:15, 252:13, 283:18, 286:11, 313:16, 322:3, 334:8, 334:9, 334:10, 347:7, 347:17, 354:9 specifically 15:5, 40:13, 48:6, 64:1, 68:5, 68:22, 74:14, 104:11, 132:18, 138:7, 138:15, 155:20, 159:16, 189:14, 189:16, 225:9, 234:16, 247:14, 280:4, 313:14, 346:9 specification 80:1, 80:14, 177:2, 178:12, 179:18, 189:2 specifications 208:1 specifics 59:18, 65:11, 83:9, 94:17, 101:18, 103:5, 132:6, 194:7, 215:2, 254:12 specified 109:11 speculate 253:11, 271:10, 274:2 speculating 158:12 speed 101:11, 104:4, 104:19, 117:19, 254:9 spencer 3:3 spend 67:12	spent 12:7, 18:14, 327:11 split 159:11, 159:13, 161:10, 162:13, 173:2, 251:4, 252:11, 252:17, 275:8, 278:8, 319:3, 324:1, 326:20 splits 161:17 spoken 248:11, 248:18 spot 222:13 spots 311:10 square 271:4 st 33:11 stage 144:21 stages 97:21, 144:20 stand 75:16, 142:22, 297:3 standard 342:19 standards 43:16 stands 58:18, 59:5, 208:16 start 16:13, 17:21, 32:3, 76:17 started 15:6, 181:5 starting 23:14, 110:5, 300:15, 309:21 starts 109:17 state 2:12, 7:18,
--	---	---	--

8:9, 8:16, 40:21, 56:4, 126:9, 137:10, 174:1, 176:5, 187:3, 187:14, 188:10, 188:13, 188:22, 247:8, 269:14, 294:20, 356:4 stated 55:19, 140:13, 210:2, 210:8, 296:8, 353:19 statement 77:21, 112:1, 139:6, 200:18, 222:10, 305:4, 307:11 states 1:1, 7:6, 79:2, 152:10, 345:9, 345:10 station 308:5, 308:6, 310:1, 311:4, 311:21, 312:2, 312:16, 313:15, 315:11, 315:14, 315:15, 315:18, 316:12, 317:1, 318:15, 319:7, 321:9, 322:1, 322:2, 322:16, 322:18, 323:3, 324:1, 326:3, 332:7 stations 311:15, 315:2, 315:10, 316:17, 316:20, 316:22 stays 25:9 steam-generating 193:11, 193:16, 194:3, 203:12, 210:14, 214:20, 320:14, 323:4 stenographer 191:5, 355:1,	355:18 stenographer's 4:21 stenographic 16:20, 304:12, 355:2 step 14:2, 39:9, 49:4, 53:3, 66:11, 83:6, 83:12, 115:7, 129:8, 129:15, 130:19, 131:14, 159:19, 258:6, 263:6, 263:9, 290:14, 325:15, 325:19 steps 54:5, 54:8, 97:8, 160:20 stick 16:17, 32:21 sticking 65:19 still 28:22, 76:4, 213:12, 218:6, 221:4, 221:14, 221:21, 223:5, 223:18, 223:21, 224:10, 224:17, 242:15, 292:14, 292:15, 324:6, 335:17, 339:5, 339:12 stoichiometric 102:6, 336:1, 336:4, 336:10 stopped 179:9 stored 298:19 straightforward 313:21 strategies 247:15 stream 52:20, 98:9,	100:1, 100:11, 100:16, 100:19, 101:22, 103:2, 118:15, 125:18, 129:3, 130:3, 131:2, 131:5, 131:7, 131:11, 131:18, 132:1, 132:10, 132:14, 132:15, 132:19, 132:20, 132:22, 133:3, 133:9, 133:10, 133:22, 134:1, 134:7, 134:8, 134:11, 134:21, 134:22, 135:8, 135:11, 135:16, 135:21, 136:6, 137:4, 140:18, 155:11, 157:6, 157:7, 157:8, 159:17, 161:17, 161:20, 161:21, 161:22, 162:5, 244:5, 251:12, 252:11, 253:15, 253:16, 254:18, 254:20, 255:3, 255:14, 255:22, 256:1, 257:4, 275:19, 278:8, 288:16, 289:11, 324:2, 326:1, 326:4, 328:1, 328:6, 328:13, 328:14, 330:1, 330:10, 330:22, 333:3, 333:4, 337:20, 337:22, 339:6, 345:4, 345:17, 345:18, 346:10, 348:1, 350:16, 351:2 streams 72:5, 73:15, 93:20, 94:4, 94:9, 94:13,	94:21, 95:6, 95:14, 96:4, 101:7, 102:16, 104:21, 153:20, 155:17, 172:8, 252:10, 262:21, 288:11, 316:10, 326:9 street 2:5, 3:13, 7:16, 356:17 strenuously 285:10 strike 34:19, 309:12, 309:16, 309:20, 324:15 structure 88:10, 103:19 students 28:2, 28:17, 29:3, 29:21, 30:11, 92:9, 195:6 stuff 165:6 subject 105:3, 271:10 submits 176:6 submitted 297:17, 297:18 subsequent 126:9 substantially 336:20 substitute 41:12, 74:1, 74:9, 75:8 substitutes 23:11 substituting 72:5 substitution 70:18, 71:8, 72:2, 125:10 success 70:2
--	---	--	---

suggest 168:17, 173:18, 248:4, 250:5, 250:9 suggested 281:5 suggesting 265:5, 266:13, 348:6 suggests 266:15, 335:9, 346:18 suite 2:6, 3:6, 3:14, 7:14, 356:18 sulfur 251:17, 252:1 summer 27:6, 33:7, 33:17 superheat 205:17 superheated 192:13, 201:1, 201:8, 202:10, 330:9, 331:1 superheater 117:13, 174:5, 178:3, 203:22, 233:1, 331:12 superheaters 82:14, 106:4 supplemental 231:20 supplemental-fir- ed 232:3 supplementary-fi- red 231:12 supplied 120:13, 137:20, 190:14, 209:4, 253:16, 277:17, 292:9, 310:4, 313:18, 328:8, 330:11, 330:12, 335:5	supplies 281:5 supply 46:20, 51:5, 137:12, 138:10, 162:17, 164:20, 167:6, 210:19, 253:20, 269:8 supplying 129:14, 203:21, 265:12, 267:10, 286:12, 286:13 support 6:5, 16:3, 69:7, 297:18, 317:4, 318:14 supposed 287:14 sure 9:8, 9:21, 14:2, 15:12, 17:3, 17:20, 21:21, 23:22, 24:3, 26:19, 31:17, 31:19, 36:13, 37:5, 40:8, 41:21, 50:5, 58:12, 63:8, 63:9, 68:19, 71:1, 71:4, 75:14, 81:13, 95:10, 95:12, 104:13, 104:16, 111:13, 118:9, 130:15, 137:9, 142:19, 150:9, 153:3, 153:6, 166:9, 177:7, 185:12, 191:7, 193:4, 196:17, 198:7, 201:19, 203:10, 206:20, 217:7, 219:1, 220:20, 221:18, 223:7, 240:16, 250:15, 255:19, 261:4, 262:17, 268:7,	269:4, 272:9, 274:20, 275:16, 289:13, 290:4, 302:2, 306:10, 313:4, 313:12, 314:20, 324:8, 324:9, 324:19, 325:13, 332:20, 332:22, 333:2, 334:17, 340:17, 346:6, 350:18 surprise 157:9, 157:17, 158:5, 192:21, 193:3, 353:7, 353:15 surprised 336:12, 336:17 surprises 159:3 svend 5:8, 248:14 swing 24:21, 25:1, 97:2, 129:18 switch 76:6, 119:20 sworn 8:6, 8:9, 356:8 syn) 129:4 syngas 25:9, 39:21, 41:6, 52:20, 111:3, 111:18, 112:5, 112:10, 115:17, 115:19, 116:21, 128:19, 137:11, 138:1, 139:12, 143:12, 143:14, 152:14, 152:16, 153:8, 153:10, 157:5, 157:18, 158:7, 160:17, 170:20, 171:13, 172:2, 173:3, 244:4, 245:3, 252:8,	329:8, 343:1, 344:6, 347:15 synonymous 60:13 systems 2:11, 35:6, 55:22, 56:6, 56:19, 57:3, 357:15 T tail 99:2, 99:5, 99:9, 99:17, 100:17, 134:21, 153:20, 154:3, 154:6, 154:14, 154:22, 171:19 take 10:2, 10:10, 14:2, 21:8, 66:11, 142:18, 146:16, 159:17, 161:9, 161:19, 162:7, 166:11, 166:15, 201:1, 219:8, 292:20, 296:22, 322:5, 327:3, 355:16 taken 39:8, 75:19, 143:3, 222:21, 297:6, 356:9 takes 61:21 taking 7:15, 87:10, 257:4, 257:8 talk 9:15, 17:19, 21:19, 55:6, 58:9, 65:2, 76:7, 81:10, 130:11, 249:20, 292:16, 354:10 talked 14:14, 26:3, 106:3, 123:4,
--	--	---	---

123:12, 129:19, 131:14, 193:18, 238:1, 283:13, 308:15, 333:10 talking 15:4, 46:10, 48:6, 62:9, 65:21, 68:3, 71:19, 73:5, 74:5, 74:13, 87:1, 104:9, 104:14, 108:10, 111:9, 111:12, 123:2, 132:15, 144:16, 158:13, 159:16, 161:11, 161:13, 161:14, 171:19, 173:5, 183:2, 183:3, 223:7, 231:19, 240:3, 266:21, 269:6, 271:13, 272:5, 273:18, 278:20, 316:21, 316:22, 324:4, 331:8, 332:6, 348:15, 351:12 talks 41:14, 268:21, 285:14, 319:14, 320:19 tank 19:16 target 44:17, 71:18, 239:17, 239:18 targeted 239:21 taught 26:9, 31:9, 195:9 tax 60:16, 61:12, 61:17, 78:9, 79:2, 79:5, 163:7, 163:9, 163:19, 165:7, 165:12, 167:9,	239:9 teach 26:5, 26:8, 26:11, 26:15, 27:1, 28:6, 29:12, 195:5, 345:16, 346:10 teaches 347:21 teaching 322:1 team 14:18, 67:5 teams 28:2, 28:5 technical 67:3, 115:15, 249:18, 300:22, 301:12, 302:6 technique 24:16, 144:9, 240:9, 241:14, 244:11, 245:2, 245:21 techniques 22:3 technological 170:11 technologies 24:18, 25:11, 43:6, 54:13, 54:17, 55:8, 59:6, 300:21, 353:9 technology 14:22, 170:16, 270:9, 270:20, 342:19 tell 142:17, 169:13, 199:8, 298:22 temperature 86:6, 86:14, 91:1, 117:15, 117:16, 117:17, 123:9, 192:2, 192:5, 193:11, 254:9, 342:17	temperatures 85:11, 85:19, 85:21, 86:1, 90:21, 101:22, 102:11, 104:4, 104:20, 122:22, 194:4, 349:5 ten 293:2 tend 177:18 tendered 15:19, 17:5, 17:15, 246:17, 297:13, 304:6, 327:17 term 27:13, 32:1, 36:8, 60:7, 78:12, 78:16, 87:3, 87:12, 87:16, 137:17, 143:17, 174:2, 174:12, 175:5, 176:6, 176:12, 176:19, 177:3, 177:12, 177:22, 178:5, 178:13, 178:18, 179:17, 179:19, 181:5, 181:17, 198:15, 216:13, 225:11, 225:15, 225:16, 230:9, 232:19, 234:18, 235:4, 235:6, 236:15, 238:3, 272:11, 273:10, 275:14, 276:16, 279:7, 279:19, 282:20, 286:3, 286:4, 287:12, 287:13, 287:16, 294:21 terminology 80:17, 190:16, 203:18 terms 38:10, 43:22,	45:2, 52:7, 60:8, 73:19, 92:10, 169:14, 172:6, 176:17, 183:13, 184:15, 225:21, 234:22, 286:7, 286:9, 338:17, 355:9 terrible 197:11 terrien 12:17 testified 8:10, 11:2, 153:19, 154:21 testimony 10:18, 11:6, 68:6, 73:12, 79:8, 104:8, 119:6, 125:3, 153:22, 154:2, 180:8, 205:12, 228:5, 335:16, 335:19, 337:18, 356:10 texas 3:7, 11:21, 20:4, 26:17, 151:16, 151:20, 152:4, 152:9 textbooks 342:12 th 299:3, 299:9, 357:8 thank 76:5, 181:18, 355:18 thanks 191:6, 341:2 themselves 7:18, 125:12 therefore 187:22 therefrom 330:9 therein 23:1
--	--	---	---

thereof 316:14 thermal 187:5, 187:11, 209:11, 209:21, 309:5 thesis 18:12, 21:22 thing 84:14, 136:17, 137:3, 198:8, 202:22, 204:3, 206:14, 207:16, 210:9, 292:3, 308:5, 315:19, 315:21, 316:3, 323:21 things 20:1, 26:12, 29:10, 30:1, 32:19, 32:21, 43:13, 44:8, 67:7, 69:5, 85:6, 100:14, 103:16, 112:15, 141:7, 145:1, 151:4, 154:5, 155:19, 165:8, 165:19, 168:13, 169:22, 170:1, 176:1, 176:8, 176:9, 186:17, 189:18, 189:21, 194:22, 202:22, 208:3, 210:3, 211:14, 215:15, 215:16, 217:19, 254:9, 295:3, 295:6, 295:9, 300:7, 314:19, 344:4, 349:7, 351:15 think 12:22, 36:14, 48:15, 50:6, 58:5, 58:18, 62:19, 64:18, 71:17, 71:20,	75:12, 80:21, 90:3, 90:18, 95:17, 96:7, 97:15, 105:8, 111:22, 113:11, 118:18, 124:16, 130:6, 130:10, 130:12, 132:17, 135:18, 142:20, 143:17, 144:12, 145:2, 146:11, 162:4, 162:15, 168:10, 170:7, 170:15, 171:22, 172:15, 173:19, 179:2, 181:3, 181:9, 182:3, 182:12, 182:16, 183:9, 184:17, 188:3, 189:12, 190:21, 193:14, 222:9, 222:16, 223:12, 226:2, 227:3, 229:20, 230:5, 230:17, 231:15, 231:16, 238:6, 246:10, 255:2, 260:12, 260:19, 262:7, 266:17, 273:12, 273:22, 275:7, 275:10, 281:5, 281:8, 281:10, 282:7, 287:8, 296:4, 307:17, 309:8, 311:12, 315:6, 319:15, 321:20, 322:22, 324:20, 324:21, 325:10, 326:18, 327:8, 331:6, 333:10, 341:9, 344:19, 350:11, 353:20, 354:1, 355:4, 355:10 third 265:20 thought 243:10, 276:22	three 17:17, 167:2, 262:7, 302:18, 303:8, 306:21, 313:17, 340:21 three-day 355:6 through 25:7, 25:12, 40:10, 74:1, 76:18, 90:10, 90:14, 97:12, 123:17, 134:9, 166:13, 198:10, 228:18, 234:15, 258:6, 297:19, 302:19, 309:10, 311:9, 311:19, 316:9, 317:15, 320:22, 331:4, 334:11, 334:12, 343:17 throughout 29:7, 64:6, 233:7, 278:21, 283:20, 287:18, 311:1, 312:9, 312:10, 317:11 thrown 172:17 thursday 1:17, 356:18 tie 281:15, 321:22, 322:13 tied 181:6, 221:8, 273:13, 281:14 tier-based 60:16 ties 61:4 time 7:9, 12:7, 15:5, 18:14, 20:16, 22:18, 28:19, 31:9, 65:18, 75:18,	75:21, 93:12, 93:17, 95:2, 95:18, 105:9, 105:12, 118:19, 119:3, 119:4, 128:1, 143:2, 143:5, 159:2, 221:16, 222:20, 223:1, 243:17, 270:6, 270:9, 277:1, 287:10, 297:5, 297:8, 355:19 times 20:2, 164:3, 167:2, 287:17, 313:17, 321:3 title 58:6, 247:17, 264:22, 265:11, 279:14, 280:3, 284:22, 296:1, 296:4, 299:13, 299:17, 299:20 titled 265:17, 266:4, 295:17 today 7:11, 8:4, 8:20, 8:22, 10:1, 10:19, 12:6, 13:12, 22:20, 63:7, 76:15, 95:18, 105:2, 105:8, 119:6, 224:17, 333:11, 342:20 today's 7:8, 15:3, 28:20 together 147:13, 176:2, 203:1, 250:10, 281:13, 281:15, 281:16, 317:3 told 9:10, 192:21, 231:15, 336:13
---	---	---	---

ton 295:3 tonight 355:12, 355:17 tool 245:20 toolbox 49:17 tools 28:18, 28:21, 49:17 top 261:5, 266:3, 268:2, 274:18, 276:5, 281:2, 282:16, 283:22, 284:11, 284:19, 341:21, 342:10 topic 31:6 topics 30:16, 30:18, 340:18 topsoe 1:4, 7:5, 7:22, 8:15, 11:20, 13:18, 13:20, 14:3, 14:6, 17:14, 54:16, 60:17, 157:4, 157:13, 157:15, 172:22, 184:5, 185:3, 190:22, 246:16, 297:12, 297:18, 304:5, 327:16, 345:22 topsoe's 156:22, 183:20 total 103:19 totally 101:16, 105:5 touch 272:7 tough 327:12 toward 23:16, 109:5	towards 61:8 trademark 1:1, 7:6 traditional 21:2, 121:18, 157:8, 158:9, 226:8, 333:17 transcript 4:6, 197:9, 198:6, 249:8, 355:3 transfer 26:13, 90:5, 90:6, 91:14, 92:14, 141:15, 187:5, 189:6, 209:11, 209:21, 210:3, 211:12, 211:13, 230:15, 231:5, 309:4 transferred 89:3, 185:22, 211:18, 216:1, 216:2 transferring 182:10, 183:13, 188:16, 211:15 transfers 121:9, 182:1, 187:10, 187:21, 209:5, 212:3, 231:9 transformed 188:6 transport 26:12 trapezoid 204:10, 204:11, 204:12, 204:15 treat 207:17 treated 120:16, 172:18 treating 19:19, 19:21 treatment 85:9, 86:12,	91:18, 128:22, 136:7 trees 298:17 trial 1:2, 11:3 trick 9:22, 36:17, 89:17, 89:18, 241:10 tried 249:3, 249:4 true 44:16, 50:20, 101:6, 162:5, 164:7, 185:17, 249:2, 260:5, 281:20, 281:22, 336:3, 337:7, 340:8, 356:10 truth 8:10 truthful 10:18 try 60:2, 91:20, 119:18, 140:7 trying 9:21, 9:22, 36:17, 47:9, 89:12, 89:17, 89:18, 167:8, 170:3, 178:9, 179:8, 199:2, 214:8, 216:4, 217:4, 241:9, 241:10, 274:12, 281:17, 316:5, 323:16, 342:14 tube 90:9 tubes 89:7, 203:12, 210:16, 226:13 turbine's 119:13 turbines 65:5, 65:13,	65:17, 69:3, 111:3, 111:19, 113:12, 118:18, 119:7, 152:5, 192:1, 198:13, 199:21, 227:9, 228:2, 228:7, 228:17, 269:19, 270:4, 310:22, 311:3, 311:15, 314:18, 315:9, 318:3, 320:20, 320:22, 321:8, 334:12, 335:10, 335:20 turn 76:18, 78:22, 142:2, 142:3, 142:4, 177:5, 314:8, 314:15, 343:22 turning 23:10, 191:22, 318:3, 318:4 turns 19:16, 52:15, 142:3, 222:5 twin 33:12 two 18:21, 26:20, 26:21, 27:4, 55:21, 63:14, 88:22, 90:10, 97:7, 110:4, 126:15, 154:5, 166:13, 176:4, 181:21, 188:4, 197:1, 197:2, 205:13, 252:10, 262:3, 262:21, 273:12, 277:20, 279:12, 280:14, 281:12, 281:15, 286:6, 288:11, 297:21, 300:4, 308:4, 313:10, 313:17, 317:3,
---	---	---	--

326:9, 330:21, 331:20, 331:22, 349:16 two-sided 298:16 tying 181:10, 281:12 type 39:21, 94:8, 134:22, 146:1, 167:22, 172:7, 182:21, 183:9, 223:8, 252:2 types 30:10, 39:17, 151:12, 172:17, 343:10 typical 51:18, 81:21, 82:1, 252:1, 252:4, 254:19, 269:19 typically 28:3, 30:6, 38:16, 38:22, 39:1, 42:14, 52:13, 52:17, 60:12, 63:10, 78:19, 80:5, 84:21, 88:17, 92:2, 93:5, 97:7, 98:7, 99:10, 101:12, 116:19, 117:8, 122:4, 123:10, 143:20, 174:19, 188:14, 197:1, 200:7, 337:8, 347:2, 352:12 typing 9:13 U ultimately 88:19 um-hmm 21:18, 146:6, 175:7, 209:14,	261:9, 271:1, 302:9, 310:11, 333:5, 333:9, 333:12 unburned 318:6 unclear 51:13 under 41:4, 51:18, 56:11, 76:4, 81:21, 82:5, 102:19, 142:1, 223:5, 233:18, 234:1, 234:9 undergrad 33:15 undergraduate 26:5, 33:6, 33:8, 33:20 understand 9:18, 42:5, 42:11, 47:2, 47:6, 47:10, 60:1, 71:2, 71:15, 81:5, 99:5, 105:16, 107:2, 107:5, 111:7, 112:12, 113:2, 144:15, 144:18, 145:7, 153:3, 167:8, 168:13, 170:3, 173:9, 176:5, 179:8, 180:18, 183:20, 184:1, 184:9, 185:13, 217:4, 240:18, 240:22, 246:6, 251:22, 278:18, 280:19, 308:10, 344:9 understanding 39:3, 53:21, 59:20, 60:6, 71:21, 78:15, 86:18, 97:5, 109:3, 110:12,	180:21, 185:9, 189:4, 203:3, 204:20, 208:13, 251:8, 346:22 understood 61:12, 105:6, 105:8, 177:12, 178:1, 269:20 unfortunately 151:19 unique 27:9 uniquely 27:5 unit 26:17, 27:7, 28:3, 35:14, 42:4, 43:2, 45:9, 52:8, 53:8, 98:4, 98:13, 126:10, 128:3, 129:2, 130:12, 130:18, 131:10, 133:14, 134:10, 138:6, 138:17, 145:1, 146:18, 148:15, 166:14, 171:20, 171:21, 181:22, 187:4, 190:12, 196:13, 202:17, 203:4, 205:3, 209:10, 210:20, 211:2, 216:21, 218:6, 219:21, 220:1, 220:3, 220:8, 222:4, 229:11, 243:3, 243:12, 246:11, 274:22, 275:21, 309:3, 312:14 united 1:1, 7:5, 79:2 units 63:11, 154:7, 159:22, 160:3, 199:8, 219:19 universally 275:22	university 18:3, 26:16, 33:8 unless 291:1 unnecessary 342:18 unquote 278:14, 278:18 unreacted 130:22, 256:4 unreasonable 193:5 unrelated 280:12 until 355:13 uploaded 248:8 upper 206:19, 274:21 upper-left 276:10 upstream 123:4, 123:12, 126:3, 157:6, 159:13, 162:13, 251:17 urea 109:20 url 198:17 use 9:19, 16:11, 24:17, 29:1, 29:4, 29:6, 29:7, 29:9, 47:17, 49:4, 52:8, 52:14, 52:16, 59:6, 65:5, 91:14, 93:8, 93:14, 93:19, 95:5, 95:14, 96:4, 103:1, 117:12, 136:3, 139:17, 139:20, 140:7, 140:14, 142:15,
---	---	--	--

149:14, 154:10, 162:1, 163:3, 165:5, 172:7, 182:18, 194:20, 194:21, 194:22, 195:1, 201:2, 201:21, 216:20, 217:8, 217:10, 222:8, 223:13, 223:14, 240:8, 240:20, 241:13, 244:11, 244:18, 245:2, 245:7, 245:8, 245:9, 271:19, 271:20, 276:16, 278:21, 282:19, 286:6, 287:11, 287:17, 311:14, 316:20, 322:21, 330:1, 336:1, 342:2, 345:10, 346:19, 350:2, 350:5 uses 52:4, 286:4, 312:18, 330:21 using 22:2, 24:14, 28:18, 32:6, 73:14, 84:8, 94:4, 97:1, 100:21, 101:22, 102:15, 104:20, 109:21, 118:15, 120:12, 124:12, 137:22, 141:6, 141:8, 141:9, 141:11, 141:17, 152:11, 153:14, 160:17, 161:7, 178:18, 201:8, 215:14, 216:13, 220:15, 231:13, 232:4, 234:3, 234:5, 234:20, 235:4, 241:16, 244:4, 245:21, 267:19, 275:13,	286:12, 289:11, 310:14, 323:18, 329:7, 329:12, 333:2, 333:6, 333:15, 333:16, 333:18, 337:16, 345:16 usually 60:8, 60:13, 85:9, 195:21, 228:11, 336:1, 350:9 utilities 36:6, 36:19, 37:9, 61:22 utility 264:11 utilization 23:8, 72:1, 73:20, 80:19, 138:22 utilize 349:8, 349:20 utilized 78:20 utilizes 318:16 V vagarities 53:16 vaguely 298:3 validity 75:4 value 136:1, 148:5, 164:4, 164:20 vanes 228:10, 229:4 vapor 22:1 variable 30:13, 99:21 variety 93:20, 102:11, 139:18, 225:22 various 14:17, 19:22,	20:2, 22:3, 32:20, 53:8, 54:9, 55:7, 60:4, 67:17, 81:8, 109:10, 134:18 vary 148:14 velocity 101:11 vented 131:17 venting 194:10 versa 41:13, 348:19 versus 7:5, 43:18, 66:1, 101:20, 115:18, 116:16, 135:16, 136:3, 168:7 via 70:18, 71:8 viable 163:11, 194:12, 332:16 vice 41:13, 348:19 video 7:9, 7:14, 118:11, 355:10, 355:13 videographer 3:19, 7:2, 7:11, 8:3, 75:15, 75:20, 142:22, 143:4, 222:19, 222:22, 297:3, 297:7, 354:20 videotaped 1:15, 2:1, 7:3 view 64:10, 174:11, 210:6, 239:10, 243:8 viewing 206:22	vitae 5:20 voice 7:17 volume 337:9 volumetric 164:4, 164:12 W wait 181:1, 233:22 walk 297:19 want 9:21, 16:10, 16:15, 40:9, 41:15, 48:5, 61:6, 71:1, 76:7, 92:12, 92:13, 93:4, 95:10, 97:22, 125:2, 142:15, 142:18, 149:5, 153:2, 158:17, 158:18, 159:10, 160:16, 181:11, 194:20, 195:1, 195:2, 195:12, 199:3, 207:4, 207:16, 217:13, 223:4, 252:18, 255:2, 272:7, 277:6, 282:20, 299:12, 300:1, 301:18, 310:9, 335:1, 343:18, 343:19, 347:6, 350:8, 350:9, 350:18, 351:14, 355:10 wanted 59:4, 76:3, 185:8, 199:1, 223:7, 237:22, 295:11 wants 19:5, 195:15,
--	--	---	--

306:14, 347:12 warmer 90:16 waste 19:22, 93:20, 94:4, 94:8, 94:13, 135:8, 135:11, 135:21, 136:7, 154:6, 155:17, 156:3 watch 355:12 water 10:5, 19:15, 19:16, 36:21, 84:18, 174:20, 174:21, 187:21, 188:4, 188:6, 209:6, 211:19, 222:5, 227:5, 230:15, 231:6, 231:9, 330:8 water-gas 31:11, 41:22, 43:3, 44:4, 49:5, 50:3, 50:7, 50:12, 50:14, 50:22, 51:7, 51:15, 51:19, 52:9, 52:14, 54:4, 54:13, 57:9, 126:16, 166:13, 173:1, 238:9, 342:5, 343:22, 349:20, 350:2, 350:5, 350:10 way 30:13, 49:3, 49:4, 67:7, 77:20, 103:11, 110:19, 117:7, 124:6, 128:10, 160:6, 161:2, 173:17, 178:8, 179:5, 242:15, 242:19, 244:2, 253:19, 265:13,	288:17, 300:7, 303:5, 325:7, 335:9, 346:18, 357:5 ways 18:22, 22:4, 35:7, 103:14, 110:1, 110:5, 117:4, 128:7, 129:17, 139:18, 160:13, 194:21, 225:22, 237:10, 238:15, 239:19, 268:21, 277:20 we'll 10:10, 110:21, 191:2, 191:3, 340:18, 355:14 we're 16:16, 17:18, 31:20, 46:17, 48:5, 61:2, 62:9, 65:2, 65:19, 68:3, 73:5, 75:12, 76:6, 104:14, 144:16, 150:11, 158:12, 166:11, 166:12, 166:14, 166:15, 171:5, 173:5, 175:9, 179:3, 190:18, 206:22, 223:4, 280:4, 291:8, 292:15, 292:16, 316:21, 316:22, 327:4, 327:5, 331:8, 340:12, 348:15, 350:20 we've 23:8, 35:5, 131:13, 216:13, 222:12, 225:3, 265:2, 326:18, 333:10, 334:14 web 298:18, 299:1 website 292:17, 293:10,	294:3, 294:7, 294:10, 294:15, 294:18, 295:4, 302:19 week 195:9 weeks 27:8 welcome 223:3 went 26:16, 100:11, 122:6, 134:9 weren't 224:10, 250:9, 296:9 wet 337:14 wewatta 2:5, 3:13, 7:15, 356:17 whatever 10:8, 10:11, 39:14, 48:13, 61:16, 92:15, 256:9, 298:11, 339:15, 355:10 whenever 159:11, 163:3 whereof 357:7 wherever 274:16, 311:8 whether 66:8, 124:6, 134:9, 135:15, 136:19, 144:21, 203:4, 216:21, 217:10, 220:15, 223:9, 292:3, 303:2, 332:6 whitney 2:4, 3:11, 12:3, 13:17, 356:17 whitney's 14:18 whole 8:9, 64:17,	100:13, 146:12, 147:9, 168:12, 243:2, 246:12, 249:19, 284:16, 285:7 wide 102:10 wildly 44:20 williams 301:22 wind 108:12, 152:5 wind-producing 152:10 withheld 69:10 within 89:7, 144:2, 188:1, 203:12, 206:10, 209:2, 217:21, 218:1, 221:5, 221:22, 232:11, 320:10, 356:4 without 83:15, 137:12, 173:12, 173:14, 207:21, 296:11, 308:12 witness 8:6, 9:1, 15:19, 17:6, 17:16, 246:18, 297:14, 304:7, 327:18, 354:18, 356:7, 356:11, 357:7 wolden 1:15, 2:1, 4:2, 5:21, 6:5, 7:4, 8:8, 8:13, 8:18, 9:3, 16:3, 76:2, 143:7, 199:21, 223:3, 246:7, 262:20, 268:9, 297:10, 298:2, 315:8, 322:8,
--	--	--	---

354:21, 356:6, 356:16 wondering 14:8, 37:7, 61:12, 61:20, 68:20, 74:11, 278:22, 279:2 word 63:20, 180:20, 180:22, 182:6, 182:8, 182:9, 185:9, 274:10, 278:21, 323:14 wording 67:6 words 77:17, 207:21, 233:12, 233:14, 253:8, 307:3, 315:22, 316:2, 323:16 work 11:17, 18:16, 23:2, 23:7, 23:8, 24:8, 25:11, 25:20, 25:22, 28:1, 28:2, 28:4, 30:17, 32:10, 32:12, 32:17, 33:21, 33:22, 34:9, 34:18, 35:10, 36:4, 37:8, 55:7, 87:20, 147:13, 169:15, 194:17, 213:10, 224:16, 224:19, 332:3, 336:8 worked 34:11, 34:13, 38:6, 56:16, 147:7, 239:15 working 15:6, 22:6, 22:7, 23:15, 23:16, 30:8, 54:11, 55:21,	105:19, 348:17 works 30:13, 59:19, 90:6, 191:4, 208:14 world 185:6 worry 85:3 worse 118:3 worth 21:9 wouldn't 80:12, 98:15, 105:13, 118:6, 118:14, 142:15, 142:16, 143:13, 144:18, 162:21, 172:5, 173:18, 196:20, 230:20, 257:6, 257:20, 279:11, 284:10, 285:3, 285:8, 289:5, 320:11 writ 269:1 write 66:16 writing 67:12, 67:15 written 66:19, 67:9, 299:6 wrong 9:19, 9:20, 80:22, 164:2, 175:16, 175:17, 235:10, 236:19 wrote 67:2, 300:14, 335:8 X xanthan 34:13 Y y'all 27:19, 28:6,	179:9 yeah 12:17, 15:22, 16:16, 17:3, 20:8, 25:11, 25:19, 26:22, 27:15, 27:21, 27:22, 28:10, 29:6, 33:13, 38:7, 40:12, 45:4, 46:6, 46:7, 48:11, 91:6, 93:3, 116:3, 119:15, 122:5, 123:7, 132:7, 135:5, 146:3, 159:9, 160:14, 161:15, 164:16, 175:19, 183:17, 187:19, 192:19, 197:20, 197:22, 201:7, 215:10, 218:2, 219:20, 220:18, 222:9, 223:20, 230:19, 236:2, 249:15, 260:11, 266:15, 270:13, 270:15, 274:15, 276:4, 276:10, 290:5, 290:13, 291:4, 291:10, 295:3, 299:17, 300:4, 301:9, 302:2, 306:13, 312:17, 314:21, 315:9, 326:7, 327:6, 327:21, 331:8, 331:16, 334:22, 339:22, 341:1, 346:6, 346:8, 346:13, 347:15, 347:16, 348:4, 350:22 year 21:5, 269:20 year's 21:8	years 33:8, 55:21, 56:16 yep 12:21, 15:22, 16:5, 17:13, 18:18, 32:13, 32:15, 40:11, 40:20, 42:3, 55:18, 66:14, 69:16, 108:8, 120:3, 120:6, 126:13, 129:6, 130:7, 187:1, 187:8, 189:8, 191:5, 199:22, 240:6, 247:7, 247:12, 251:7, 261:6, 261:11, 261:22, 265:19, 266:7, 266:12, 267:16, 269:4, 269:22, 271:3, 272:15, 272:17, 275:2, 290:6, 291:7, 301:3, 301:9, 301:15, 301:19, 304:15, 304:21, 309:8, 310:3, 321:4, 326:2, 328:10, 329:16, 330:14, 335:7, 338:5 yourself 118:4 youtube 118:12 Z zero 270:22, 271:21 \$ \$10,000 11:14 \$300 11:10 . .1234 3:8
--	--	--	---

.3400 3:16	299:3, 299:9 11,286,168 1:13, 5:4, 17:11	125:15, 142:1, 154:19, 155:7, 159:7, 162:16, 167:13, 170:10, 173:6, 174:8, 174:10, 174:15, 175:22, 176:22, 177:5, 179:19, 180:14, 181:13, 183:4, 184:17, 184:18, 186:11, 188:1, 206:11, 216:14, 217:14, 217:22, 218:1, 218:9, 221:6, 222:1, 225:4, 225:5, 225:9, 232:12, 233:5, 234:12, 238:14, 238:19, 240:9, 240:20, 240:21, 241:14, 242:19, 243:5, 244:3, 244:16, 244:18, 250:20, 251:12, 251:16, 285:19, 320:11	1997 22:17, 25:16, 94:10 1998 329:18
0			2
01454 1:11, 7:7	114 334:19, 334:21, 337:18		2
1	12 120:6, 161:17, 161:20, 162:5, 222:20		2 266:5, 297:5, 297:8
1 201:21, 223:1, 315:6	125 346:4, 346:6		2-to-1 347:12, 347:16, 347:22, 351:11, 352:8
1's 246:2	13 309:10, 317:15		20 15:9, 67:14, 75:21, 131:7, 305:18, 306:12, 354:11
10 75:21, 118:19, 119:8, 270:5, 270:10, 270:12, 309:10, 309:21, 309:22, 313:5, 317:15, 330:12, 337:9, 338:4, 354:11	14 128:19, 132:19, 133:4, 159:18, 161:13, 161:17, 161:21		2000 85:22, 86:3, 90:22, 91:8, 193:19, 269:20
100 98:19, 214:1, 221:3, 221:20, 329:7	1400 2:5, 3:6, 3:13, 7:15, 356:17		2003 329:14
1000 85:22, 86:3, 90:21, 193:18	15 6:4, 98:7, 99:1, 131:6, 131:11, 131:12, 131:18, 133:1, 133:9, 133:22, 337:9, 338:4, 339:3, 339:4		2005 5:20, 17:1, 17:5
1001 5:4, 17:10, 17:15, 76:10, 107:20, 177:7	16 223:1, 328:2		2007 5:9, 6:4, 12:10, 15:16, 15:18, 16:1, 40:7, 66:12, 68:7, 68:15, 69:1, 69:6, 69:18, 70:14, 70:19, 71:9, 71:19, 72:6, 72:18, 73:10, 73:15, 75:8, 120:2, 138:20, 157:15, 174:1, 187:2, 190:8, 196:12, 196:15, 202:17, 233:8, 235:3, 236:12, 246:19, 247:6, 247:8, 247:14,
1006 5:6, 246:15, 246:17, 250:13, 270:11, 272:19, 295:12, 301:17	168 12:10, 14:22, 39:19, 42:6, 57:15, 70:20, 71:10, 74:17, 76:7, 76:14, 77:5, 107:20, 111:1, 111:4, 111:13, 111:17, 111:20, 112:1, 112:4, 112:22, 113:9, 113:13, 114:13, 114:19, 123:18, 125:7, 125:9, 125:10,	17 5:4, 5:20, 305:18, 306:12, 328:1, 328:6, 336:5 18 128:20, 143:2, 161:17, 161:22 19 67:20, 129:1 197 4:8, 4:9, 4:11, 4:13 198 4:15 1980 157:5, 157:19, 157:22, 158:4, 172:4 1993400370 357:16	
1008 5:11, 304:4, 304:6			
1010 5:13, 327:15, 327:17			
1020 5:15, 297:11, 297:13			
11 143:2, 143:5,			

247:20, 253:19, 269:5, 272:11, 292:14, 294:3, 294:6, 294:11, 294:14, 294:15, 294:22, 295:7, 295:12, 295:14, 296:8, 300:22, 301:12, 302:6, 302:11, 303:9, 303:17, 308:17, 328:12, 329:6, 332:14, 333:1, 353:19, 353:22 2009 5:19, 299:3, 299:8, 299:9 2017 65:15, 92:21, 93:8, 93:19, 95:5, 95:14, 96:4, 96:14, 99:7, 99:14, 104:6, 104:15, 105:20, 119:3, 124:14, 124:21, 125:5, 126:21, 126:22, 127:8, 128:11, 128:14, 134:2, 134:15, 135:9, 156:6, 156:15, 158:3, 158:4, 158:7, 158:18, 170:22, 171:15, 194:10, 224:3, 224:14, 224:20, 243:13, 243:21, 244:1, 291:18, 294:3, 294:6, 294:11, 294:15, 308:10 2025 1:11, 7:7, 293:19, 293:20, 294:18 2026 1:17, 7:9, 356:19, 357:8	2029 357:9 21 338:6, 338:8, 338:18, 338:19 22 120:14, 297:5 23 1:17, 7:8, 129:3, 356:18, 357:9 24 74:1, 328:8, 330:7, 335:2, 337:20, 339:5 246 5:6 25 56:16, 119:14, 173:22, 175:3, 175:11, 175:14, 175:15, 178:10, 225:2, 225:7, 273:1, 273:21, 275:10, 283:6, 328:8, 354:22 26 186:21, 188:9, 188:12, 188:22, 209:8, 309:1, 330:7, 330:18, 355:19, 356:19 27 74:1, 330:9, 331:8, 331:14 28 143:5, 357:8 29 107:19, 108:1 297 5:15 3 3 354:22, 355:19, 356:19 3.3 164:3	30 304:14, 304:15, 307:8, 330:10, 331:9, 331:11, 354:12 303.629 3:16 304 5:11 3040 3:5 31 297:8, 330:10 32 311:18, 328:1, 330:11 327 5:13 33 315:1, 315:6 34 69:12 35 222:20 357 1:24 36 311:19, 315:1, 315:6 38 300:8 3m 32:12, 33:10, 33:21 4 40 67:14, 138:19, 143:8, 161:20, 161:21, 162:1, 162:7, 162:8, 166:15, 336:14, 354:11 400 2:6, 3:14, 7:14, 356:18 42 119:21, 120:9,	126:7, 126:9, 128:17, 130:6, 130:9, 159:8, 300:1, 300:3, 300:6, 300:15, 300:17, 330:6 43 137:7, 301:8, 321:14 44 109:16, 301:4, 301:7, 301:9 45 10:3, 239:9 451 7:13 46 301:20 47 40:10, 40:11, 177:10, 225:8, 234:15 48 341:16 49 55:10 5 50 55:14, 61:15, 100:5, 100:6, 100:9, 155:1, 155:11, 318:22, 352:12 51 318:22 52 40:10, 40:14, 40:21, 110:6, 234:15, 318:22 54 300:2, 300:6, 300:16, 301:4, 301:7, 301:20 59 1:18, 7:10, 75:18, 247:5, 356:19
--	---	--	--

6 6,505,467 5:13 6,809,121 5:11 60 161:21 600 193:1 61 292:11, 293:8 63 316:9 64 292:12, 293:8, 294:20 642940 1:23 67 316:9 68 272:8, 272:10	90 92:5, 214:4, 266:10, 270:8 91 269:2, 269:15 99 155:6	
7 70 336:14 713.552 3:8 75 272:22, 273:20, 275:8, 283:5 77056 3:7 79 338:19		
8 1:18, 7:10, 356:19 80 172:13 80202 2:7, 3:15		
9 75:18		