UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

QSC AUDIO PRODUCTS, INC., Petitioners,	)	
vs.	)	Case No. IPR2014-00131
CREST AUDIO, INC., Patent Owner.	)	U.S. Patent 5,652,544

VIDEO DEPOSITION OF DANIEL P.W. ELLIS, Ph.D.

Seattle, Washington

Friday, June 27, 2014

Reported by:

Donald W. McKay, RMR, CRR, CCR 3237

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CREST 2002

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vs.	)	Case No. IPR2014-00131
CREST AUDIO, INC., Patent Owner.	)	U.S. Patent 5,652,544

Video deposition of DANIEL P.W. ELLIS, Ph.D., taken on behalf of Patent Owner, at 1201 Third Avenue, Suite 4900, Seattle, Washington, beginning at 9:00 a.m. and ending at 6:02 p.m., on Friday, June 27, 2014, before Donald W. McKay, RMR, CRR, CCR No. 3237.

A P P E A R A N C E S

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A P P E A R A N C E S (continued)

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Videographer

I N D E X

E X H I B I T S

Seattle, Washington; Friday, June 27, 2014
9:00 a.m.

THE VIDEOGRAPHER: We're on the record.
This is the beginning of Media No. 1 in the deposition of Dr. Daniel Ellis, in the matter of QSC Audio Products, Inc., versus Crest Audio, Inc., Case No. IPR2014-00131.
Today's date is June 27, 2014 and the time is 9:00 a.m.
My name is Patrick Norton and I am the videographer. The court reporter is Donald McKay. We are here with Huseby Court Reporting.
Counsel please introduce yourselves, after which the court reporter will swear in the witness.
MR. CRAIN: This is Andrew Crain and Vivek Ganti for the patent owner, Crest Audio.
MR. GRAVOIS: This is Robert Gravois and Spencer Mead, on behalf of the patent owner, Crest Audio.
MR. DAS: Kaustuv M. Das, on behalf of petitioner, QSC Audio Products LLC. Along with me, Rodney Tullett.
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DANIEL P.W. ELLIS, Ph.D. called as a witness in the above-entitled cause, being first duly sworn, testified as follows:

E X A M I N A T I O N

BY MR. CRAIN:

Q. Good morning, Dr. Ellis.

A. Good morning.

Q. I just want to run through some of the same type of housekeeping-type issues that we did yesterday. I'll try to do it more quickly since this is day two of our time together in deposition.

A. Okay.

Q. As you know, my name is Andrew Crain. Just for this record, would you go ahead and introduce yourself and give your name and address.

A. Daniel Ellis, 456 Riverside Drive, Apartment 8B, New York, New York. Did you want my telephone number as well?

Q. That's fine.

I think I asked you yesterday, had you ever been deposed before, and you said no.

A. That's right.

Q. So now the answer to that would be yes.

A. That's right.
Q. From yesterday, obviously.
As you'll know, just like yesterday, I will ask you questions. Your answers will be recorded by the court reporter to your left, and also recorded across the way by the videographer. To that end, please remember that we need to have verbal responses to questions so that our court reporter can record yeses and nos.
A. Yes.
Q. I think we did run into a couple of instances yesterday where we need to speak clearly --
A. Right.
Q. -- so that we can get to that.
They will certainly remind us if we have any troubles. Are you okay with that?
A. Yes.
Q. Okay. Very good.
I'm sure yesterday, I think I probably asked a few questions that I probably didn't state very well. Much like yesterday, if I do that today, I ask that you please let me know that a question is unclear to you for any reason --
A. Yes.
Q. -- and I will do my best to try to address the

point of unclarity for you.

A. Thank you.

Q. If you answer the question without doing that, then I'll just understand that you understood the question.

A. Right.

Q. Is that fair?

A. Yes.

Q. Just like yesterday, we'll plan to go for periods of about an hour, an hour and 15 minutes or so. If you need a break at any time, that's fine, please let me know. We'll do our best to accommodate that as quickly as possible. My only request to you, like yesterday, is if there is a question pending, that you go ahead and answer the question as fully and completely. The only caveat to that would be if there is an issue of privilege. It's not my desire to get into issues that are truly protected by an applicable privilege, but to the extent you can answer the question without doing that, I would like to go ahead and try to do that and we'll take the break. Is that okay?

A. That's great.

Q. Certainly, if you need to speak with one of the attorneys that are present in the room, you're more than welcome to do that. If there is a question outstanding,

those same instructions. Let's try to answer the question to the extent we can, without getting into the substance of any privilege content that you may feel is potentially invoked by the question. Is that okay?

A. Yes.

MR. DAS: Just to clarify, if you're not sure if privilege applies and you need to speak with Mr. Tullett or me, feel free to do that before responding to the question.

THE WITNESS: Okay.

BY MR. CRAIN:

Q. Each situation will be fact specific or it will be unique unto itself. So I'm sure we can work through it. I don't think we had a problem with it yesterday.

A. No.

Q. I don't think it came up yesterday. But again, I want to remind you, if you happen to recall information that may be responsive to an earlier question that you didn't share with me when the earlier question was posed to you, what I would like for you to do is stop the question or just stop us wherever we are, and go back and address whatever the prior information that's come to your mind may be. Once we feel like -- once you feel like we've exhausted that information and you've provided a full and complete response, based upon

your remembering new information, then we'll jump back to wherever we were. Is that okay?

A. That's great.

Q. Much like yesterday, we'll probably be talking about some documents. If you feel like there is a document that may help you frame a response, please let me know. I may have it. But I mean if you -- there were a couple times yesterday where maybe we don't have a document, but if you can at least identify it, that can be helpful to the process as well, to the best you can.

Dr. Ellis, do you happen to be taking any medications or can you think of any other reasons that might make it difficult for you to answer my questions today?

A. No.

Q. Can you think of any reason, Dr. Ellis, why you may not be able to answer my questions truthfully today?

A. No.

Q. Do you understand that you're under oath?

A. Yes.

(Exhibit 11 marked for identification.)

BY MR. CRAIN:

Q. I'm going to hand to you what we've marked as Exhibit 11. Would you please take a moment to review it

and let me know when you have completed your review.

A. Okay.

Q. Are you able to identify what appears to be Exhibit 11?

A. It appears to be the notice of this deposition.

Q. Do you recall if you've ever seen a document like Exhibit 11 before?

A. I think I have. Yeah, I've seen a document like it. I think I've seen this one before.

Q. Or a copy of it.

Do you have any understanding of whether or not Exhibit 11 is why you're here today?

A. I understand that's why I'm here today.

Q. I know we talked about some of these issues yesterday. I want to walk through some of them again. To the extent there is any differences, then we can talk about that. There may not be. That may help us move things along.

Dr. Ellis, can you describe for me what you did in preparation for today's deposition.

A. I reviewed some documents relating to my declaration, and I had discussions with my attorneys. So the attorneys.

Q. Do you recall what documents you reviewed in relation to your declaration?

MR. DAS: I'm going to object on privilege and work product grounds and instruct the witness not to respond.

MR. CRAIN: Let me see if I understand. You're not going to let him answer what documents he reviewed in preparation for his deposition?

MR. DAS: Yes.

MR. CRAIN: Under what basis?

MR. DAS: On the basis that that can go to our strategy and what documents we are showing him. Again, what documents he relied on in preparing his opinion, that's fair game, but what documents we have elected to show him to prepare for his deposition is not fair game.

MR. CRAIN: I didn't ask him what documents you showed him. I asked him what documents he reviewed.

MR. DAS: And the --

MR. CRAIN: So you're construing it to be that he reviewed no documents other than what you showed him?

MR. DAS: If you can respond to that question without getting into documents that were given to you by QSC's attorneys, then you can answer that question. But I would instruct you not to get into documents that were given to you to review by QSC's attorneys.

MR. CRAIN: All right. I disagree with that instruction, but let's see if we can -- what we can

parse out. Then we're going to come back to that issue.
MR. DAS: Sure.
MR. CRAIN: Because that objection was not lodged yesterday. And we got into, I think, a number of documents in the transcript. But we'll see.
BY MR. CRAIN:
Q. What documents did you review in preparation for your deposition?
A. I reviewed my declaration and the references that I -- the references that I make reference to in the declaration and the patent at issue.
MR. DAS: Who just joined?
MR. CRAIN: Robert, are you still there?
MR. GRAVOIS: I'm still here. I don't know what that was.
BY MR. CRAIN:
Q. When you reference -- that's a bad word -- when you reviewed the references that you make reference to -- if you can follow me there -- does that include all references that are recited or listed in your declaration?
MR. DAS: Objection, form.
THE WITNESS: I think so. If you want to show me the declaration, I can check.
BY MR. CRAIN:

Q. Well, it's at least your belief that you reviewed all of the documents that are referenced in your declaration?
A. Yes. I mean, the ones that I'm using as the basis for my -- for my points.
Q. When did you review the references that are identified in your declaration?
A. I reviewed them earlier this week.
Q. Was that on Tuesday?
A. That includes Tuesday.
Q. Again, to the extent we can streamline this from our discussion yesterday, I will try to do that, because I think it could help us conclude earlier. I understand, from your testimony yesterday, that you met with your attorneys on Wednesday, and then you did some review on Tuesday, if I understood you correctly.
A. Yes.
Q. So I'm just trying to understand, is this contemporaneous with that or not?
A. Yes.
MR. DAS: Objection to form.
BY MR. CRAIN:
Q. Approximately how much time do you recall spending on Tuesday with respect to your declaration or any of the references contained or referenced in it?

MR. DAS: Objection, form.

THE WITNESS: So on Tuesday, I was traveling out here for both yesterday and today's deposition. I was reviewing documents relevant to both events. The total time spent was eight to ten hours.

BY MR. CRAIN:

Q. Are you able to parse the amount of time that you spent reviewing the declaration and references related to the '544 patent in comparison to the '542 patent and its documents that you may have reviewed?

A. Not easily.

Q. Are you able to give me an approximation?

A. A first approximation would be that I spent equal time on both.

Q. Okay. What other documents did you review in preparation for your deposition?

MR. DAS: Again, if you can answer that question without getting into privileged issues, feel free to do so.

THE WITNESS: I don't recall any other documents.

BY MR. CRAIN:

Q. Are you testifying that you don't recall any other documents with the exception of any documents that may have been presented to you from your attorneys?

That's a yes or no question.

A. The only yes or no part is like -- I want to know if there is a privilege risk or waive the privilege --

MR. DAS: No, you can say --

THE WITNESS: But the answer is -- tell me the question again. I would like to answer the question.

BY MR. CRAIN:

Q. Sure. Are you testifying that you do not recall reviewing any documents other than what you've told me, with the exception of any documents that may or may not have been presented to you by your attorneys?

A. In the matter of the '544 patent --

Q. Correct.

A. -- I'm saying that there are no other documents.

Q. Including any documents that may or may not have been presented by your attorneys.

A. Sorry. Which one?

Q. Let's just try it this way: Yes or no, did your attorneys present documents for you to review in preparation for today's deposition?

A. Am I allowed to answer that?

MR. DAS: Yes.

THE WITNESS: They gave me -- when I met with them on Wednesday, they gave me a folder with the

documents that are referenced in my declaration. But I had already reviewed them on Tuesday. Because like I had my own copies.

BY MR. CRAIN:

Q. Were there any documents given to you by your attorneys that were not documents that you had already reviewed on Tuesday?

A. Not that I recall.

Q. Are you able to indicate how long you met with attorneys of QSC in preparation for today's deposition regarding the '544 patent?

A. So I met with the attorneys on Tuesday for -- from about 8:30 until 4:30, something like that. That was discussing both depositions. So some of it was spent -- some of it was relevant to this deposition.

Q. Now, you said Tuesday. Do you mean Wednesday?

A. I mean Wednesday. Thank you.

I also met with them this morning before we came in.

Q. Do you recall speaking to anyone else, other than QSC's attorneys, with respect to today's deposition?

A. I've spoken -- you know, I've mentioned to my family and friends incidentally that I'm coming out here to do this, but that's all.

Q. Did you bring any documents with you today?

A. No.
Q. You seemed to pause with that. So you did not bring any documents to today's deposition?
MR. DAS: Objection, asked and answered.
MR. CRAIN: Go ahead.
THE WITNESS: Yes. That's right. I didn't bring any documents with me today.
MR. CRAIN: Okay.
(Exhibit 12 marked for identification.)
(Exhibit 13 marked for identification.)
BY MR. CRAIN:
Q. Dr. Ellis, I'm going to give you two documents that we'll be referencing, I'm sure, throughout the day, marked Exhibit 12 and Exhibit 13. Go ahead and just take a few moments and let's look at both of them and see if we can identify them. That way, we can maybe be more efficient with our time.
A. Okay.
Q. Would you go ahead, please, if you're able, and identify Exhibit 12.
A. Exhibit 12 is the Corrected Petition for Inter Partes Review in the case of the patent, 5,652,544.
Q. Do you recall if you've ever seen Exhibit 12 before?
A. I'm not sure. I think I probably have seen it.

Q. Do you recall when you may have first seen it?
A. If I've seen it, it would have been, you know, in late 2013, probably -- or if I hadn't -- maybe I didn't see it then and maybe -- maybe I saw it first more recently.
Q. Do you recall if Exhibit 12 was one of the documents you reviewed in preparation for your deposition?
A. It was not.
Q. If you'll take a look at Exhibit 13.
A. Yep. This is my declaration.
Q. The answers may be similar to yesterday. But when were you first engaged with respect to your involvement in this matter on the '544 patent?
A. According to my recollection, it was sometime during the summer of 2013, late summer of 2013, I think.
MR. CRAIN: Let's go ahead and do one more document so that we're --
(Exhibit 14 marked for identification.)
BY MR. CRAIN:
Q. I'll give you that one, too.
A. Thank you.
Q. Dr. Ellis, you have what has now been marked as Exhibit 14.
A. Yes.

Q. When you're able, would you please identify it.
A. This appears to be the patent at issue, No. 5,652,544.
Q. Who contacted you in regard to your potential involvement in this matter?
A. As I recall, I was contacted by the -- I don't remember whether the initial contact was by phone or by e-mail, but by Attorney Tullett.
Q. Sometime in the summer or late summer of 2013?
A. That's my recollection.
Q. Did you enter into a written engagement agreement with QSC Audio with respect to your efforts to provide a declaration in this case?
A. I entered into a written agreement. I couldn't tell you for sure exactly who it was with. Obviously, my interaction was with the attorneys.
Q. When did you enter into this written agreement?
A. Shortly -- you know, within a few days or weeks of the initial contact.
Q. Could you describe for me your efforts from -- let me start again.
Would you describe for me your efforts that you engaged in after your initial contact from QSC Audio with respect to the '544 patent. Again, I'm not asking you for any communications you may have had with them,

but I'd like a description of your efforts.

MR. DAS: Objection, form. And again, just to clarify, don't get into privileged communications.

THE WITNESS: I reviewed some relevant documents and I discussed with the attorneys.

BY MR. CRAIN:

Q. Do you recall what the relevant documents were?

A. I recall the documents that I've mentioned in my declaration, that I've used in the declaration. There may have been others, but I don't recall any.

Q. Of the documents that are recited in your declaration that we have, do you recall which one or ones you would have reviewed subsequent to your initial contact? What I'm asking for is, do you remember specifically which ones you may have reviewed then? If it was all of them, it was all of them. If it was one or more, which ones do you remember? Does that make sense to you?

MR. DAS: Objection to form.

MR. CRAIN: Let me ask you the question again.

BY MR. CRAIN:

Q. Do you recall the specific documents from your declaration that you may have reviewed shortly after your initial contact from QSC's attorneys?

MR. DAS: Objection, form.

THE WITNESS: Let me think. Obviously, I certainly remember, you know, seeing the actual '544 patent. I don't remember the -- any particular details of the sequence or timing of the other documents.

BY MR. CRAIN:

Q. I'm sorry? What were you saying?

A. I don't recall any details about the precise sequence of the other documents.

Q. Well, let's walk through, as systematically as we can, with a description of your activities that commence with your involvement in the matter to your declaration. Okay? So would you explain your activities from the time from which you were engaged, and walk me all the way through when you completed your declaration.

MR. DAS: And I caution you not to get into privileged communications in that explanation.

THE WITNESS: I had some discussions with the attorneys. I reviewed some documents on my own, the documents we've discussed. I had further discussions and further review. And then I wrote my declaration.

BY MR. CRAIN:

Q. Are you being compensated for your efforts --

A. I am.

Q. -- with respect to your service in this case?

A. Yes.
Q. By whom are you being compensated?
A. My impression is I'm being paid by the attorneys' law firm. Presumably, ultimately I'm being paid by the petitioner.
MR. DAS: Dr. Ellis, I'm just going to caution you to let Mr. Crain finish his question before you start answering.
THE WITNESS: I'm sorry. Thank you.
BY MR. CRAIN:
Q. Have you ever spoken with anyone that is employed by the petitioner?
MR. DAS: Again, I would caution you not to get into privileged communications.
THE WITNESS: I don't know whether the attorneys representing the petitioner count as being employed by them.
BY MR. CRAIN:
Q. Let's exclude them.
A. No.
Q. How much are you being compensated with respect to your efforts on the '544 patent?
A. I'm being paid $250 an hour.
Q. Is there any adjustment in your rate depending upon the type of activity?

A. No.
Q. How many hours do you believe that you've worked with respect to your efforts on the '544 patent to date?
A. My recollection is that the work that I performed preparing the declaration, both for the '544 patent and the '542 patent, was a total of 20 hours, which was completed in 2013. This week, I've been engaged in additional work, which is now three long days worth, and then today.
Q. So, if I understand you correctly, approximately 20 hours of your time was spent in preparation of declarations on the '542 patent and the '544 patent.
A. Yes.
Q. And you may have mentioned it yesterday, but let's ask it again with respect to the '544 patent. Are you able to break out the 20 hours in any way to let us know how much of that time may have been devoted strictly to the '544 patent and your declaration for it?
A. It's not easy for me to do that, but it's reasonable to say that it's evenly split between the two.
Q. Did you tell me that you spent approximately -- was it eight to ten hours on Tuesday, in preparation for this deposition?
A. Yes. Well, in preparation for both depositions.

Q. Thank you for the correction.

Then, I think on Wednesday, it was pretty much an all-day effort with the QSC attorneys as well, in preparation for the '542 and the '544 depositions. Correct?

A. That's right.

Q. So is that approximately 20 hours or so, according to your estimation?

A. Yes.

Q. So, of that 20 hours, again, split roughly evenly between the '542 and '544 patents?

A. I think that's the most -- if we had to split them, that would be the way to do it.

Q. Like the '542 patent, have you invoiced your time with respect to the '544 patent in preparation for the declaration?

A. Have I invoiced the time spent preparing the declaration? Is that what you're asking?

Q. Yes, that's a better question.

A. I haven't invoiced them separately. I've made a single invoice for my work on both declarations.

Q. Right. And I think it was around $5,000, if I recall yesterday. So again, $2,500 or so would have been invoiced with respect to the preparation of your declaration in the '544 patent?

A. As I said, I didn't -- as I recall, I don't remember breaking it down. It's like there is a single invoice for the total work. It doesn't specify a breakdown.

Q. Have you received payment on the invoice associated with your services preparing the declaration on the '544 patent?

MR. DAS: Objection, relevance.

THE WITNESS: I've received payment for my single invoice for the work I conducted in 2013 in preparing the two declarations.

BY MR. CRAIN:

Q. With respect to the '544 patent and your preparation of a declaration in the '544 patent, did QSC's attorney identify any facts or data, which could include documents, to you that you considered in forming your opinions expressed in your declaration?

MR. DAS: Objection to form.

THE WITNESS: So what are you asking? Did they specify any facts that --

BY MR. CRAIN:

Q. Did QSC identify any documents to you associated with the preparation of your declaration for you to consider?

MR. DAS: Objection, privilege. I would

instruct the witness not to respond to that question.
MR. CRAIN: That's clearly allowed by Rule 26(b)(5)(ii). Facts and data provided by the party's attorney that the expert considered.
MR. DAS: That's not the question you asked. So you might want to reconsider asking your question.
MR. CRAIN: I believe it's the exact same thing.
MR. DAS: I instruct the witness not to answer that question.
BY MR. CRAIN:
Q. Dr. Ellis, please identify any facts or data -- and that would include documents -- that QSC's attorneys provided and that you considered in forming the opinions that are expressed in your declaration. And before you answer, considered would include documents even if they're not listed in your declaration.
MR. DAS: Objection, form.
THE WITNESS: So I'm confused, because it seems like you're asking me about the documents that were shown to me that were provided to me by the attorneys. It seems like that's an issue of privilege. And I understand there is some legal technical stuff going on about exactly which question you can ask and which you can't.
MR. DAS: Do you want to take a break and

discuss? We can do that.

MR. CRAIN: That's fine. If you need to. I mean, I'm going to stand on this. We're going to get through this. Because this is clearly allowed by the rules. If we need to, we can call the board.

MR. DAS: He's expressed confusion.

MR. CRAIN: That's fine. That's fine. If you need to take a break, sure.

THE VIDEOGRAPHER: We're going off the record. The time is 9:37 a.m.

(Recess taken from 9:37 to 9:44.)

THE VIDEOGRAPHER: We're back on the record at 9:44 a.m.

BY MR. CRAIN:

Q. Dr. Ellis, did you have an opportunity to speak with your attorneys during the break?

A. Yes.

Q. I understand that we took the break so that we could assess whether or not there may be an applicable privilege that may apply with respect to the questions that were asked before the break.

A. Yes.

Q. So let's ask the question again and see where we can get with it.

Dr. Ellis, please identify the facts or data

that QSC provided and that you considered in forming the opinions to be expressed in your declaration.

A. So you're asking specifically facts and data. Is that right?

Q. That's right. And as we said before, I believe that includes any documents that would be provided to you as well.

A. Okay. So the only material -- the only thing that's coming to mind that I used -- you know that I considered in forming my declaration is the documents that I refer to in my declaration. I think that's what I've said before. Although, I've just remembered another one.

Q. Okay. What's the other one?

A. There was a document describing an early experimental digital audio signal processing device manufactured at BBC Research in the mid 1980s. I remember seeing -- reviewing a document describing that.

Q. This document was provided to you by QSC's attorneys?

A. Not as I recall.

Q. We'll come back to that.

A. Yes.

Q. Again, seeking to focus on any documents that were provided to you that you considered. You should

understand, when I say considered, even if it's not referenced in your declaration, that you may have reviewed, then I take the position that that also includes considered.

MR. DAS: Objection, asked and answered.

BY MR. CRAIN:

Q. So are there any other documents that --

A. Not that I can recall. There are no other documents that I considered which would -- yeah. That's what I said.

Q. Dr. Ellis, would you identify for me any assumptions that QSC counsel provided and that you relied on in forming the opinions expressed in your declaration.

A. I can't think of any assumptions that I relied on in forming my declaration. But I, you know -- you could possibly help me by explaining what that counts -- what counts.

Q. Do you understand what an assumption would be?

A. I understand the common usage of the term, assumption.

Q. Based on your understanding of the common usage, applying it to my question with regard to any assumptions that QSC's attorneys may have provided to you, are you able to answer the question with that

understanding?

MR. DAS: Objection. Again, clarifying, the question is not assumptions that were provided to you; the question, I believe, is assumptions that you relied on. I just want to make sure that's the question. Because assumptions that were provided to you is privileged.

BY MR. CRAIN:

Q. I think the question -- just so your clear -- identify, please, any assumptions that QSC's attorneys provided and that you relied upon in forming the opinions expressed in your declaration.

A. I can't think of anything that would fit that description.

Q. I think yesterday, in talking about the '542 patent, you indicated that you were familiar with the concept of invalidity contentions.

A. Yes.

Q. Do you recall, as part of your efforts in forming your declaration, ever reviewing any invalidity contentions with respect to the '544 patent?

MR. DAS: Again, I instruct you not to answer that on privilege grounds.

MR. CRAIN: So let's play this out. If he reviewed QSC's invalidity contentions, and they were

provided by you, QSC, you're taking the position that he cannot tell me that?

MR. DAS: Yes.

MR. CRAIN: Under what basis?

MR. DAS: Because it could be work product. You can ask him what opinions and what assumptions he relied on in forming his opinions. You can ask him about what documents he relied on in forming his opinions. You can't ask him about what documents we may otherwise have provided him. Rule 26 doesn't allow you this broad fishing into what documents or what facts were provided to the expert unless the expert relied on it or considered it in forming his opinion.

MR. CRAIN: And I don't see how you could possibly contend that he would not have considered the content in QSC's invalidity contentions in forming the nature of his opinions.

MR. DAS: It doesn't matter what I contend.

MR. CRAIN: Is that your contention?

MR. DAS: No. My contention is the question you've asked seeks privileged information.

You can reask the question and not have it be privileged, but the question you've asked seeks privileged information.

BY MR. CRAIN:

Q. Let's try it this way, just to make sure:
Did you consider QSC's invalidity contentions in forming the opinions expressed in your declaration?
MR. DAS: Objection, lacks foundation, but you can answer.
THE WITNESS: I don't -- I don't really know what you're talking about as QSC's invalidity contentions. I'm not aware of being -- you know, of that specific concept.
BY MR. CRAIN:
Q. Have you ever seen a document identified as QSC's invalidity contentions? Yes or no?
A. Not as I recall.
Q. To be clear, have you ever seen a document pertaining to QSC's invalidity contentions related to the '544 patent in any venue?
MR. DAS: Again, I would caution you, yes or no response to that.
THE WITNESS: Not as I recall.
BY MR. CRAIN:
Q. Do you recall ever having the occasion to review or consider QSC's invalidity contentions prior to today?
MR. DAS: Objection, form. Objection, privilege.
BY MR. CRAIN:

Q. Yes or no.
A. No.
Q. Did you do any research into the '544 patent as part of your efforts to prepare your declaration?
MR. DAS: Objection, form.
THE WITNESS: Yes.
BY MR. CRAIN:
Q. Describe the research that you did with respect to the '544 patent in preparing your declaration.
A. I was interested to see what contemporary digital audio signal processing devices there were and I tried to find some documents describing them.
Q. Where did you go to try to find the documents?
A. I used a web search.
Q. Do you remember the search that you ran or searches that you ran?
A. No.
Q. Was this a Google search?
A. Probably.
Q. What other searching mechanisms might you have used if it wasn't a Google search?
A. There is a search interface to the AES. AES has an interface for searching their publications.
Q. Did you use the AES search interface with regard to --

A. I think so.

MR. DAS: Again, Dr. Ellis, please let Mr. Crain finish his questions.

THE WITNESS: Yes.

BY MR. CRAIN:

Q. What documents did you discover through the AES interface search that you ran?

A. I don't recall. I don't recall any -- I don't recall any important documents coming out of that.

Q. Do you recall any documents coming out of that?

A. Yes.

Q. Are you able to describe or identify them?

A. I cannot identify them, but I can tell you the sort of things they were.

Q. Okay.

A. Which were -- the sort of things I was looking for were papers that discuss or relate to digital audio signal processing devices in the years leading up to the -- to this patent.

Q. Do you recall how many documents you discovered in your AES search, even though you deemed them to be unimportant?

A. I have a recollection of going through several screens of titles. So maybe -- maybe dozens of documents. But only a small number of those would I

have actually taken the extra step to look at the document.

Q. Do I understand you correctly that you're not able to identify any of the documents from the AES search, even the small number that you had actually taken the extra step to look at?

MR. DAS: Objection, form.

THE WITNESS: I recall looking at one document from the AES site that was an overview paper of then current developments in digital audio signal processing. I don't recall any more detail, but if I had to find it again, maybe I could.

BY MR. CRAIN:

Q. Sorry?

A. If I had to identify which one it was again.

Q. How would you go about trying to identify it again?

A. I would attempt to go through the process of trying to recall the kinds of search terms I would have used and looking at the results and seeing if one reminded me of that one.

Q. Do you remember any authors of any of these documents?

A. No.

Q. Was the AES interface the only resource that you

sought to find documents related to the '544 patent?
MR. DAS: Objection, form.
THE WITNESS: I also -- I think I -- I think I also used the Google search interface.
BY MR. CRAIN:
Q. I thought you did, but I wasn't sure. So I had to get there.
Do you remember the search or searches you ran on Google?
MR. DAS: Objection, asked and answered.
THE WITNESS: Not in any detail.
BY MR. CRAIN:
Q. Do you remember any documents that may have been returned to you from your Google search or searches?
A. I remember one document which described an early digital audio signal processor developed by the BBC.
Q. That was the one you referred to maybe ten or fifteen minutes ago?
A. Correct.
Q. Do you remember the author of that BBC paper?
A. No. I think it may have been, you know, corporate author, BBC Research.
Q. Why did you not reference the BBC Research paper in your declaration?
A. It was not -- it didn't provide anything

particularly useful over my other references.
Q. Are there any other efforts that you can describe with regard to researching the '544 patent that you've not already shared with me?
A. I thought about my own experience in that period of working with digital audio signal processing devices.
Q. Did you speak with anyone -- not attorneys of QSC -- with regard to research on the '544 patent?
A. Not as I recall.
Q. I understand that you have -- your department at Columbia has some very talented and well-informed people in some of these areas from your testimony yesterday. Why didn't you speak with some of them with respect to your efforts to research the '544 patent?
A. In this material, I would consider myself the most relevant expert among my colleagues at Columbia.
Q. Dr. Ellis, why would you consider yourself the most relevant expert among your colleagues at Columbia with respect to the teachings of the '544 patent?
A. The patent is about digital audio signal processing. That's -- I'm the person who does that at Columbia.
Q. So not only did you not speak to anyone at Columbia, but I take it then that you really didn't communicate with anyone else with regard to your

research; again, excluding the attorneys?

A. I can't think of anyone.

Q. As a result of any of your efforts to research the '544 patent, did you find anything that you would consider to be prior art?

MR. DAS: Objection, form.

THE WITNESS: You know, forgive me that I'm not -- I'm not as well versed in the strict definition of a term like prior art as you would be. But I mentioned this BBC digital audio signal processor. That is a very similar device or a relevant device that precedes this patent, as are the other -- you know, some of the contents of the other references I've described.

BY MR. CRAIN:

Q. Thank you for bringing up the issue with regard to prior art.

A. Yeah.

Q. Would you share with me what your understanding of prior art is.

A. My understanding is that it's something that has already been disclosed or that is known that is relevant to the -- relevant to the content of the patent.

Q. Using your definition of prior art --

A. Yeah.

Q. -- did you identify any documents that are in

your opinion -- or your declaration, that is?

A. Yes. I identified all the documents, those being relevant in terms of prior art.

Q. What I'm asking is, how did you come to discover the documents that are referenced in your declaration?

A. Does this get into issues of privilege?

MR. DAS: No.

THE WITNESS: These documents were shared with me by the attorneys. I think. Let me see.

BY MR. CRAIN:

Q. It may be helpful for you, Dr. Ellis --

A. Sorry.

Q. No. Go ahead. We can probably get there a couple different ways. Go ahead.

A. I'm not sure about the TMS320 data sheet. That may have been -- I'm not sure about the TMS320 data sheet which I referenced. That may have been something that I discovered in the course of the research that we've been discussing.

Q. Before you move on, what makes you unsure about that?

A. Well, I -- I own a copy of it.

Q. Of the TMS320 second generation digital signal processors --

A. Yes. I mean, I'm not sure if it's that exact,

but I own documentation relating to that device.
Q. What is the purpose for why you own that documentation?
A. It's of interest to me.
Q. Have you ever had occasion to work with the digital signal processor that may be known as TMS320?
MR. DAS: Objection, form.
THE WITNESS: I'm not sure. I've worked with several different digital signal processors. I can't recall the exact ones.
BY MR. CRAIN:
Q. I'm just trying to understand why it is that you happen to have that data sheet.
MR. DAS: Objection, relevance.
You can answer.
THE WITNESS: It's actually something of, you know -- it's an interest of mine. I like -- it's a nice historical artifact.
BY MR. CRAIN:
Q. What makes it such a nice historical artifact?
A. Because it -- you know, it's symbolic of the dawn of the DSP revolution.
Q. That's interesting. What is the DSP revolution?
A. The DSP revolution is the -- the increasing -- you know, the transition to using digital signal

processors in practical applications.

Q. When did the DSP revolution begin?

A. I would say -- you know, it has its origins in the 1960s.

Q. Walk me through that. Tell me about that.

MR. DAS: Objection, form.

THE WITNESS: So in -- to my knowledge, it was not until the 1960s that people started actually thinking about trying to process signals, including audio signals in a digital form on a computer. But then as those ideas developed over several decades and as the technology became faster and cheaper, the kinds of applications that were possible became broader and broader, and the applications for which it made good engineering sense to use a digital signal processor rather than say the preceding analog technology also became broader.

BY MR. CRAIN:

Q. What were some of the first applications for digital signal processors that you can recall or have knowledge about?

MR. DAS: Objection, form.

THE WITNESS: You're asking about digital signal processors, which means hardware specialized for calculating digital signal processing functions.

Correct?
BY MR. CRAIN:
Q. I don't know. Is that what digital signal processors are?
MR. DAS: Objection, form.
THE WITNESS: That's one definition.
BY MR. CRAIN:
Q. What are the others?
A. Any computational device which is performing digital signal processing function.
Q. So would you consider a central processing unit also to be a digital signal processor?
MR. DAS: Objection, form.
THE WITNESS: If the central processing unit is performing the arithmetic operations which are -- which constitute signal processing, then it would be a very -- it would be a reasonable way to describe it.
BY MR. CRAIN:
Q. So my question to you was: What were some of the first applications for digital signal processors that you can recall or that you have knowledge about?
And then you stated: You're asking about digital signal processors, which means hardware specialized for calculating digital signal processing functions. Correct?

Yes, I am.

A. Okay. I think one of the earliest applications was the TI Speak & Spell, which was a voice synthesis device that came out in the mid 1970s.

Q. That was a kids' toy?

A. That's correct.

Q. I remember that.

What others can you remember, moving forward in time?

MR. DAS: Objection, form.

THE WITNESS: There are earlier ones. I mention that one because it was maybe the first really mass market application that I can think of. Certainly even before that, I can think of instances where DSPs were used for things like specialized speeding up and slowing down of speech recordings, something I happen to know about.

BY MR. CRAIN:

Q. Could you give me a specific example of that and a time.

A. I have a recollection that there is a paper discussing a box built, I think, by BBN, Bolt Beranek & Newman, in maybe 1972 that does voice speed conversion.

Q. Do you have any understanding of what the digital signal processors, the actual physical devices,

of their architecture in these devices that you're discussing?

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: I have some understanding of the early implementations of digital signal processors, special-purpose digital signal processors.

BY MR. CRAIN:

Q. Would you please try to describe these early digital signal processors and perhaps their evolution over time.

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: The reason that digital signal processor specialized hardware developed was because digital signal processing specifies a number of algorithms which can easily incorporate a large number of multipliers and additions, even for just a relatively simple function, in contrast to other applications that computers may be used for which would not require so many -- such a high density of these operations. So the field of specifically developing digital signal processors is concerned with the issues of building specialized hardware to do just that limited task, multiplication and addition of numbers, but to do it rapidly and at a constant rate, typically.

The earliest -- as I understand, the earliest

implementations relied on so-called bit slice devices which, as I understand, are digital logic devices, which aren't quite a whole microprocessor, but kind of smaller components that you can put together that will end up giving you a more complete digital processing system. These were very inflexible. So the development of digital signal processor hardware is mainly about -- well, it's about two things -- well, three things. Making them more flexible and easier to program, making them faster, making them cheaper.

BY MR. CRAIN:

Q. Do I understand you correctly to say that earlier DSPs were inflexible?

A. Yes.

Q. Is that because they were not as fast, they were more expensive, and they were difficult to program?

MR. DAS: Objection, compound.

THE WITNESS: It doesn't relate to their speed and cost. It only relates to their -- their flexibility, which includes how difficult they are to program.

BY MR. CRAIN:

Q. I was just giving you those three reasons back to see.

A. Yeah.

Q. So the programming ease or difficulty, do I understand you correctly that that has been a -- I don't know if it's been an impediment or an issue in the development of DSPs. That may not be the correct way to say it.

MR. DAS: Objection, form.

THE WITNESS: In my understanding, when you're working with a bit slice processor, a bit slice system, it's not even really recognizable as programming. It's more in a gray area between building hardware and programming. So that's why I mean they were not very flexible. By the end of the 1970s, as I recall, we had devices that were more -- were much more recognizable as more or less conventional microprocessors with additional specialized multiply and accumulate hardware.

BY MR. CRAIN:

Q. Has the progression of digital signal processors allowed for the inclusion of more components in what we might today call a digital signal processor chip?

MR. DAS: Objection, compound. Objection, form.

THE WITNESS: Normally, when we talk about components in electronics, we're talking about individual physical things. So the chip would just be one component. It doesn't contain components.

BY MR. CRAIN:

Q. When I was thinking of components, I was thinking more like logical, functional components.
A. Certainly the development of all digital logic is an incessant increase in the number of gates included, transistors.
Q. Did earlier DSPs, according to your understanding, say include on-board memory, on the chips?
MR. DAS: Objection, form.
THE WITNESS: I can't speak to bit slice processors. It seems -- I can't -- it seems likely that -- I'm having difficulty imagining a DSP chip that doesn't have any on-board memory. They probably did exist, but that would be something you would want to incorporate.
BY MR. CRAIN:
Q. Memory, that is?
A. Yes.
Q. Well, and -- I'm just trying to gain an understanding from you what earlier digital signal processors looked like. You mentioned some devices maybe in the '70s. I don't know if you have an understanding of their architecture or design or not. Maybe you do. What they would have looked like. Maybe they would have had on-board memory or maybe they

wouldn't have. I don't know.

So let me see if I can ask it this way: You mentioned a Speak & Spell device, I believe.

A. Yes.

Q. Do you have any understanding, just from your experience, about the form or design of the DSP used in that device?

A. Unfortunately, not any level of detail.

Q. Do you have any understanding with respect to DSPs that may have existed in the 1970s?

A. Yes.

Q. Which ones would you feel most comfortable talking about?

A. I can't recall the names, the designations of any of these chips, but I have an idea of when -- you know, the chips that I've discussed, which are -- more or less look like my contemporary microprocessors with additional hardware to make them specialized for DSP operations. I think they emerged before 1980.

MR. CRAIN: Let me see if this helps our discussion at all.

(Exhibit 15 marked for identification.)

BY MR. CRAIN:

Q. Dr. Ellis, you have Exhibit 15 in front of you. I see you've taken a moment or two to review it. Are

you able to identify it?

A. It's some technical documentation describing the Texas Instruments TMS320, some chips within that series. The TMS320 is more of a brand than a particular device.

Q. I think you mentioned or seemed to express an affinity for the TMS320 earlier, that it had a special significance to you.

A. I said that I own one.

Q. What you're referring to about what you own, is that also the same as what we see in Exhibit 15?

MR. DAS: Objection, form.

THE WITNESS: The device that I'm thinking of is one of these devices, yes.

BY MR. CRAIN:

Q. And you mentioned something about maybe this TMS320 has either broad application or is a name used for many devices. Did I understand you correctly?

A. That's right. Yes.

Q. Does the name TMS320 second generation digital signal processor mean anything to you?

A. It could mean a couple of things. It could mean that this is the second generation of the TMS320. It could mean that this is a second generation digital signal processor. People in industry are fond of labeling generations.

Q. Okay. Are you familiar with the various generations that people consider with respect to digital signal processors?

MR. DAS: Objection, form.

THE WITNESS: I'm not -- it's not that interesting to me. That's more of a marketing consideration.

BY MR. CRAIN:

Q. But I asked you if you had familiarity, even though it may not be of interest to you.

A. Oh. I -- I -- I wouldn't be able to tell you what the difference between a first generation and second generation digital signal processor is.

Q. Why not?

A. As I say, you know, understanding the generations is not that important to me.

Q. The TMS320 that you believe -- that you indicated that you own, do you know if it's this TMS320 second generation digital signal processor?

A. Yes.

Q. And how do you happen to know that?

A. I believe it's a TMS320C25.

Q. In having the opportunity to review Exhibit 15, does this refresh your memory on whether or not you may have been the person to identify what we see in

Exhibit 15?

MR. DAS: Objection, form.

THE WITNESS: It doesn't -- no, it doesn't -- it doesn't change my understanding, which is like I think I may have been.

BY MR. CRAIN:

Q. So you remain uncertain?

A. Yeah.

Q. Can you give me any understanding, based on your knowledge and experience with digital signal processors, of how the DSP we see in Exhibit 15 may vary from the digital signal processor in, for example, the Speak & Spell device that you referred to earlier?

MR. DAS: Objection, form. Objection, foundation.

THE WITNESS: I'm sure it's a faster device. I'm sure this one represents a faster, able to perform more computations in a fixed amount of time.

BY MR. CRAIN:

Q. So speed. What else?

A. I'm sure -- I expect it has both larger memory on board and the ability to access larger external memory. And it probably has -- I assume it has an expanded instruction set. The Speak & Spell may not have been -- it may not even make sense to talk about

its instruction set, but if so, then this is a much -- a greatly expanded instruction set.

Q. Anything else that you can think of?

A. It's implemented using more advanced silicon -- you know, more -- a finer line width in the silicon chip and probably more advanced chemistry to etch the chip. The packaging is different. I'm sure they didn't have these kinds of 68-pin devices in the Speak & Spell.

Q. What is an instruction set?

A. An instruction set is the -- it's the core set of commands that a programmer can employ to instruct the -- a microprocessor to do a particular task. It's like the vocabulary of the program.

Q. Is that a standardized thing among DSPs?

MR. DAS: Objection, form.

THE WITNESS: That's an interesting question. So if you're building a DSP chip, if you're the manufacturer like Texas Instruments, part of that is you get to design the instruction set. You get to define it. And when you're doing that, you -- it's a compromise between what you can feasibly implement in your hardware and what's going to make it easier for a programmer to write in what they want to use.

In the nature of this technology where new chips, better-performing chips may come out every year

or two, on the one hand, you want to give the programmer the opportunity to exploit the added capabilities of your new device. On the other hand, you want to try and retain whatever audience or constituency of developers are already using your devices. So that means that you want to maintain some consistency in the programming model, the instruction set, et cetera, that they're used to.

In addition, there are some standard operations that any digital signal processing chip needs to perform, such as the multiply and addition operation that I mentioned before.

So there is no -- there is no formal standard, but different manufacturers will try and both maintain consistency within their own successive devices, and, of course, they will also -- there will be some compatibility or analogy between the instruction sets of the families of devices from different manufacturers, both because -- if someone -- if a competitor comes up with a good idea, they're going to want to incorporate it. And, you know, if they want to try and draw market share away from their competitors, then they want to make sure that the people working with competing products don't feel like it would be too difficult to transfer.

BY MR. CRAIN:

Q. That's kind of what I want to focus on now, between two different manufacturers of DSPs.

Can you think of another manufacturer of DSPs that would have been contemporary to what we see in Exhibit 15?

A. Yes.

Q. Can you give me an example of one.

A. I'm thinking of Motorola.

Q. Is there a specific chip design?

A. I'm thinking of the Motorola 56000 series.

Q. Is that a well-known DSP of that time?

A. Yes. I mean, it's not -- it's, you know, like the TMS320. There were a good number of chips that were in that family. But it's very much the big market competitor to the TMS320. Possibly the TMS320C20 generation.

Q. Now, based on your understanding -- well, let me back up.

I think you have indicated that you really consider yourself to be kind of the DSP guy at Columbia.

A. That's correct.

Q. Do you own the Motorola chip that you referenced?

A. I don't. Although, I have worked with it.

Q. That's what I was going to ask. Some people, like with automobiles, Porsche, Corvette, or something like that. Right?

A. That's right.

Q. Is that kind of true with DSPs, that people have maybe brand allegiance?

A. Not really like that. I think people have brand allegiance, but not for reasons of romance or sentimentality.

Q. DSPs aren't very romantic?

A. Well, no, not to many people. But the manufacturer will have a whole ecosystem and people will be familiar with that, which will incline them to stick with that.

Q. Based on your understanding of DSPs -- and specifically, we'll use as an example, the TMS320 that maybe you own, in comparison to the Motorola 56000 --

A. Yes.

Q. -- that you've also worked with and have familiarity -- can you share with me any understanding that you may have with respect to how hard it would be to take one chip and replace it with the other for a given application.

MR. DAS: Objection, form.

THE WITNESS: Replacing a chip would require

redesigning the circuit board.
BY MR. CRAIN:
Q. Why is that?
A. There is no standardization of the pin-outs on these chips. It's not like, oh, we're going to make a compatible chip you can just plug straight in instead.
Q. What is a pin-out?
A. The pin-out is the device. It has a bunch of little metal conductors coming out of the side or coming out of the bottom. Each of those has a specific function. That's what we call a pin-out.
Q. Can you show me -- is the pin-out represented in Exhibit 15 anywhere? Can you flip through it and see if you can find it?
A. This picture we're looking at on page -- on the face, you see the lower large square has --
Q. I do.
A. -- a number of -- it has -- in the inside of the square, there are a set of numbers, which are the pin numbers. On the outside of the square, alongside each number is a short label which identifies the function of that particular pin. That's the pin-out.
Q. Let's turn to the back and see if maybe we can further amplify this. This is very interesting.
A. Isn't it?

Q. Sorry?
A. Isn't it?
Q. Page 55. I can tell we're in your wheelhouse.
A. Yes.
Q. Your smile gives it away that you really seem to like these things.
Does 55 show us a pin-out? Page 55.
A. Yeah. So 55 shows us where the pins are for a different form of the device. It doesn't give us the labels. There would be additional information indicating which of these particular functions that are shown on the FN and FZ package diagram on page one, how these would appear on this GB package. I think the only -- there is a picture of the GB package on page one. I think the only reason they didn't label the pin functions is it's difficult to fit it in, into that picture.
Q. Well, going back to page one, I think you were showing me the bottom image or pointing to the bottom image as the pin-out.
A. Yes.
Q. The lower image, that is.
What does the upper image show?
A. The upper image shows the physical form of a GB package.

Q. So does -- for example, in the upper image, do I understand that I can correlate -- well, let me lay the foundation here.

What do the black circles inside the -- it looks like a square -- almost a square -- appear to be to you?

A. They indicate where pins -- metal posts that are connected to the chip inside -- where they stick out the bottom of the package.

Q. Is there a way to correlate the pin to what's shown in the image below, the lower image?

A. No. In all likelihood, there is an exact one-to-one correspondence, that every one of those black dots corresponds to one of those pins in the lower image. But without having a table, we wouldn't know which one was which.

Q. Would you expect there to be such a table in the document?

A. I would.

Q. Let's see if we can find it. This is helpful.

A. All right.

It's not here. I don't find it.

Q. Okay. I don't think it's crucial to our understanding.

A. Okay.

Q. It would have just been helpful.

Turn to page 56 of Exhibit 15.

A. Yes.

Q. Do we see the pins of the DSP of Exhibit 15 on page 56?

A. Yes.

Q. Would you identify them, please.

A. So this is two views, a top view and a side view. We can see them in both views. In the top view, we can see the top of each of the pins -- of each of the four rows of pins -- the individual pins in the four rows. In the side view, we can see the edge -- it's the side-on view of one row of pins, and we can see the edge-on views of two other rows of pins; but because we're looking at them edge on, we only see one pin.

Q. Hold on to that.

A. Yeah.

Q. Would you put a line out and just label what you've circled. You're calling them pins. So if you want to call them that, that's fine. If you'll just identify them by what you'd like to call them.

A. (Complies).

Q. Would you the turn to page 55. Let's do it there as well. Because I think we get a different understanding of the pins.

Before you do, specifically point me to where

you see pins. Show me.

A. These are the pins seen from the side and these are the pins --

Q. Kind of the middle image?

A. Yes.

Q. The side view?

A. And these are the pins seen from underneath, end on.

Q. Would you mark them for us.

A. Sure.

MR. DAS: Mr. Crain, we've gone an hour and 45 minutes.

MR. CRAIN: Have we really?

MR. DAS: Yes. We've been having way too much fun with pins.

MR. CRAIN: This is awesome. Let's take a break.

THE VIDEOGRAPHER: This is the end of Media No. 1 in the deposition of Dr. Daniel Ellis. The time is 10:45 a.m. We are now off the record.

(Recess taken from 10:45 to 11:09.)

THE VIDEOGRAPHER: This is the beginning of Media No. 2 in the deposition of Dr. Daniel Ellis. The time is 11:09 a.m. We are back on the record.

BY MR. CRAIN:

Q. Dr. Ellis, during the last break, did you have an opportunity to consult with QSC's counsel?
A. I had the opportunity.
Q. Did you consult or confer with QSC's counsel regarding any of your prior testimony?
A. No.
Q. Did you consult or confer with QSC regarding the substance of any testimony that may be anticipated to be given?
A. No.
Q. And during the break, did QSC's counsel suggest to you the manner in which questions should be answered?
A. No.
Q. If you'll return to Exhibit 15. We were talking about pins.
A. Yes.
Q. Remind me again, what is the purpose of the pins in this TMS320?
A. The pins are to connect the DSP chip to other devices in the whole circuit.
Q. I think we kind of got into this because we were talking about how easy or difficult it might be to take this TMS320 and replace it with say a Motorola 56000 in a given board or application. Do you remember talking about that?

A. Yes.
Q. If I understand you correctly, I think you indicated that it would be extremely difficult?
A. Yeah. My understanding is it would require a redesign of the board.
Q. The board that the DSP connects to?
A. That's right.
Q. How does this DSP that we see in Exhibit 15 connect to the board?
MR. DAS: Objection, form.
THE WITNESS: So the document describes several different packages which would have different ways of connecting.
BY MR. CRAIN:
Q. Can you point me to where in the document it discusses that issue.
A. Oh, the picture on the front shows these two different packages, which would have different ways of connecting to a board.
Q. Please describe them for me.
MR. DAS: Objection, form.
THE WITNESS: In these cases -- I think in both of these cases, there would be a socket on the board that the device fits into.
BY MR. CRAIN:

Q. Is the socket a standard-type socket for any type of DSP?
MR. DAS: Objection, form.
THE WITNESS: The socket is specific to the -- to the mechanical form of the chip. In this case, a 68-pin GB or a 68-pin FN or FZ.
BY MR. CRAIN:
Q. Are those standard packages?
MR. DAS: Objection, form.
THE WITNESS: Yes. These are not the only chips that have this form.
BY MR. CRAIN:
Q. How is a chip secured in a socket?
MR. DAS: Objection, form.
THE WITNESS: Usually by friction.
BY MR. CRAIN:
Q. What do you mean?
A. There is mechanical -- the pins will mechanically touch the socket, which is how the electrical connection is made, because of two pieces of metal pushing against each other. And then there will also be friction associated with that pushing together, which will hold the -- can hold the chip in.
Q. So is it your understanding that some type of securing like soldering is required or not required?

A. In the case of these devices, they would not require soldering. It's quite likely that these chips were also released -- ultimately released in packages that did require soldering, thereby avoiding the expense of a socket.

Q. So does Exhibit 15 demonstrate or illustrate configurations that do require sockets?

A. Yes.

Q. Would you turn to page 59, please.

A. Yes.

Q. Would you please take a moment to review page 59 of Exhibit 15.

A. Yes.

Q. Can you explain to me what page 59 appears to depict to you.

MR. DAS: Objection, form.

THE WITNESS: Well, according to the caption, it's showing how to connect the DSP chip -- a particular version of the DSP chip -- to -- let me just read the previous page to get the context.

It shows how to connect to the pins of the TMS320E25 to make it appear as a different chip, an EPROM chip, the TMS27C64. Based on my review, that's what I believe is happening. The diagram shows -- so on page 58, there is a picture of a device, and I think

this is the wiring of that device.
BY MR. CRAIN:
Q. You're referring to Figure 8 on page 58?
A. That's right.
Q. What do you understand Figure 8 to be?
A. It's the EPROM adapter socket. It's a socket that you can plug the -- put the chip into, which then provides extra pins on the bottom which allow you to plug that whole assembly into an EPROM programmer.
Q. Do you have any understanding of why -- let me ask it again a different way. Do you have any understanding of the purpose of having an EPROM cell?
MR. DAS: Objection, form.
THE WITNESS: Yes.
BY MR. CRAIN:
Q. Why?
A. It allows you to change the program on the DSP chip. It allows you to change the program stored in the internal -- one of the internal memories of the DSP chip.
Q. Is there -- on page six -- let's turn to that. If that's not the one, maybe you can show me another page. Does page six illustrate what is contained on the TMS320 DSP chip depicted in Exhibit 15?
A. This is the functional block diagram which

shows, in schematic form, the main functional units that are part of the chip.

Q. Do you see, on kind of the center, upper half of the page, a block that has the words, "Address, program ROM/EPROM"; in parens there, it says, "4096 X 16."

A. Yes.

Q. Do you have any understanding of what that functional block relates to?

A. That's the internal read-only memory that I was referring to.

Q. That you were referring to that is resident on the chip, itself?

A. When we were discussing the pin-out on page 59, I was saying it was to allow for programming of one of the internal memories of the chip, and that's the one, the one that you just described.

Q. Are there any other memories that you are able to identify in the functional block diagram on page six?

A. Yes.

Q. Where are they?

A. Well, I -- I haven't gone through all the units, but I see two -- two boxes containing the word RAM, R-A-M, towards the bottom. One is the Data RAM, Block B1 and Block B2; and the other is called the DATA/PROG RAM, Block B0.

Q. Do you feel like you have any understanding of what those two blocks you just identified do in the DSP?
A. Yes.
Q. Please share that with me.
A. So RAM stands for random access memory, which means memory that you -- which actually means memory that can be both read and written on the time scale of individual instruction cycles. The Data RAM is specifically to hold data values, such as the sampled values of signals. The DATA/PROG RAM is separate because it can either be used to hold data that would then be used as part of the algorithm, or it can be used to hold the program -- the actual algorithm that's being executed.
Q. Now, are either one of these devices that you've identified as RAM or types of RAM non-volatile memory?
A. These would be normally considered volatile memory. Of course, non-volatility is not necessarily an intrinsic property of the memory. It's a property of the entire implementation. So if you provide -- if you have a memory chip that, under certain conditions, will lose its memory, you can say it's the volatile memory; but if you embed it in a system that prevents it from losing its memory, then you've got a non-volatile memory.

Q. Do you see any other memories other than the three we've identified so far?
A. There are a bunch of buffers or registers, I guess. Like the AR0, these are registers. The stack, these are registers. They are similar to memory, because they hold binary numbers, but they are smaller, they have fewer bits.
Do I see any others? There are other registers described. But that's it.
Q. Do you have any understanding of whether these buffers and registers that you're speaking about are non-volatile memory?
A. They are not.
Q. Do you see yet any other types of memory in the functional block diagram of the TMS320 shown on page six of Exhibit 15 that we've not already identified?
A. No.
Q. I don't think -- let's go back and look at the first one that we were talking about, the Program ROM/EPROM. Do you have any understanding of what that component appears to be?
A. Yes.
Q. Please explain.
A. It's a memory for storing the program to be executed, which is either a mask programmed ROM, where

the program is stored -- is defined at the time of manufacture of the device; or it's an EPROM, a programmable read-only memory, where the program can be written into the device after it's been manufactured.

Q. Do I understand you to say that the functional block diagram that you're focusing on as ROM/EPROM could be either/or?

A. That's correct. And it's not that I don't know which one it is, but they're using this to cover both of those cases.

Q. What's your understanding, if you have one, on why the memory might actually be a ROM and not an EPROM?

A. The reason would be if you developed a program and you don't -- you want to mass produce it, then the cheapest way will be to have it specially manufactured -- if you're manufacturing very large volumes, to have it as a mask programmed ROM.

Q. What's cheaper about that?

A. It's probably simpler. It's probably a simpler circuit. And then, of course, you know, if you were going to use the EPROM, you would then have to actually program that ROM for each device that you manufactured, as a subsequent stage to manufacture.

Q. I don't understand that last statement.

A. So we could take the chip with the EPROM, we

could -- it comes off the production line. We have the program that we want to write into the read-only memory. We take the chip and put it into the programmer or somehow arrange it in circuitry that performs the programming, and then we write the program in. If we didn't have the EPROM, if it was part of the actual manufacture process, then the chip that came out of the manufacturing would already have the program in it.

Q. Is ROM non-volatile memory?

A. Yes.

Q. Is EPROM non-volatile memory?

A. Yes.

Q. Does -- according to your understanding -- Exhibit 15 give us any additional information about the ROM and the EPROM, about the type?

A. It probably does. It might not. As we noticed with the pin-out, this is clearly marked, "Advance Information." So there may be some details which are simply not included.

Q. Well, based on your understanding of Exhibit 15, what would you understand the ROM to constitute?

A. I would understand ROM to be the situation where it's mask programmed.

Q. What is your understanding of what the EPROM would constitute if it were EPROM and not ROM?

A. That would mean a different device where that memory was in the form of a programmable read-only memory.

Q. And we talked yesterday about a couple of different types of EPROM -- or EPROM, and I think the comparison between what's known as EPROM and EEPROM. Are you able to tell us what may be included or excluded by the EPROM shown in the functional block diagram on page six?

A. Sorry. There is no mention of EEPROM in this document. Okay?

Q. How do you know that?

A. Oh, sorry. I don't. I'm not aware of -- I haven't noticed any mention of EEPROM in this document.

Q. Well, you said that with such seeming sureness, I thought maybe you had checked.

A. I would have expected it to be something that they put on the headlines on the front page.

Q. In that they apparently have not, then what does that leave you, according to your understanding, as to what an EPROM is, in this situation?

A. You know, all I can say is the E in EPROM is for erasable. The P is for programmable. I don't know how they're going to do the erasing.

Q. Do you know whether or not the EPROM referenced

in the functional block diagram speaks to the type of EPROM that requires an ultraviolet light to be erased?

A. I don't know. Wait.

I don't know, but I notice, on page 57, a round window.

Q. What does this round window on page 57 tell you?

A. It suggests to me that that is the window to provide the ultraviolet light to erase the ROM.

Q. So should I understand that the image that we see on page 57 correlates to the functional block diagram of an EPROM or ROM on page six? Is that what you're saying?

MR. DAS: Objection, compound.

THE WITNESS: The image on page 57 is another mechanical encapsulation of this chip.

BY MR. CRAIN:

Q. Oh, okay. So does the image of the chip show -- hold on a second. Let me make sure I understand.

Are the images on page 57 one instance of the TMS320 chip, according to your understanding?

A. Yes.

Q. State again, what does that circle in one of the diagrams of the chip mean to you?

A. It looks like the window that would be provided to allow erasing the PROM with UV.

Q. Would this be the EPROM then that you're referring to that requires an ultraviolet light to be erased?
A. Yes.
Q. Go to the next page. We were talking about this a moment ago. Let's see if we can wrap this up.
Do you see the paragraph -- I guess at the bottom of the page -- talking about the TMS320E25 EPROM cell?
A. Yes.
Q. I believe it does go on to talk about that they're ultraviolet light erasable, if you see that.
A. That's right. I see that.
Q. Now, is that referencing the DSP, according to your understanding, or something else?
A. No. It's referencing the TMS27C64.
Q. What do we understand the TMS27C64 to be?
A. It's an EPROM chip.
Q. But that chip is separate to the DSP; isn't it?
A. That's right.
Q. So this is an entirely different EPROM than what we see on page 57. Is that correct?
A. Yes.
Q. Thank you. But both of those EPROMs, on 57 and 58, are the ultraviolet light erasable type?

A. It doesn't -- I haven't seen it say that, but the inclusion of a window makes me think that.

Q. Let's go back to page six. We were talking about the ROM and the EPROM. What type of information would you expect to be contained in either the ROM or the EPROM, based on your understanding of what's depicted in the functional block diagram of page six?

MR. DAS: Objection, asked and answered.

You can answer.

THE WITNESS: As I mentioned before, the labels are -- one of these areas is labeled Program ROM/EPROM, one is labeled Data RAM, one is labeled DATA/PROG RAM. We notice that the EPROM is labeled Program ROM, which means that it stores the program, the algorithm, and also -- but the program could also be stored in the DATA/PROG RAM.

BY MR. CRAIN:

Q. So then, naturally, that means that we would not store data in the ROM or EPROM block?

A. Actually, I don't think that's true.

Q. What do you base that on?

A. My experience.

Q. Why do you believe that's not true?

A. It's -- when you're distinguishing between data and program memories, generally you're talking about a

restricted capability for the data memory and a less restricted capability for the program memory.

Q. So?

A. I'm sorry. I've forgotten what I'm trying to explain.

Q. Well, I think you're trying to tell me --

A. Are you --

Q. Sorry?

A. You were asking whether the program memory could be assumed to not contain data.

Q. Well, yeah. Because you were telling me that, well, these things have labels.

A. Yes.

Q. So, therefore, it's pretty clear. But then, I seem to hear you say that perhaps, well, I could put data in the program.

A. Yes.

Q. Okay. I'm trying to understand how you know that --

A. Yes.

Q. -- or what in Exhibit 15 suggests that to you.

A. Data is not a very specific term. Right? It's not -- there are different kinds of data. But in general, when you're writing a program, you can have the -- some of the data directly within the program,

itself. So, in that case, you would be storing data in the program memory.

Q. Define data for me, then.

A. That's a very broad term. Here, they're distinguishing between program and data. So the program is specifically the machine code instructions, and the data is the parts of -- the values we're moving -- we're dealing with which are not the machine code instructions.

Q. So the block having the words "Program ROM/EPROM" in figure -- the functional block diagram on page six, are you telling me that it is or is not limited to machine code instructions?

A. It's not.

Q. Does Exhibit 15 teach that to you?

A. It's inherent. I'm -- if that's the right term. It's something that -- I don't think -- in any kind of processor of this kind, it would -- it's normal to have data mixed in, in the program memory.

Q. Would this data be data that would be updated from time to time?

A. This would be the data which is much -- no, this would be the data that's intrinsic to the program, to the algorithm.

Q. Can you give me an example of data that you consider not to be intrinsic to the program, so I'll

know a clear distinction.

A. Anything that you would want to change through the operation of -- that you would want to be able to take on different values during the operation of the program.

Q. Can I call that non-intrinsic data, for our purposes, or is there a better title?

A. There is a better title. The data in the program memory would be called constant data.

Q. Okay. And what would other type of data be called?

A. Data.

Q. All right. That's fair enough.

A. Variable data. Okay. Variable data.

Q. I don't want to suggest a term. I want to use a term that you tell me is the correct term.

A. I know.

Q. So we're going to use constant data and variable data. Is that correct?

A. Yes.

Q. Where would you expect for me to find variable data in the functional block diagram on page six?

A. In either of -- any of the RAM blocks.

Q. Would you expect me to find variable data in the Program ROM/EPROM block?

A. No.
Q. Why not?
A. The definition I'm using for variable data is data that constitutes a variable in the program. That means that's something whose value changes during the operation of the program. You would not be able to change the value of something stored in the ROM during the operation of the program.
Q. What about if it was an EPROM?
A. In this case, the EPROM -- erasing and reprogramming the EPROM is a lengthy process. It requires several minutes say at least. So that's totally outside the scope of the program.
Q. Because a person actually has to shine a UV light on it?
A. We have to somehow cause UV light to be shown on it.
Q. Also looking at figure -- the functional block diagram, figure -- page six, I see two items that appear to be similar to me. One appears to be identified as a data bus; another appears to be identified as a program bus. Do you see those?
A. Yes.
Q. Can you describe each of those two items for me.
MR. DAS: Objection, compound.

THE WITNESS: The data bus would be a set of essentially wires that carry values of data between memories and registers and processing units. The program bus would be a similar set of wires that carry the elements of the -- of the program between the different places they may need to go. As we've discussed, elements of the program may include constant data.

BY MR. CRAIN:

Q. Let me see if I can summarize to make sure I understood you. The program bus carries the program and constant data, comprised of a series of wires?

A. Electrical connections. Obviously, they're not really wires.

Q. Electrical paths or connections?

A. Okay.

Q. Is it more than one?

A. Yes.

Q. How do you know?

A. The -- well, again, because it always is. But in the figure, there are these -- when we see the connections -- the marks that connect to these two wide gray buses, they're single lines, which have a short diagonal line with a number next to it. That indicates the number of actual separate binary values being

carried. You can't always assume that that number is the same as the total number in the bus, but I think you can assume that it's at least -- the bus is at least as big as those numbers.

Q. Is it the nature of a bus to allow for either -- faster communication?

MR. DAS: Objection, form.

BY MR. CRAIN:

Q. I'm trying to understand what the nature of it is. Is it a capacity or speed issue?

MR. DAS: Objection, form.

THE WITNESS: Is what?

BY MR. CRAIN:

Q. Is the data bus or the program bus -- let me back up even further. Are they essentially the same in construct, but perhaps different in purpose?

MR. DAS: Objection, form.

THE WITNESS: They are different buses. They're given different names.

BY MR. CRAIN:

Q. Right. But I mean, are they -- would you expect them to be constructed similarly?

MR. DAS: Objection, form.

THE WITNESS: You know, at the level of the chip -- these are abstract concepts.

BY MR. CRAIN:

Q. Right.

A. But I would expect some similarity between them, yes.

Q. Why, according to your understanding, would you expect to have any type of bus on a digital signal processor?

A. So as I said, the bus is an abstract concept. It's a way of explaining to the human, a human potential user, and to some extent, allowing a designer to explain to him or herself what's going on. You know, all -- let me leave it at that.

Q. Did I understand you correctly earlier to indicate that a bus would be understood as a multiple number of communication paths or connections?

A. In this instance, I'm confident that the data and program bus have multiple connectors -- have multiple bits.

Q. Why is that?

A. Because of the notations on the block diagram showing, in many cases, 16 lines coming in and out of the bus -- both buses.

Q. Okay. So for any of these connections coming off a bus that has the little diagonal line with a 16 --

A. Yeah.

Q. -- we're to understand that there is actually 16 lines?
A. That's right.
Q. And were you telling me earlier -- well, that means that the bus then has to at least have 16 lines? Is that what you meant to say?
A. That's what I was saying. So you notice, there is one over here with only three. So sometimes you don't take all the pins off a bus. But I don't see any numbers larger than 16. So I think the buses are probably 16 bit.
Q. Is this like a parallel-type connection, a bus?
MR. DAS: Objection, vague.
THE WITNESS: The buses they're talking about here are, in my estimation, 16 parallel lines, yeah.
BY MR. CRAIN:
Q. Does that mean that one component can either send or receive data on all 16 lines at one time?
MR. DAS: Objection, form.
THE WITNESS: That -- that's -- I think that's what -- I think that's what I mean. So yes. The bus would be a set of -- would allow connection between two different components; and in this case, most likely 16 bits at a time.
BY MR. CRAIN:

Q. How is a parallel connection different from a serial connection?
A. So we haven't discussed serial connections at all. Right?
Q. No.
A. It's used in a bunch of different ways. There is no -- I'm not sure there is any discussion of serial connections in this document.
Q. Can you answer the question, though?
A. Well, it would be easier to answer it if you were telling me about a particular domain in which those terms might be used.
Q. Well, do you have an understanding of what a serial connection is?
A. I have several.
Q. Lay them on me.
A. Okay. So the most common -- the first usage that comes to mind is the serial port commonly found on computers.
Q. Does it have a name?
A. There are many different kinds of serial ports.
Q. What do we call them? Just a serial port?
A. They're often called a serial port. Yes. Again, what are you trying to -- what is the question, names of serial ports?

Q. Well, if they have them.
A. I can give you two instances.
Q. Okay.
A. The -- well, they have a lot of names. But let's say the RS-232 port is a serial port.
Q. Okay.
A. And another one is the USB, the universal serial bus. That's a serial port. So I've named two serial ports.
Q. Okay. I'm trying to understand how a serial communication --
A. Yes.
Q. -- link, line, whatever you want to call it, is different than what we may understand to be a parallel communication link, line, or whatever.
MR. DAS: Objection, form. Objection, compound.
BY MR. CRAIN:
Q. Let me give you another question. I don't mean to frustrate you. You seem to be frustrated.
A. I just wanted to point out that it's -- you're characterizing this program bus as a parallel connection, which seems reasonable to me, but it's not the way it's being described here.
Q. Well, you've forgotten more about buses than I'll probably ever know. So I'm just going off of what

I understand you to share with me. If I misstate that, please correct me.

A. So where did the term "parallel" come from?

Q. Well, I thought we were talking about communication -- you said 16 communication lines. Even though you may have forgotten what I already know, I may have a little bit of understanding. So I'm wondering if that's a parallel type of communication. Whether this one is or not is immaterial. But I'm trying to understand how that might be commonly implemented. And of course, you've indicated that you're kind of a -- you know, understand DSPs. So I want to understand from you what you understand it to mean. Does that make sense?

A. Okay.

Q. Okay. We need to start at a high level and maybe drill down as needed. At a high level, what do you understand the differences to be between a serial communication path or link and a parallel communication path or link?

MR. DAS: Objection, compound.

THE WITNESS: So the -- in computers, we often talk about serial and parallel buses actually -- sorry -- serial and parallel interfaces. In fact, these days, parallel interfaces are pretty rare. But in early -- you know, in the IBM PC over many years, there

would be both a serial and a parallel interface on it. And the distinction there is that the serial port has fewer wires and it manages to convey comparable information by sending successive data bits down the same wire, whereas in the parallel port, those data bits would be sent over separate wires all at the same time.

BY MR. CRAIN:

Q. You asked me where I got the notion of parallel.

A. Yes.

Q. Does that not seem to be more akin to what you describe with respect to either one of the two buses shown in the figure on page six?

A. Yes.

MR. DAS: Objection, form.

BY MR. CRAIN:

Q. Okay. So I think we're talking about the same thing.

You mentioned USB as a type of serial interface. Is that an accurate description?

A. Yes.

Q. Do you recall when USB first was introduced?

MR. DAS: Objection, form.

THE WITNESS: USB was -- is the -- is very much the successor to the RS-232 port that was present on many of the PCs of the '80s and '90s. And my

recollection, USB appeared sometime between 1995 and 2000. That is -- that's when it would be, you know, something that you would actually have on a piece of equipment you would buy.

BY MR. CRAIN:

Q. What about RS-232? Do you have an understanding of when RS-232 was introduced?

A. RS-232 is, in technology terms, ancient. So I don't know when it was introduced, but it could have been the '50s or the '60s.

Q. I think you indicated that USB replaced RS-232?

A. Yes.

Q. Why?

A. There were various limitations to RS-232 which were improved upon by USB.

Q. What were some of those limitations?

A. USB is faster.

Q. Any others?

A. Oh, yes. USB allows more sophisticated configuration of the device so that when you plug it in, the computer can find out what the device is, which -- it was both -- USB is a much more complicated standard. An RS-232 device was not well standardized. So there was no way that -- there was no nice industry standard way that people producing RS-232 peripherals could allow

the devices they were connected to, to automatically identify what they were.

Q. Going back to the first reason you gave, faster, or speed, faster in what regard?

A. Higher data rates. Able to transfer a large amount of data in the same amount of time.

Q. On USB versus RS-232?

A. Yes. The RS-232 has a relatively low maximum bandwidth.

Q. Do you have any understanding with respect to data transfer rates or speeds in parallel interfaces?

A. Yes.

Q. Can you give me a frame of reference for a parallel interface in comparison to what you've described with USB or RS-232?

Let me help you further. I'm trying to understand how it may fit, relate, if at all.

A. The difference between RS-232 and USB is -- the reason the USB is faster is mainly due to improved specification of the electrical characteristics, which allow the voltages to change more rapidly without becoming distorted. If it weren't for that, USB would not be intrinsically faster than RS-232.

Using those kinds of electrical specifications, you could implement a parallel interface. Typically,

the parallel interface would be -- would have intrinsic higher bandwidth, with a higher data rate for both cases. So if we have a single electrical standard, we build a serial port, we build a parallel port, the parallel port is faster.

Q. Is that a general truth?

A. Yes. Okay. It's a rule of thumb. Parallel port -- serial port, as I've said, covers a lot of different things. Parallel port probably covers an even wider range of things.

Q. An even wider range.

A. Um-hmm.

Q. How so?

A. Because you have to specify how you're going to manage --

(Interruption.)

THE WITNESS: You have a lot of choices of how you're going to manage the parallel transfer of data.

BY MR. CRAIN:

Q. Is it common to interface a serial connection with a parallel interface?

MR. DAS: Objection, form.

THE WITNESS: They're different interfaces.

BY MR. CRAIN:

Q. Okay. I apologize for my overly simplistic --

but if I had an RS-232 wire. Right? And I had a parallel -- like a ribbon cable? Is that a parallel type of connection?

A. A ribbon cable would be something you could use to carry the electrical signals from a parallel interface.

Q. Can you interface the parallel cable to the serial cable in some fashion?

A. You could build a device that converts between them.

Q. What would this device be?

A. It would be a piece of electronics with a parallel port on one side and a serial port on the other and some circuitry in between to transfer the data between them.

Q. Are these off-the-shelf-type devices?

A. Obviously, it depends on the particular choice of parallel and serial port. I know for a fact you can get off the shelf, a device that converts between a USB port and a so-called Centronics parallel printer port.

Q. Is that a device that's available now or sometime --

A. It is.

Q. Could you design such an interface yourself?

A. Yes.

Q. How hard would it be?

A. It's not something I would do every day. It's not -- I mean -- well, that's interesting. That depends. I'd have to think about how to do it. It wouldn't be that hard. It wouldn't be -- you know, I would have to have a good reason to do it, but I could certainly do it.

Q. Okay. Tell me how you would do it.

A. Well, you have one part of the circuitry which is, you know, doing whatever is required of the serial interface. For instance, there is a -- you know, you can buy chips that are specifically assembled to make that easy, a so-called UART, U-A-R-T. You could have one of those to deal with assembling and disassembling the information on the serial side. You would then have a bunch of pins that came out of that device. You would then have some kind of buffer and some control logic to handle the parallel port.

Q. When you say a buffer, you would need some type of memory?

A. It depends. It would make it a lot more complicated if you wanted to give it a memory buffer. The easiest thing would be to have something where the speed of communication was the same on both ports, the serial and the parallel port.

Q. Didn't you tell me generally that parallel ports are faster?
A. What I meant to indicate by that was they're potentially faster. Any data port, you can run at less than its maximum rate. But usually in design, the maximum rate is the most interesting -- is the thing you care about.
Q. I was going to say, I wouldn't think you would want to slow something down if you didn't have to. Right?
MR. DAS: Objection, form.
THE WITNESS: I mean, all other things being equal. But that's -- in many cases, that's not the primary design limitation.
BY MR. CRAIN:
Q. Well, if I understood you correctly, I thought you were saying that, well, you might ideally want them to be at the same speed.
A. Yeah.
Q. Again, from a general perspective, a serial connection may not be as fast as a parallel connection. Is that fair?
A. The maximum throughput, as imposed by the interface, using the same electrical standards, would be -- the parallel port would have a higher maximum

throughput capacity than a serial port.

Q. Would that have been true in 1994 as well?

A. Yes.

Q. So if there is a higher throughput on the parallel connection, how do you make it the same speed as the serial interface?

MR. DAS: Objection, form.

THE WITNESS: Well, it's the -- it's the maximum speed. So, you know, you could build the interface such that it was only able to transmit data up to the speed of the slower of the two interfaces. In fact, you know, at some level, you would have to do that.

BY MR. CRAIN:

Q. So if I was communicating the data across the parallel interface into the serial interface, if I understand what you're saying, I may have a larger amount of data coming through the parallel interface. How do I keep -- I want to say it's like a bottleneck or it seems like it would crash or something.

A. Um-hmm.

Q. How do I get it into what I need for the serial interface?

MR. DAS: Objection, form.

THE WITNESS: It's easy to imagine a circumstance where you wouldn't be able to do that. But

at the same time, I've described that such devices exist. So there is this whole area of communications interfaces we haven't spoken about called handshaking, which is wires other than the ones we've discussed that are used to modulate the transfer of data.

BY MR. CRAIN:

Q. What I'm trying to get back to was you had mentioned a buffer. Would that be a way to do it, to buffer what's coming on the parallel so that I can read that out on the serial?

A. No. That's not what I'm talking about.

Q. I wasn't sure. That's the reason I'm asking. What was the purpose of the buffer that you referenced earlier?

A. The buffer is like these registers. Like we've got this single word coming in on a serial port. We get it coming out of the UART, we store it in the register, and then that becomes -- that drives our parallel port.

Q. Look back at page six.

A. Yeah.

Q. Again, I understand that this is a functional block diagram. I'd like your understanding, based on your experience, as best you can ascertain it, for what this document appears to disclose as of, I guess, 1990.

You pointed my attention to several smaller

lines with the diagonal lines through them. Do you remember that?

A. Yes.

Q. And they have the numbers out beside them as well, such as 16.

A. Yes.

Q. Would you expect each of the communication links here that we see, these types of diagonal lines coming off the bus, to be the same type of interface as the bus? I don't know if I'm even asking that right.

MR. DAS: Objection, form.

THE WITNESS: It's not -- within the chip here, it's not really -- I don't really -- I'm not sure what you mean by "interface."

BY MR. CRAIN:

Q. An overly simplistic here issue would be if we were to consider one of these buses as a parallel type of interface, would I expect any of these traces to any of the functional blocks to be a serial interface?

MR. DAS: Objection, form.

THE WITNESS: It's possible. I don't think it's true, but it is possible there is some serial device in here, but I don't see it. The lines coming off the program bus would not be -- I mean -- would not be serial.

BY MR. CRAIN:

Q. I'm sorry?

A. The lines coming off the program bus or the data bus would not be serial.

Q. Hopefully, last question on this. You said you didn't see any, but you seem to think that, well, I guess that's possible.

A. Yes.

Q. What would it look like if that were the case?

MR. DAS: Objection, form.

THE WITNESS: I was looking for a box, one of these functional boxes that had one of these lines going out that looks like it was a serial interface line.

BY MR. CRAIN:

Q. How would it be represented, according to your understanding, if it were a serial interface line?

A. There are conventions for labeling these lines. These little letters we see on the edge of the diagram and elsewhere, they -- if you're looking at this, there is a bunch of conventions that you'd know what they mean -- you'd have a good idea what they mean.

In a classic serial interface, there is an RX and a TX line for receive and transmit.

Q. Right.

A. I was looking to see if there are any pins

marked like that. I don't see them.

Q. Dr. Ellis, has there been an occasion where you have been requested by someone to develop a DSP solution?

MR. DAS: Objection to form.

THE WITNESS: Yes.

BY MR. CRAIN:

Q. Are you able to share with us who it was that approached you?

MR. DAS: I'm going to caution you not to get into other people's confidential information.

BY MR. CRAIN:

Q. To the extent it's confidential, that's fine. Are you able to share that?

A. I'm thinking of -- I mean, I'm thinking of several consulting things, just because the way you phrased it makes it sound like kind of a business thing. That's the closest relevance. But, you know, for the purpose of the question -- I don't know. What do you want me to say? Most often, when I'm developing things, it's because I'm asking me to do it.

BY MR. CRAIN:

Q. Okay. Without -- let's try it this way, if we can:

Without identifying any company or person -- outside person -- have you been approached and asked to

develop a DSP solution for someone else?
A. Yes.
Q. Without identifying the person, can you give me at least a description of the person or entity that made the request?
A. For instance, a small company trying to develop a product that will be responsive to certain kinds of sounds.
Q. Are you thinking of a specific instance when you share that?
A. I'm thinking of two at the moment.
Q. When were those?
A. Oh.
MR. DAS: Objection, form.
THE WITNESS: They're the most recent ones. Like within the past couple of years.
BY MR. CRAIN:
Q. Can you speak to the type of problem that you were asked to solve with respect to the DSP solution that you developed?
MR. DAS: Objection, form. Also caution you not to get into confidential information.
THE WITNESS: Thank you.
My current research is about sound processing. So it's those kinds of problems, recognizing or

processing sound.
BY MR. CRAIN:
Q. Is this through LabROSA?
A. Yes. I mean -- is it through LabROSA? No. It's my independent consulting, the ones I'm thinking about.
Q. Oh, okay.
Were you compensated in each of these two instances you're thinking of?
A. One of them, I haven't completed, and I have not received any compensation. The other one, I think I was -- I think I have some equity.
Q. Again, what -- I'd like to understand the scope of what you're trying to do. So can you explain that to me, to the best of your ability.
A. What do you mean?
MR. DAS: Objection, asked and answered.
BY MR. CRAIN:
Q. The scope of what you are trying to develop or solve.
MR. DAS: Objection, asked and answered. Again, I would caution you not to get into confidential information.
THE WITNESS: Okay. It would -- maybe it would be easier to have these questions if I could think of

one where there was no confidentiality involved.
BY MR. CRAIN:
Q. Is there one you can think of?
A. Sure.
Q. Okay. Which one?
A. I'm thinking about some work I did -- this time, through LabROSA -- for the -- a government project where we were trying to recognize a particular tone in a signal, in an audio signal.
Q. Did you design a digital signal processor to do that?
A. No.
Q. Have you ever designed a digital signal processor?
A. Again, it depends what you call a digital signal processor. I haven't ever designed anything like these kinds of -- what I would call a DSP chip.
Q. Or could we say hardware even? Would that be an accurate --
MR. DAS: Objection, form.
THE WITNESS: No.
BY MR. CRAIN:
Q. Why not? What's wrong with hardware?
A. Well, because a system -- a digital signal processing system always comprises hardware. Right? So

there is -- and there is the -- you know, it also comprises software, but the software doesn't do anything without the hardware that it runs on.

Q. Have you ever designed DSP hardware?

A. Let me think of a good example then.

Q. Before you do, let me ask you this: This may help us. Have you ever designed DSP software?

A. Yes.

Q. Of the two, is there one that you've done more of?

A. Yes.

Q. Which?

A. Software.

Q. Is DSP software more of your area of expertise?

A. Yes.

Q. I did interrupt you a minute ago. So let's circle back to that. I think I was asking you, could you think of any instances where you had developed DSP hardware. Isn't that what I was asking and you were thinking about?

A. Yes.

Q. So let me ask you the question. Can you think of any instances when you developed DSP hardware?

A. Yes. I'm thinking of one. I mean, like I say, any DSP solution involves hardware.

Q. Okay. Is one the total that you can think of right now?
A. Well, no. Any of them. Right? I mean -- but it just depends on what -- how involved is the design of the hardware.
Q. Well, let's talk about it in the context of what we see in Figure 6 (sic).
A. Um-hmm.
Q. Now, these are functional block diagrams; but if I understand it correctly, it relates to a chip.
A. Yeah.
Q. Can we call it hardware?
A. Yes.
Q. Have you had instances where you designed hardware in a similar fashion to what we see on page six of Exhibit 15?
MR. DAS: Objection, form.
THE WITNESS: No.
BY MR. CRAIN:
Q. When you say "no," are you able to think of any instance when you engaged in the design or development of hardware for a digital signal processor chip in a similar fashion to what we see on page six of Exhibit 15?
MR. DAS: Objection, form.
THE WITNESS: So I understand your question to

mean work that would involve drawing a diagram like this, but a new one, as part of the design. And in that case, I have not.

BY MR. CRAIN:

Q. Have you ever created a design for a DSP chip?

A. No. That's a very specialized activity.

MR. CRAIN: Let's go off the record.

THE VIDEOGRAPHER: We're off the record at 12:23 p.m.

(Lunch recess taken from 12:23 to 1:18.)

THE VIDEOGRAPHER: We're back on the record. The time is 1:18 p.m.

BY MR. CRAIN:

Q. Dr. Ellis.

A. Hi.

Q. During your lunch break, did you have an opportunity to speak with QSC's counsel?

A. I did.

Q. Did you consult or confer with QSC's counsel during the break regarding the substance of any testimony you've given so far today?

A. No.

Q. Did you consult with QSC's counsel during the break regarding the substance of any testimony that may be anticipated to be given by you today?

A. No.
Q. Did QSC's counsel, during the break, suggest to you the manner in which any questions should be answered?
A. No.
Q. Earlier today, we were talking about the TMS320 DSP. Do you recall that?
A. Yes.
Q. I believe you own such TMS320, the C25?
A. Yes.
Q. Is the TMS320 DSP, like we see in Exhibit 15, the state of the art, according to your understanding, with respect to DSPs?
MR. DAS: Objection, form.
THE WITNESS: Certainly not.
BY MR. CRAIN:
Q. Why not?
A. Well, it's -- this is a device from the late '80s.
Q. Okay. Well --
A. So you said if there was something that I remembered, I should tell you about it?
Q. Oh, yes. Okay. You were anticipating that I was going to tell you something. I was going to ask you that. I forgot. So thank you.

A. You know, just before the break, we were talking about this block diagram on page six, I think it was. You were asking me, "Have you ever designed one of these yourself?" And I said, "No, it's a very specialized thing." This is the domain of digital VLSI, which is not my particular area. Because in order to design one of these, you would need then a whole infrastructure to go out and manufacture it, which means somebody etching silicon chips somewhere. People in my department do it, but I don't.

However, I then remembered that I've recently had some experience which is actually very similar to this. I teach signal processing, and I'm very interested in the ways that people can understand it. One of the things that I've found that is helpful in having people understand signal processing is to have something that responds immediately. This is the kind of thing that DSP chips were initially developed to be able to do. It turns out, these days, you don't actually use a DSP chip at all. I've been able to do a lot of work like this just running on my regular laptop, the stuff like that on my website.

But I've also been interested in the educational power of things that you can hold and build, because that's -- there is a whole trend going on at the moment

which seems very powerful to me. So I've been looking for something like this that I can use in that context to give people -- give my students an opportunity to work with basic DSP operations and have something that works in real time that's a small little device they can run by themselves.

So I've been experimenting with an FPGA chip. These are relatively recent developments, so they've only relatively recently become affordable. And instead of having to do a design like this and then send it out to some fab, fabrication, to have it made in silicon, they have a set of -- a very large collection of individual gates with some mechanism for electrically connecting the gates. And you can do basically the same things you would do if you were designing a DSP chip, but you don't need a fabrication. You can just download it onto this FPGA and you can try it out. And I've been experimenting with some signal processing systems using that.

Q. When did you start doing that?

A. I think -- I think within the past two years.

Q. This sounds at least somewhat similar to the kit that you used to do -- and you mentioned yesterday -- with a Class AB amplifier. Is it kind of like that? Did you have a kit and you can make it -- configure it

the way you want it?

A. It's not like that.

Q. I'm sorry. I don't mean to insult you.

A. No, it's much more like -- that's the amazing thing about it. It's much more like actually full-up VLSI hardware design.

Now, in the late '80s, VLSI hardware design was a very difficult thing to do. Because I don't know -- you know, these chips had tens of thousands of individual gates. And that was the point at which, you know, it was like, well, a single design that can actually go and individually assign tens of thousands of individual gates, but, you know, it's really hard.

Since then, the field of VLSI has developed a set of design tools where you have a hierarchical way of specifying the sets of gates that are being used. That's how you would design the chip. In fact, there are these standard languages, like Verilog and VHDL, which are used for specifying the layout of a chip in terms of gates through a set of design files. And you use the same design language for FPGAs. So that's what I've been working with.

Q. Are you writing some type of software that -- let me back up just a second. FPGA?

A. Yes.

Q. Stands for, again?
A. Field-programmable gate array.
Q. And I know you said it, so I'm sorry to have to go back and ask more about it. But how do you actually program the gate array? Is it through some type of software configuration?
A. It uses -- it involves software. So you have the board containing the FPGA. It has -- actually, this one, the one I'm using, has a USB port on it. So you connect it to the USB port of the host computer. The host computer is running these design tool software applications, which is a standard way of designing large-scale digital systems now and basically for the last 20 years at least. And you -- in that software, you type in the files that describe your design.
Q. Okay.
A. But the reason that I wanted to mention it is because what happens then is it will -- there are various ways you specify it, but mostly just typing in text into data files. It then draws pictures which look like this. Because that's what -- that's what you're specifying.
Q. Once you write these text files -- into your laptop?
A. Yes.

Q. That's connected by a USB connection to the FGPA --

A. FPGA --

Q. Can we call it a chip?

A. Sure.

Q. How does the instructions that you write become implemented in the actual chip?

A. The instructions that you're writing are specifying how to connect together units. Basically, at some level, you're just saying what each of the arcs -- each of the lines are on a diagram like this. Now, obviously, this is a high-level view; that each of the boxes could then be blown up, and you would have a bunch of lines inside there. Until you get down to the lowest level, which would be the individual logic elements.

Q. Right.

A. That's exactly how these things work. You have one file which will define a particular block. You know, at some level, you're going to bottom out in these files that place individual gates. There is some level of abstraction there, because again, it's trying to make design easy. But you've got that level of control.

Then you write files that reference those things and specify how they're connected together. Then you can write files that reference the already encapsulated

things. You can keep doing it. That's why it's called -- VHDL is one of the languages. It's called VLSI hierarchical description language.

Q. Now, again -- this is all very interesting. My question to you about this is once you program the text files --

A. Yes.

Q. Can we call that software or is that not software?

A. It's not -- it looks like software, because you're typing in some text files to make a device do something, but it's so different from programming.

Q. Right. Because -- sorry?

A. It's just different.

Q. So when these text files are communicating from your laptop over the USB connection into the actual chip, is there some type of processor or controller that receives that and says, oh, okay, so I need to implement whatever instructions is received?

A. No. The -- so the text -- okay. I said it was different. You can think of the text files as describing where the wires go. Right? There is a bunch of gates on the chip, a large number of gates, like a million. From the user's point of view, I can ask any of these gates to be connected together. Of course,

that would be very difficult. But the software is clever enough to hide the limitations until you bump up against them.

So there is design software which takes your specification of what you want to connect together, knows about, you know, what's in the chip, and figures out a -- the set of data, which then gets basically written into a set of registers on the chip, which then basically switch these things so the gates are connected together according to your specification.

Q. Is the chip that receives these instructions making new physical connections on the chip?

A. They're electrical switches. But the point is that it's -- it's analogous to the EPROM simulating the ROM. This is like these electrical connections simulating what would happen if you actually taped out, as it's called, and got a chip manufactured.

Q. And you've never done this other than within the last two years.

A. No, that's right. Well, these -- these devices have come down a lot in cost. So I have never had access to them before.

Q. Did I understand you to say that your design -- the purpose -- did I understand you correctly to say that the purpose that you have in using these devices is

largely educational?
A. That's my motivation.
Q. Well -- and so you've not implemented one that has resulted in the manufacture of a device, for example.
MR. DAS: Objection, form.
THE WITNESS: No, I haven't. That's, you know -- that would be a nice thing to be able to do in academia, but it's not that common.
BY MR. CRAIN:
Q. What's not that common?
A. You know, to have the work that you do as an academic turn into some kind of commercial device.
Q. Does Columbia not have a tech transfer office?
A. Oh, yes. Of course.
Q. Are inventions that people at Columbia come up with not commercialized through that text transfer office?
A. Some are.
Q. So, in fact, it does happen.
A. I said it wasn't very common.
Q. But it happens.
A. Of course. I didn't say it was impossible.
Q. Have you ever had an invention go through the tech transfer office?
A. Yeah.

Q. Has one ever been commercialized and been part of a business that was spun out of the tech transfer office?

MR. DAS: Objection, form.

THE WITNESS: I've had a couple of patents that have been licensed, so I believe.

BY MR. CRAIN:

Q. What do you mean, so you believe?

A. That's what I've been told.

Q. Do you know if they're the patents that are listed on your CV?

A. They probably are listed on my current CV. I believe they're listed on my current CV.

Q. But not the CV that we have as an exhibit from yesterday?

A. That's right. Well -- that's right.

Q. What made you remember this --

A. Because it was -- you know, you were asking me about these diagrams, and it's like, yeah, for sure, I've never taped out a chip. But it was like, oh, wait, but there is something relevant here. That's why I didn't think of it immediately. Right? Because it's not the exact same thing you were asking about. Have I ever been a DSP chip designer? No, I've never worked in a company like that.

Q. So the closest you've ever been to a DSP chip designer is the experience of FPGA --

A. Yeah.

Q. -- design?

A. But, you know, I thought that was nice to introduce, because actually, that's what a contemporary -- I'm using the same software tools or tools which look very similar -- no, I'm using the same specification language that today's chip designers use.

Q. When you use this phrase, "today's chip designers," who are you referring to?

A. People working in industry. You know, companies like Intel that create new chips for people to use in devices.

Q. Are you saying that the way Intel or a company like Intel designs their chips is exactly what you're doing with this FPGA --

A. It's the same specification language. In the same way -- what they're working at would be much larger-scale projects, but it's the same basic process, yes.

Q. I'm not sure I follow you with respect to what you mean when you say "same specification language." That sounds like software, but I don't think that's what you mean. Or is it more analogous to we're speaking

English language?

A. No, no, no. It's a machine readable specification.

Q. Oh, it is. So it sounds like it is more akin to software then.

A. That's the state of the art in -- so let's try and imagine what a -- someone designing a chip, what they actually do. They could solder things together. Well, obviously, you can't do that on a silicon chip. It's too small. You could draw out the masks, but then go into some photo lithography process to make the chip through etching, et cetera. That's how it was done in the 1970s and 1980s. You could have some software tools that generate those masks that then -- I guess that was -- maybe hand drawing would be a 1970s technique. Software tools to generate those images would be a 1980s technique. Or you could allow computers to take on some of the burden of having to decide each of those decisions of where the traces and doping goes, and you just -- now you can specify it at a more abstract level, to say okay, I want some gates and some latches, and I want them connected together in this topology; but I'll let you, my software tool, decide for me where to put them. This is called CAD, computer-aided design, for VLSI. That's how it's been for 20 years or so.

Q. Is that the state of the art for chip design now?
A. That's the -- what industry does, yeah.
Q. Would it be true that at least one difference between what a company like Intel may be doing in their chip design as opposed to someone using --
A. FPGA?
Q. Thank you.
-- is that you're constrained by what may be available on the chip or is that the --
A. Yes.
MR. DAS: Objection, form.
THE WITNESS: Any designer is constrained by some kind of resource limitation. That's engineering. If I'm designing to an FPGA, then there is a finite number of gates on the particular FPGA I'm using. If I'm designing a chip, then there is a finite number of gates that can fit on whatever size chip I decide to use. I potentially have the option to make large or small chips. There is not a limit on how large a chip you can make.
BY MR. CRAIN:
Q. Is there anything else about this that you want to share with us before we get back to --
A. No.

Q. In clarifying this, I still believe I understand that you've not had the occasion to design a hardware DSP chip.

A. That's right. But I'm saying this is -- you know, it's not like I have no conception or no experience -- no relevant experience.

Q. Well, I understand. With the exception of the recent advent of FPGA chips, you've not had the opportunity to design a DSP chip hardware.

A. That's correct.

Q. But thank you. That's helpful.

I think where I had left off, or what I was starting to ask you about, was about whether the TMS320 DSP that's described in Exhibit 15 is currently the state of the art.

A. Oh, that's right. Yes.

Q. So let me ask you, then we'll get back to that. Is the TMS320 digital signal processor, as described in Exhibit 15, the current state of the art in digital signal processors, according to your understanding?

A. I'm sure it isn't.

Q. Could you explain the basis of your conclusion.

A. Well, the reason I'm sure is because there has been a significant advance in technology, particularly this kind of chip technology, since the time of this

document. I mean, that's one -- one reason.

Q. Are you aware of any others?

A. Well, other -- I mean, I know -- you know, I know of some of the subsequent chips in the TMS320 series that replaced this one.

Q. And you mentioned some advances.

A. Yes.

Q. Are you able to speak to any of those advances that you have familiarity with?

A. I mean, the events I'm talking about are just basically primarily advances in chip manufacture that increase the number of gates and the speed -- the switching speed that you can achieve in large-scale integrated chips.

Q. What are some of the advantages that these advances provide for users of DSP chips?

A. They can -- the problems that the chip can solve become faster. So the time of this chip and the time of the work we're talking about, DSP chips were beginning to -- were beginning to be used in audio. Because at that time, it was pretty hard to process audio on a conventional computer, nay impossible. But the additional speed afforded by the special purpose hardware in a DSP chip would mean that you would be able to do something like simulate a particular concert hall

in real time using a DSP system.

Q. It says concert hole in the transcript. You mean hall.

A. Hall.

Now, what's interesting -- that's why I was interested in it at the time -- what's interesting since then -- although it was -- it wasn't that pleasurable to use, so a lot of the work I've done has been still running in software on computers and sacrificing the realtime aspect, because for me, my interests led to, well, what can the algorithms do. I'll let someone else worry about how to make it run fast enough to run in real time.

As I mentioned, I've recently been increasingly interested in the problems of teaching signal processing. To my delight now, that kind of software is actually -- because computers have gotten that much faster -- the same software is now able to do very nice, sophisticated digital signal processing operations without the need for a special DSP chip.

DSP chips have continued to become faster and more powerful. What that's meant is that they've moved on from applications in audio to more demanding applications in things like radios and video.

Q. What's the first instance that you are

personally aware of, of the use of a digital signal processor in an audio application?

A. We mentioned the Speak & Spell. That's a nice starting point. Like I say, I think there are earlier ones. I have this memory of this speed control system that was from the early '70s.

Q. Moving forward from the Speak & Spell, would you walk through the ones that at least today, as you sit here, that you can recall. And as you think of your answer, Speak & Spell, I think you said earlier, was mid '70s?

A. Yes. That's my belief.

Q. Okay.

A. You know, some of the -- in the late '80s, I was interested -- I was particularly interested in music and in -- you know, music production, music studio practice. As someone with a technological bent, I was interested in studio processing gear. That was the time at which digital audio signal processing was moving into music recording studios.

Q. What I'm trying to understand -- let me ask my question again to see if it changes what you want to share as a response -- I'm trying to understand from you any devices or specific applications -- you mentioned like the Speak & Spell. That's a device. Right?

A. Yeah.
Q. I'm trying to understand if you have any familiarity with other devices that --
A. So --
Q. Let me get my question. I know you're ready to go.
-- that use a DSP in audio application.
MR. DAS: Objection, form.
THE WITNESS: So I mentioned studio gear. So the kinds of things you would have in a studio would be things like delay lines and reverberators. So digital versions of those.
BY MR. CRAIN:
Q. Do you recall any particular brands or models of such devices?
A. I'm thinking about the Lexicon. Lexicon made a digital reverberator. They made a series of them. I don't remember when the first one was, but I think it was in the mid '80s, that was very well renowned.
Q. So we've gone from '75 to the mid '80s.
A. Yeah. So now we're switching from things I know about as a student of the history of signal processing to things that I have direct personal memory of.
Q. Okay. So you understand, we've been talking about kind of this DSP revolution.

A. Yeah.

Q. I'm trying to understand this revolution from what you had shared earlier, how it started and some of the various things we've talked about. So really what I'm trying to get to now is how did this revolution grow and change to where we are now? That's why I asked you about the -- whether or not this TMS320 is the state of the art now. You've told me it's not, things have changed. So now what I'm trying to get to is your understanding, recollection, prior experience, with respect to maybe devices along that revolution. Okay? So let me ask you the question.

Again, what devices do you know about or perhaps have had personal experience about that use a DSP in an audio application during this digital revolution that we've been talking about?

MR. DAS: Objection, asked and answered.

THE WITNESS: So I mean --

BY MR. CRAIN:

Q. Well, let me speak to the objection. To the extent that you've not shared one. If you've exhausted your information, that's fine. I'm not asking you to go back and re-cover any that you've already shared.

A. Oh, you know what? Lexicon was, you know, a major player in -- oh, no. There is -- there is --

there is a device in the studio called a harmonizer. Eventide was a company that manufactured the harmonizer. And the harmonizer will take audio input and produce a simulation of someone singing in harmony or multiple instruments playing in harmony. I want to say that those are also things that were emerging in the mid '80s.

Most of these devices had analog precedence. So when I talk about the digital -- DSP revolution, it's the replacement of analog implementations with DSP-based implementations of these things.

MR. DAS: Dr. Ellis, you're tending to swallow the last couple of words that you're saying.

THE WITNESS: Sorry.

BY MR. CRAIN:

Q. How quickly did this DSP revolution occur that involved the replacement of analog implementations with DSP-based implementations?

MR. DAS: Objection, form.

THE WITNESS: It's pretty difficult to draw boundaries on it. Right? It's spreading through different application areas, as I've discussed.

BY MR. CRAIN:

Q. Why is it difficult to explain?

A. Just it's difficult to draw a boundary. Like

well -- I guess, when there is no longer any analog processing, that everything that could have been replaced by the digital domain processing has been replaced, then we can say it's over. And we may be getting close to that now, but probably not.

Q. Why is it taking so long?

A. One obvious reason is because you require, you know, the digital technology to be a preferable solution, meaning in particular a cheaper solution. And that depends on the technology. The technology becomes cheaper.

Q. So there are times when a DSP solution is not cheaper than an analog solution with respect to audio?

MR. DAS: Objection, form.

THE WITNESS: There certainly have been times.

BY MR. CRAIN:

Q. Help me understand one or more of those times.

A. So let's say in 1985, I could maybe buy a Lexicon digital reverberator probably for several thousand dollars, or I could buy an analog spring reverb for maybe $50.

Q. Well, I'm asking you more from the manufacturer's viewpoint. You're sharing with me the retailer. I was presuming that you were speaking to it from the creator, the designer's perspective, but I

don't think you are.

MR. DAS: Objection, form.

BY MR. CRAIN:

Q. Am I mistaken?

A. I was explaining it. I was illustrating it from the consumer's point of view.

Q. Right. But I mean --

A. But there is no difference between that -- engineering is about can we make something useful, at a price that people want it.

Q. What I was trying to understand from you is the digital revolution that you're talking about maybe is nearly complete where the replacement of an analog solution to a DSP solution can be accomplished. It sounds like there is still analog applications that have not been so replaced for one reason or another. Did I understand that correctly?

MR. DAS: Objection, form.

THE WITNESS: I mean, like I say, there probably are some. I'm not thinking of any specific ones. But, you know, like ten years ago, full digital processing for video systems would be very high end. Now it's more commonplace. Now it's ubiquitous.

BY MR. CRAIN:

Q. What do you attribute that to, over the last ten

years, for video?

A. I mean, okay, ten years isn't actually long enough. Let's say 15 years.

Q. Well, whatever time it is.

A. Yeah. It's the increasing speed and capacity of the digital devices. You know, I'm not sure that the concept of a DSP chip is as important as it was at the time that we're talking about here, because as I've said, general purpose chips have become so fast and so powerful that they can do -- we can do many of these things without special purpose hardware. But certainly on the leading edge of things like video processing, you will still have special purpose hardware that's doing digital signal processing functions.

Q. So, 15 years ago, or for example, back when the TMS320 --

A. Which is 25 years ago.

Q. Twenty-five years ago.

I think you said one of the advances in DSP since the TMS320 is speed.

A. Yes. The biggest advance was the switch to floating point, actually.

Q. So DSPs today can do more than the TMS320 DSP?

A. Yes.

Q. Then, would we likewise be safe in understanding

that the TMS320 DSP could do more than the DSP of ten years earlier than that?

A. The TMS320C25 was significantly more powerful than the TMS320C10, which was the preceding generation.

Q. Really? Okay.

So you've given me a reference point here. I'm just going to use C10 and C25. We're talking about the TMS320. Okay?

When I only had the C10, could I do as much digital signal processing with it as compared to what I could be able to do if I had the C25?

MR. DAS: Objection, form.

THE WITNESS: You know, it's like -- we're being -- we're being a little bit fuzzy about what -- how we measure the quantity of digital signal processing. The C25 would be able to process a larger amount of data in the same amount of time.

BY MR. CRAIN:

Q. So would that allow me to accomplish more functions?

A. Yes.

MR. DAS: Objection, form.

BY MR. CRAIN:

Q. Okay. While you've got that TMS320 document, turn back to the functional diagram, please.

A. Yes.
Q. According to your understanding -- and if you need to look anywhere else in the documents, please do --
A. Okay.
Q. -- what type of interfaces does the TMS320 -- we can talk about the C25 since that seems to be the one that you have great familiarity with -- so my question is, what type of interfaces does the TMS320C25 support, according to your understanding?
MR. DAS: Objection, form.
THE WITNESS: What kind of interfaces? You know, the way we're using interfaces is more a property of the computer system. The processing chip is the hardware computer system, but there are typically a number of other parts around it. The interface is, in a sense, like an RS-232 or a USB port, would, particularly at this time, be provided by other chips that were part of the computer system.
BY MR. CRAIN:
Q. What does that mean?
A. That if you wanted to build a TMS320C25 system, you could put whatever interfaces on it you wanted.
Q. So according to your understanding, does it support a serial interface?

A. It would be very easy to build one with a serial interface.
Q. Tell me how you would do it.
A. You would add a serial interface chip to the design.
Q. What is a serial interface chip?
A. It's a chip that allows -- supports -- drives, you know, a serial interface standard.
Q. Can you identify any by name?
A. Yes. I recently had cause to use a MAX232. This is a contemporary chip that wasn't available at the time. But it's a chip for interfacing between logic levels inside a computer, and the particular voltage levels used in RS-232, which are higher voltages than are used within a computer.
Q. For purposes of this specific discussion, let's constrain our time to around the time of the TMS320C25.
A. Right.
Q. Late '80s, early '90s. I mean, I think the document is dated November 1990.
A. Yeah.
Q. Is that an adequate time for you?
A. Sure.
Q. So if you were using the chip at that time, the TMS320, would it have supported a serial interface?

A. It would be easy to build systems, based on this chip, that had a serial interface.
Q. I want to talk about the systems that would be easy to build.
A. Yeah.
Q. In the time frame of when the TMS320C25 was available.
A. By the way, you asked me earlier about applications. I did not finish listing all the applications. One that we might want to include is, of course, digital hearing aids -- digital signal processing in hearing aids.
Q. Why do we want to include that?
A. Because one of the references I use in my statement is -- describes such a system. Also, it's been -- it's of huge impact -- it's been of huge impact to the millions of people around the world who have hearing loss.
Q. So applications for what exactly again?
A. For digital audio signal processing. For DSP chips used in audio.
Q. Oh, okay. Was that with respect to the TMS320?
A. No. In hearing aids, they're typically custom chips.
Q. Why is that?

A. Hearing aids are a very demanding application where you need -- you need the greatest possible efficiency. You can't really afford to use a chip that's been designed -- that's been specified for anything other than being used in a hearing aid.

Q. I still don't understand why -- give me just a second. Why not? I still don't understand why.

MR. DAS: Objection, form.

THE WITNESS: Why what?

BY MR. CRAIN:

Q. Let me read it back. Where you need the greatest possible efficiency. You really can't afford to use a chip that's been designed -- specifically designed for anything other than being used in a hearing aid.

A. Yes.

Q. Why not?

A. So the hearing aid application has extreme requirements in terms of size, in terms of power budget. So those are the things that -- you have no flexibility in your design to waste on making the chip larger than you need it to be or making it use more power than you need it to use.

Q. Why is power of grave concern?

A. Because the hearing aid is going to run off of

battery, and you want to make the battery last as long as possible and/or be as small as possible.

Q. Size is obviously crucial because of the application of where a hearing aid is installed.

A. Yes.

Q. Have you ever designed a DSP for a hearing aid?

A. No.

Q. Have you ever had occasion to work with a DSP for a hearing aid?

A. I haven't worked at that level. Some of the work that I've done, some of the research that I've done, has been motivated by hearing aid type applications. I've interacted with people in hearing aid companies. But again, that's -- the actual dealing with the chip, itself, is specialized and not something I've been involved in.

MR. CRAIN: Let's go off the record.

THE WITNESS: Okay.

THE VIDEOGRAPHER: This is the end of Media No. 2 in the deposition of Dr. Daniel Ellis. The time is 2:03 p.m. We are now off the record.

(Recess taken from 2:03 to 2:18.)

THE VIDEOGRAPHER: This is the beginning of Media No. 3 in the deposition of Dr. Daniel Ellis. The time is 2:18 p.m. We are back on the record.

MR. CRAIN: Thank you.

BY MR. CRAIN:

Q. Dr. Ellis, did you have an opportunity to speak with your attorneys during the break?

A. Yes.

Q. Did you speak with your attorneys about your testimony?

A. No.

Q. Did you speak with your attorneys about any testimony anticipated to be given?

A. No.

Q. If you recall, before our break, we were speaking about the TMS320 and the type of interfaces that it may or may not support.

A. Um-hmm.

Q. Do you recall what your response was to that?

A. I was saying that it would be easy to build a system with a TMS320C25 and a serial port.

Q. And again, constraining our analysis and your response to the time frame of around 1990 or so --

A. Yes.

Q. -- tell me, please, how you would go about doing that.

MR. DAS: Objection, asked and answered.

MR. CRAIN: Actually, it wasn't.

THE WITNESS: No. Because of the -- you -- so the functionality you would need would be something to construct the serial stream, and then some electrical interface to generate the electrical signal specified by the RS-232 standard. The formation of the stream would be most likely done with one of a number of chips that were available at that time to do that, which the generic name for those chips was a UART, U-A-R-T, universal asynchronous receiver transmitter. That's what it was for. But it would still generate logic levels which you would then have to switch up to the full plus or minus 12 volts of RS-232, using properly external transistors.

BY MR. CRAIN:

Q. Is that all?

A. That's all you would need.

Q. So you have a serial communication line coming to the chip. Then what you've described here, I'm still not clear on what it does so that it can communicate with the TMS320.

MR. DAS: Objection, form.

THE WITNESS: So with this kind of computer technology, you notice, in the pin-outs, there are a number of pins labeled D and A. I'm looking at the picture on the front cover of the reference.

BY MR. CRAIN:

Q. Um-hmm. I'm looking at it.

A. So the way -- the D stands for data and the A stands for address. The way this chip and any microprocessor of the era would interface to many of the external chips that it might connect with is through this data and address bus. The microprocessor -- in this case, the DSP -- sets up an address, a binary number on the address pins; it sets up a data -- a value on the data pins. Then there is like some other control pins. There is a read-write pin probably somewhere, which then says, okay, I want to either read data from this address or write data to this address. So the UART would similarly have a bunch of data pins. It would not need so many address pins. But there would be some logic to say, okay, when the address pins are in this particular configuration, we'll enable the UART to know if it's being written to, then basically everything else will be taken care of.

Q. So the UART would be written to from the DSP?

A. Right. So a program inside the DSP would push values, push bytes to the UART, and then the UART would just write them out as a serial stream.

Q. And the serial stream that the UART receives, how does that get into the DSP?

A. In a similar kind of way. The UART has a separate circuit that receives the inputs, the serial stream, and turns them into a byte. The way it typically works is there is a status bit that the -- either -- that the DSP chip can deliberately go out and -- that the DSP chip can go and poll, or they might use one of the interrupt lines. I guess that would be the more efficient way. So the UART would be connected to one of the interrupt lines. These are the pins marked INT0, INT1, INT2 on the chip. What happens with these lines is -- so the UART would be sitting there, getting the serial input. It would say, okay, I've received a byte of serial data, it would pull low, a data ready pin or something like that, which would be connected to the interrupt pin. This would cause an interrupt to happen in the DSP processor, which means that the program counter is modified to go and execute program statements at a particular point in memory called an interrupt handler. Those statements would know to go to the particular address of the UART data register and do a read operation to read back the byte that's just been received.

Q. What is the data register?

A. The UART has a -- has some latches internally which it uses to temporarily record the data that's

coming over the serial line. That's the thing that is connected to the data pins when this read operation happens.

Q. The register or the latches that you talk about, could I describe that also as just a type of memory?

A. That's interesting. It's the smallest element of memory. It's like one word of memory. So memory, you could view as a very large number of latches. That would be kind of stretching the definition.

Q. But it is a type of memory, even if it's small and short term.

A. It's not about it being short term. I think people in this area would be a little bit uncomfortable with calling a single latch a memory. But technically, it stores -- it remembers a value, yes.

Q. Does the same thing happen in reverse from the DSP through the UART to the serial connection?

MR. DAS: Objection, form.

THE WITNESS: That was actually the first thing I described.

BY MR. CRAIN:

Q. Right. So the data would be written to the UART, stored on a register.

A. Yes.

Q. Then --

A. Sent out in a serial line.
Q. Is the connection between the UART and the DSP a serial line?
A. No.
Q. What would you describe it as?
A. I would describe it as a hard wire connection. But if you wanted to call it parallel, it's connecting the data point -- the data bits are connected in a set of parallel wires.
Q. Have you ever heard of something called Harvard architecture?
A. I've heard it.
Q. What is that?
A. I'm not exactly sure, but I believe it's -- I wish I knew what the -- yeah, Harvard architecture is when you have separate address spaces for program and data.
Q. Does the TMS320 employ a Harvard architecture, according to what you know about it?
A. Maybe. I'm looking at the block diagram. I see a separate program bus and data bus.
Q. Let me catch up to you. Where are you looking to, sir?
A. The functional block diagram. Let me just see.
No, I don't think it does. Because there is

only one -- it looks like there is only one address space. I don't know. I don't know. You know, it's -- it's a distinction of interest to computer science theoreticians.

Q. Just to be clear, you don't know whether or not the TMS320 does or does not employ a Harvard architecture?

A. That's right.

(Exhibit 16 marked for identification.)

BY MR. CRAIN:

Q. Dr. Ellis, I've handed you what has been marked as Exhibit 16. Would you please take a moment to review it and identify it when you're able, if you can.

A. Well, this is Patent No. 5,822,775. It's the reference I refer to as Sudo in my declaration.

Q. Have you had occasion to read the patent that we're calling Sudo as Exhibit 16, though?

A. Yes.

Q. Do you recall approximately how many times you've read Sudo?

MR. DAS: Objection, form.

THE WITNESS: I've read it a couple times. I've read the whole thing a couple of times, and I've, you know, dipped into it other times.

BY MR. CRAIN:

Q. Do you recall if you reviewed Sudo this week?
A. I have.
Q. Did you read it through completely?
A. Yes.
Q. What do you understand Sudo to be related to?
MR. DAS: Objection, form.
THE WITNESS: It's describing a particular approach to transferring coefficients in a running DSP system with -- doing it efficiently and without interrupting the process.
BY MR. CRAIN:
Q. So Sudo pertains to a DSP. Correct?
A. Yes.
Q. Do you see a DSP in any of the figures of Sudo?
A. Yes.
Q. Where do you see a DSP in Sudo?
A. So Figure 1 is a functional block diagram. Item two is labeled DSP.
Q. You said item two is labeled DSAP. Are you referring to the numeral two that has connection to a dashed box?
A. Yes.
Q. What do you understand the dashed box to be?
A. The DSP.
Q. Do you understand the DSP 2 in Sudo, Figure 1,

to be a DSP chip?

A. A DSP system.

Q. What's the difference?

A. I don't know if it's a chip or if it's a -- it could be implemented as a collection of chips.

Q. What does Sudo tell you?

A. I don't know. I'm not aware of him telling me either. He just calls it a digital signal processor.

Q. So you're unable to tell whether he's referring to a single DSP integrated circuit or not?

MR. DAS: Objection, asked and answered.

THE WITNESS: That's right.

BY MR. CRAIN:

Q. What suggests to you that it may very well be a DSP system on multiple chips?

A. The material in this patent is about changing the internal -- the architecture within this box. If you had to build a new DSP chip every time you wanted to change it, you would have a very, very slow development cycle.

Q. When I asked you earlier what is Sudo related to, you said, it's describing a particular approach to transferring coefficients in a running DSP system with -- doing it efficiently and without interrupting the process. And just now, you said the material in

this patent is about changing the internal -- the architecture within this box. If you had to build a new DSP every time you wanted to change it, it would be -- it would have a very, very slow development cycle.

A. Right.

Q. Those seem to be two different things.

A. They are.

Q. So is the patent about both of those things?

A. The patent is not about the development cycle. But in order to do the work -- to do the experiments to devise the invention, you need to be able to manipulate the internals of the digital signal processor.

Q. Well, you've used the term manipulating the internals and changing the internals. What do you mean by that?

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: I mean making changes to this block diagram.

BY MR. CRAIN:

Q. Does it make changes to the physical architecture?

MR. DAS: Objection, form.

THE WITNESS: What do you mean, the physical architecture?

BY MR. CRAIN:

Q. Well, that's what I'm trying to understand, what you're saying. Does it physically change the chip?
MR. DAS: Objection, form.
THE WITNESS: If it was a chip, then these -- the kinds of changes they're talking about would involve -- the kinds of -- the kinds of modifications -- the kinds of systems -- the techniques they're talking about would involve special functionality within the chip.
BY MR. CRAIN:
Q. I'm still not following you. What do you mean by that?
MR. DAS: Objection, form.
THE WITNESS: So they're talking about, you know, a field of invention. Those inventions rely on particular hardware support within the DSP system.
BY MR. CRAIN:
Q. What hardware support are you referring to?
A. Well, many of these items are separately specified because they relate to the invention.
Q. How is that relevant?
MR. DAS: Objection to form.
THE WITNESS: I'm saying the invention is about the particular layout of these hardware items.
BY MR. CRAIN:

Q. Are you suggesting that the invention changes those hardware items?

MR. DAS: Objection, form.

THE WITNESS: The invention doesn't change them, but in order to create the invention would require changing them.

BY MR. CRAIN:

Q. What does that mean?

A. So I'm imagining these guys in a research lab doing the work that then gets reported in this patent. They have to experiment with different internal architectures of the DSP systems in order to arrive at the solution.

Q. Okay. But once they arrive at the solution and they want to change coefficients, how do you understand that to operate?

A. That's what the patent is describing.

Q. Would you explain it to me, according to your understanding.

A. There is a process by which the new coefficients are transferred from the microcomputer and they're written into the coefficient Data RAM at a particular moment that minimizes the impact on the system.

Q. Can you give me an example, according to your understanding, of impact on the system.

A. They mean that they want to be able to do it without interrupting the audio processing.
Q. Why is that important?
A. So that you can make changes smoothly.
Q. As opposed to?
A. Making changes that result in a glitch in the output.
Q. What is an example of a glitch in the output?
A. A click in the audio stream.
Q. Something that would be audible?
A. Yes.
Q. Do you understand the disclosure of Sudo to avoid such a scenario?
A. Yes. I mean -- yes.
Q. What is the significance of the dashed box that we have labeled as numeral two?
A. It's the digital signal processing system -- digital signal processor.
Q. The thing I'm still struggling with is what your understanding is of how that digital signal processor is disclosed in Sudo.
A. How it's disclosed?
Q. Yes. What is it, according to the Sudo disclosure?
A. It's this. Here it's described in terms of its

functional block diagram.

Q. So what's inside the box is part of the DSP?

A. What's inside the box is the digital signal processing system.

Q. Do you see it described as digital signal processing system in the Sudo patent?

A. No. I see it described as digital signal processor.

Q. You keep describing it as a digital signal processing system.

A. Yes.

Q. Why?

A. That seems to me a clearer form of words.

Q. Than what the inventors used?

A. Have you read the patent?

Q. Why do you ask?

A. Because the language is very poor.

Q. What's poor about it?

A. It seems like it was not written by a native speaker.

Q. Can you give me some examples of some of the poor writing.

A. The title is, "Efficient Data Processing Method for Coefficient Data in a Digital Dignal, Processor." That's clearly a typo. They meant "signal" instead of

"dignal." And the comma is completely redundant. There are quite a number of such instances.

Q. Okay. So there is no such thing as a digital dignal processor?

A. Not to my knowledge.

Q. Can you point me to some more?

A. Yeah. Yes. So, in the abstract, it says, "whereby a processing" -- starting at the end of the third line -- "whereby a processing program and coefficient data are transferred and supplied from a microcomputer determination, whether an instruction is a read instruction," et cetera. The comma should have come before "determination." It should be, "transferred and supplied from a microcomputer, determination whether an instruction is a read instruction," et cetera.

Q. Okay. So, so far, we see two typos.

A. Yeah.

Q. And a couple of misplaced commas. What else?

A. Oh, my God. It's so bad that it took me forever to figure out what they were saying -- what they were saying about that particular sentence.

I'm sorry. I can't find them. I recall noticing them when I read it, but I don't want to waste any more time.

Q. No, please go ahead.

A. Okay.
Q. Where are you in your reading?
A. I'm jumping around. I remember particularly there was like this weird misplaced article, as I remember, but I can't find where it is.
Q. Did you find it?
A. No.
Q. Are you looking for one specific item?
A. Yes. Well -- so I have a recollection of thinking, when I was reading this, that it was written by a non-native speaker. Actually, you, having more experience in patents, may know that that was almost certainly not true, which is fine.
Q. I'm sorry. I didn't understand the last thing you said.
A. You may know that it's almost certainly not true, which is fine.
Q. I don't.
A. So yeah. What do you want to do? Do you want me to read the whole thing?
Q. Well, you've identified two typos. You've indicated that it's very poorly written. This is all relevant to this thing of DSP to you, every time you see it, means DSP system. So I'm trying to understand why, and you've only shown me two typos. So if you're able

to show me more that lead you to that conclusion, please do; but if you can't, that's fine, too.

A. So there is a second sentence of the misspelling of signal as dignal. Right? I believe.

Q. Okay.

A. Just in the title. In column one. But I can't find the other instances that I recall.

Q. How many other instances are you thinking about that you may recall?

A. I'm recalling one particular thing where I seem to remember there was a miss -- there was like a redundant article, but in general, I found the language quite difficult to follow.

Q. When you say "redundant article," are you talking about a and the?

A. Yes.

Q. So that sounds like a typo, but I don't have it here. I don't know exactly where it is, so I don't want to presume. It sounds like maybe three or four typos. What else?

A. I'm just saying, that my impression on reading it was that it was not written -- it was not written in a very fluid way.

Q. Well, based on what you've identified so far, that led you to the conclusion that DSP means DSP

system?

MR. DAS: Objection, form.

THE WITNESS: Sorry. Was that a question?

BY MR. CRAIN:

Q. It was. Based on your reading of the Sudo patent and the -- I'll give you five typos so far that you've identified -- that led you to the conclusion that every reference of DSP in the Sudo patent means DSP system. Right?

A. No.

MR. DAS: Objection, form.

BY MR. CRAIN:

Q. Okay. Then how did you get to the conclusion that DSP means DSP system and not what it says in the Sudo patent?

A. Well, it says it means digital signal processor.

Q. Can you find an instance in Sudo where it describes it as a digital signal processing system?

A. I don't think so. It always refers to it as a DSP.

Q. But you're construing it, if I understand you correctly -- I'm just trying to make sure I understand you clearly --

A. Absolutely.

Q. You're construing DSP not as a digital signal

processor, but a digital signal processing system?
A. No. I'm saying a digital signal processor doesn't exclude digital signal processing system. Digital signal processor is a -- you could call that a digital signal processing system.
Q. Does Sudo?
A. He calls it a digital signal processor.
Q. He doesn't call it a digital signal processing system; does he?
A. No, he doesn't. That's not really a term of art. I mean, it's not -- there is not like specific meanings to these different forms of wordS. DSP chip, that has a specific meaning. Digital signal processor, digital signal processing system, DSP system, DSP, they're not so narrowly defined.
Q. In the time of this patent that was filed around 1991, how was a DSP implemented during that time, according to your understanding?
MR. DAS: Objection, form.
THE WITNESS: If you were developing digital signal processing systems which you would be intending to render into say DSP chips, you would most likely have some kind of discrete logic version that you would use to develop it.
BY MR. CRAIN:

Q. I don't know what you mean.
A. So let's say I'm experimenting with different architectures of this kind. Do I need this transfer buffer 18? Can I maybe get by without it? How am I going to test that idea? I need a system that has it and a system that doesn't have it. How am I going to, you know -- maybe I'm working on it and I want to introduce this transfer buffer. What am I going to do? The most natural way to be able to do it would be to have a system composed of discrete components that I could modify.
Q. Once you come up with the system, as you used the term, as we see in Figure 1, is it your understanding that this would have been created in some tangible form?
MR. DAS: Objection, form.
THE WITNESS: Sorry? Objection, form.
Yes.
BY MR. CRAIN:
Q. And what form or forms might that have taken during the time of the patent?
A. I'm imagining that the researchers in the lab had some kind of prototype system.
Q. What lab?
A. Whichever -- the research lab they were working

in.

Q. Why do you presume that they were working in a lab?

A. That's my -- that's my assumption of a patent. Patents are inventions. Inventions come from labs.

Q. Why do inventions come from labs?

A. It would be pretty hard to be developing innovations in architectures of digital signal processing systems without access to a lot of specialized equipment such as might be found in a lab.

Q. So do you have any specific understanding of whether or not the patent that we see here in Sudo was or was not developed in a lab?

A. Beyond the fact that the assignee is a known Japanese manufacturer of consumer electronics who almost surely had a lab where they developed novel devices, that's the basis.

Q. So it's a conclusion you're drawing based on your understanding and what you see as the assignee?

A. Honestly, I can't imagine any other circumstance in which -- where such an invention would come from.

Q. Do you believe that also to be true with the '544 patent?

A. No.

Q. Why not?

A. The '544 patent doesn't -- hang on. Let me just -- do I have it? I don't have it. Right? Do I have it? I do have it. Sorry.

Q. Exhibit 14.

A. It doesn't involve changes to the, you know, internal architecture of a digital signal processing system.

Q. So only patents that involve changes in architecture, you think, have to be invented in labs?

MR. DAS: Objection, form.

THE WITNESS: It's kind of -- it's not -- it's difficult to boil it down to a simple test like that, based on my assessment of the kind of work involved. There are some things that I could imagine doing at home, in my garage say; there are some things which I could not imagine doing at home.

BY MR. CRAIN:

Q. Because you describe the '544 patent as not getting into the architecture of the DSP, you believe that it likely was not invented in a lab?

MR. DAS: Objection, form.

THE WITNESS: No.

BY MR. CRAIN:

Q. When you say "no," do you mean that's correct; or no, you disagree?

A. I disagree with your statement.
Q. So then you think that it may have been invented in a lab?
A. Oh, yeah. You know -- sorry. Carry on.
Q. I'm sorry. What were you going to say?
A. Nothing.
Q. Drawing your attention back to Sudo --
A. Yeah.
Q. So the DSP 2 that we see, could that have taken the tangible form of a DSP chip around the time of 1991, 1992, when it was filed as a patent for invention?
A. The system described in Figure 1 is the kind of thing you could build as a chip, yes.
Q. Well, the system in Figure 1 has more than just -- more items than just the DSP 2. Are you saying all of it would be on one chip?
A. Sorry. No. The item labeled DSP.
Q. All right. Well, let's ask the question again so we have it clean.
A. Yeah.
Q. The item identified as DSP 2 in Figure 1, do you believe that it could have been implemented as a DSP chip at the time of invention in the year 1992?
MR. DAS: Objection, form.
THE WITNESS: I believe that the item labeled

DSP in Figure 1 could have been implemented as a single chip or equally as a system comprising several chips.
BY MR. CRAIN:
Q. Okay. So that's one part. A single chip. You agree with that. But you also believe it could have been implemented as multiple chips.
A. Yes.
Q. Do you see any suggestion in Sudo to do that?
MR. DAS: Objection, form.
THE WITNESS: The reason I mention that is because I'm imagining the process of actually doing the research involved in generating these results.
BY MR. CRAIN:
Q. But would you answer my question.
A. Do I see any direction to implement it as multiple chips?
Q. In Sudo.
A. I don't see any direction either way.
Q. Either way what?
A. Either as -- it doesn't talk about the number of chips he's going to use to implement it.
Q. So you don't believe the fact that we have a box there labeled as DSP 2 at least indicates that it can be one chip. I thought you already said it could.
MR. DAS: Objection, asked and answered.

THE WITNESS: I said it could be one chip. I think that it's -- it would have been technically possible, at the time, to put all of this on a single chip, but he doesn't say anything about it.

BY MR. CRAIN:

Q. Tell me your experience with digital signal processors in 1992 involving multiple chips.

MR. DAS: Objection, form.

THE WITNESS: I did not have any such experience. As I'm saying, this idea of this system based on multiple chips is based on my idea of how it would be done in a lab that were developing signal processing architectures at the time.

BY MR. CRAIN:

Q. Tell me all the DSP chips that you can think of -- let me start again.

Tell me, as of 1992, all of the DSPs that would have been on multiple chips that you know about.

A. So, as I'm saying, the only ones I'm imagining are systems being used for development of DSP architectures within labs, not commercial products.

Q. So you don't know of any commercial product DSPs that would have been on multiple chips as of 1992; do you?

A. You wouldn't call it a -- you wouldn't sell

multiple chips and say, "These things, use them together to make a single DSP." If you were going to sell them like that, you would put them on one chip.

Q. Then why in the world are you telling me they could be on multiple chips based on what Sudo discloses? That makes no sense.

MR. DAS: Objection, asked and answered.

THE WITNESS: I think I've explained this.

BY MR. CRAIN:

Q. You're telling me nobody would do that commercially?

A. No one would make it as a product.

Q. Right.

A. But somebody has got to figure out how those products are going to work. Someone has got to do experiments and do research before we can build the products.

Q. So they would build separate chips with these components on some chips and on other chips?

A. Yes.

Q. And those chips would never see the light of day?

A. Oh, no. I mean, the chips are just standard digital logic.

Q. So you're speaking really in the confines of

theory testing.

MR. DAS: Objection, form.

THE WITNESS: I'm talking about practical testing.

BY MR. CRAIN:

Q. Well, if someone were going to practice what Sudo teaches, which you've told me you have difficulty reading, how would they do it, on one chip or multiple chips?

MR. DAS: Objection, form.

THE WITNESS: Yeah, you would -- I think -- the goal would be to build a final product that was a single chip, involving this idea. It's interesting how you would get there. Right? So you could design -- yeah, I think -- well -- I don't know. But it's quite likely -- it's quite possible -- seems quite possible to me that you would want to build some prototypes before you committed to the final chip.

BY MR. CRAIN:

Q. Okay. What does that have to do with anything?

A. Well, the prototypes would not be a single chip; it would be more pieces. It would be some kind of development board with different -- the opportunity to put different things together.

Q. Right. And you've already told me that this

thing was assigned to Pioneer. Do you have any understanding or belief that Pioneer would have ultimately reduced this to one chip or not? Do you know?

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: This is not -- you know, this only deals with one aspect of the -- of the processing system, but -- I have no idea if they did, but I assume from the fact -- one reason for this patent existing is because this is something that they developed and used and put into chips that they manufactured.

BY MR. CRAIN:

Q. But I think you did say earlier that you wouldn't expect a commercial embodiment of the invention in Sudo to be manufactured on multiple chips.

A. That's right.

Q. In Figure 1, do you see a box labeled 19 with the text "Interface"?

A. Yes.

Q. Feel free to refer to the patent text. I'd like to understand your understanding of what do you understand Sudo to disclose interface 19 to be?

MR. DAS: Objection, form.

THE WITNESS: An interface, you know, implies circuitry whose only function is to connect together two

systems that cannot be directly connected together to -- you know, two systems. This is the interface that's handling the translation between the microcomputer and Bus 17 -- Main Bus 17.

BY MR. CRAIN:

Q. Why can the two systems that you were referring to in your prior response not be connected together?

A. You know, typically, when you're connecting an external microcomputer into some other system, there will have to be some, you know, fairly low-level translation of voltages, possibly modifications of timing, things like that.

Q. Do you believe that Sudo is disclosing Interface 19 to be a connector?

A. I don't think he's talking about the connectors. I don't think he -- this description would not be at the level of connectors. It's not -- that's not really -- that would be kind of irrelevant to the material.

Q. So it's not a connector, in your opinion?

A. He's not -- he didn't put that box there because he wanted to remind us to use a connector.

Q. Not use a connector. That it is a connector.

MR. DAS: Objection, form.

THE WITNESS: I mean, it's teaching how to do this. Right? So it's like, oh, in order to do this,

you'll have to put a connector here. That's not what he's saying. Because you wouldn't -- it would be kind of absurd to describe the use of the individual connectors at this level of abstraction.

BY MR. CRAIN:

Q. You agree with me, then, that Interface 19 is not disclosed by Sudo to be a connector, then. Correct?

A. That's right. That's my impression.

Q. What do you understand Main Bus 17 to be?

A. As we've discussed before, a bus is more of a design abstraction. It's a set of nodes that are connected together in a circuit, but they're ones where, you know, you use them for multiple purposes, which is -- so that's why you call it a bus.

Q. Let me see if I can help the discussion.

A. Yeah.

Q. Remember when we were talking about a data bus and a program bus earlier with respect to the TMS320?

A. Yes.

Q. Would you expect Main Bus 17 to be materially different from either the data bus or the program bus?

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: It looks to me like a program bus. He calls it the main bus, but it's similar to the program bus.

BY MR. CRAIN:

Q. To be clear, what you're saying, Main Bus 17 appears to be similar to you to the program bus that we saw in, I think it was Exhibit 15, the TMS320 document.

A. What I mean is if you were trying to make analogies between the two designs, that would be a reasonable analogy to make.

Q. Thank you.

What differences do you see between Interface 19 and I/O Interface 3, both within DSP numeral two?

MR. DAS: Objection, form.

THE WITNESS: Interface 19 is connecting the external microcomputer to the bus. I/O Interface 3 is connecting a different bus to the external A to D and D to A converters which are supplying the input and the output to the DSP system.

BY MR. CRAIN:

Q. Understanding that these two interfaces are shown as, I guess, functional blocks, but do they represent hard-wired components if you're going to build this physically?

A. The individual interfaces?

Q. Right.

A. Those blocks represent hard-wired components. They would be implemented with some components which

would be connected together. They would be implemented with some components which would be connected together.

Q. Is connected together and hard wired different?

A. You know, hard wired, I guess you're -- I don't know what that means. I mean, I do know what that means, but we haven't defined it.

Q. Okay. What does it mean?

A. Hard wired means -- implies that it's done in an inflexible way.

Q. What other type of connections are there that we should also be concerned with? And let me define the universe. Within what we're talking about with Sudo here.

MR. DAS: Objection, form.

THE WITNESS: You know, I'm thinking about this as a development environment. So I'm thinking about systems where you might want to change the connections between the chips. So you might have a wish to have them implemented in some mechanism whereby you could connect things together without having to go out and solder things.

BY MR. CRAIN:

Q. And that would have been the case in 1992?

A. They were not -- you don't -- yeah, you don't get out your soldering iron every time you want to

change a circuit.

Q. What suggests to you the desire to change the circuit?

A. Because they're doing research on the structure of this -- of this system.

Q. Where do you see that?

A. Well, because it's a patent about -- an idea about the structure of the system.

Q. But what makes you think there is a desire in the Sudo patent to change what's represented in the Sudo patent?

A. Well, because that's what they're talking about. They're talking about how they've come up with this new idea to how to arrange one of these, which means like -- well, they must have -- they must be starting from something different.

Q. But where is the end?

MR. DAS: Objection, form.

THE WITNESS: Where is the end?

BY MR. CRAIN:

Q. Yes. So they're starting from something. Is this not the end of what they reached?

A. This is the end, yes.

Q. So if this were being built as a commercial chip, how would you expect to see the connection between

Main Bus 17, Interface 19, Microcomputer 20, and similarly, the Bus 4, Input/Output Interface 3, and each of those A to Ds and D to As?

MR. DAS: Objection, compound. Objection, form.

THE WITNESS: If this were being built as a chip, then all the signals coming in and out of the system would be carried by pins on the chip. Those pins, of course, would not be something that you could directly connect to an external computer or an external analog-to-digital, digital-to-analog converter. As with any DSP chip, the actual product, you wouldn't -- there would be a product which was a chip, then there would be a product which was some kind of system including that chip. That system would provide some kind of ability to actually connect these things, including connectors.

BY MR. CRAIN:

Q. Where would the pins on the chip be?

MR. DAS: Objection, form.

THE WITNESS: On the chip.

BY MR. CRAIN:

Q. Where would we expect to find pins with respect to what's shown in Figure 1?

MR. DAS: Objection, form.

THE WITNESS: Figure 1 does not provide any kind of direct correspondence to individual pins. We've been

talking about the idea of reducing the digital signal processor, as he styles it, into a single chip. But those -- I think -- and earlier, I said that was a sensible thing to do. But boxes three and nineteen, the I/O interface and the interface, are probably the least -- least likely candidates to be included within a single chip. So there would certainly be pins on the chip which would be involved in the process of connecting the DSP chip to other -- other units, but it's unlikely that there would be no other -- no other circuit elements involved in those interfaces, external to the chip.

So what I'm saying is the way I imagine this, if this whole thing were reduced to a single chip, would be most of the box two would be within that chip, but some of boxes three and nineteen would be constituted by external circuits on the same circuit board as the chip to handle the details of interfacing to the converters and the microcomputer.

BY MR. CRAIN:

Q. So you believe that Interface 19 would actually be partially or completely outside of the box that we see as DSP 2?

A. I think there would -- there would almost certainly be some of it -- now we're talking about a

hypothetical rendering of the system into a chip -- I think there would most likely be some interface circuitry -- there would certainly be some interface circuitry inside the chip, and there would most likely be some that was outside the chip.

Q. Why do you say that? And qualify your answer with the time of the invention that we see in Sudo.

A. Absolutely.

Q. Okay. Make sure.

A. When you're building a chip, you know, you want to build a single chip that's going to be useful in a variety of circumstances. You don't -- it's a very delicate process in design to choose your boundaries at the right point. But you don't want to include -- particularly, you know, a chip is an expensive thing to build. You don't want to include too much inside of it. So things that you might want to vary in the different uses you might make for this chip, such as the style of the interface to other system components, it wouldn't make sense to hard wire them within the chip, to bake them into the chip.

So you would try and have some kind of very generic portions of the interface, something that you're pretty much going to need in any circumstance within the chip; and then you would be able to build boards, the

DSP boards, including this chip; and then put whatever additional circuitry you needed to specialize it for the particular devices that you wanted to connect it to, you would be able to put those on the board externally.

Q. Well, a few minutes ago, you were telling me that everything inside a DSP 2 could be implemented on a chip. Now you're telling me that's not the case.

A. Yes.

Q. Why are you changing?

A. When we were talking about it, I wasn't thinking carefully about boxes three and nineteen. You drew my attention to them subsequently.

Q. So now your testimony is that it could not be implemented on one chip, because blocks three and nineteen would have to be implemented, at least in part, outside of DSP 2.

A. No. That's not what I said. I'm saying -- you could implement on one chip, but most likely, good engineering design procedure would lead you to divide the implementation of those interfaces to be partially on the chip and partially external.

Q. So you're telling me that it would be good engineering design to not put too much on one chip. You said that phrase, too. So now, Pioneer is going to sell not one chip, but two chips.

MR. DAS: Objection, form.
BY MR. CRAIN:
Q. Because you can't put the interface now on just one chip, you've got to have two.
MR. DAS: Objection, form.
THE WITNESS: No. They're going to sell one chip, and then the point is the other half of the interface is a detail of the particular implementation. It's not a specialized chip.
BY MR. CRAIN:
Q. Show me in Sudo that supports that.
A. I don't see anything in Sudo that speaks to that. That's just how you do electronics design.
Q. Show me in Sudo that teaches pulling that box 19 out of DSP 2.
MR. DAS: Objection, form.
THE WITNESS: I don't know what I'm looking for really.
BY MR. CRAIN:
Q. It doesn't teach it; does it?
A. It doesn't really -- so you're saying what would that mean? If it was partially outside of the box, then it would say the interface which is not entirely within the digital signal processor or something like that.
Q. It makes no sense to me -- and you know more

about this than I do -- but it makes absolutely no sense to me that you would have a box with components inside it and say, well, you know, these are actually going to be outside. Well, why did you draw them inside? You're telling me they could be outside. Okay. Then where is that in Sudo? Because he seems to think something different than what you're saying. Unless you can show me where he says it.

A. Well, what's the -- I mean, you can understand this as -- well, in a sense, this sort of speaks to my original impression that the box doesn't particularly describe a chip, but describes a system. The interface -- all of the Interface 19 that we're discussing, in my view, is within the system. Part of the circuitry is on -- say on this chip, part of it is external to the chip. That would be the conventional way to do it. As I've explained, that would be good engineering practice.

Q. And you're unable to find one jot or tittle in Sudo that supports what you just said. Right?

MR. DAS: Objection, argumentative.

THE WITNESS: Because that's really not the -- that's not what the patent -- that's not the level of abstraction the patent is working at.

BY MR. CRAIN:

Q. What you're suggesting, though, doesn't that change or effectively get rid of the box that is labeled as DSP 2?

A. No. It actually puts it into my original construction, which is like this is a system. Digital signal processing, which likely consists of multiple chips.

Q. But the word "system" for DSP is not in the patent either.

A. Okay. This is a digital signal processor that likely includes multiple chips.

Q. Okay. So you've completely backed away now from what you said earlier about the DSP 2 being implemented on one chip, at least in one instance?

MR. DAS: Objection, form. Objection, argumentative.

THE WITNESS: No. I think -- remember when you asked me what an interface was, and I tried to explain that it was the name for some low-level process of translating say electrical levels? It's not -- it's something you would want to put in there, because hey, let's not forget, you're going to have to do -- you may need to do some translation of electrical levels in here. But it's not like, oh, this is some important, crucial function. It's sort of just -- it's a very

minor detail of the system.
BY MR. CRAIN:
Q. Can you tell me why a person of ordinary skill in the art of the '544 patent not understand Interface 19 to be a buffer circuit to the interface pins of the DSP, a chip, and then Main Bus 17?
A. Why they would not understand it to be that?
Q. Yes. No, no, no. Why they would understand it to be -- well, let me flip it. Because I think the not there is confusing.
Do you believe a person of ordinary skill in the art would understand Interface 19 to be a buffer circuit to interface the external pins of the DSP chip as connected to Microcomputer 20 and then Main Bus 17?
MR. DAS: Objection, form. Objection, compound.
THE WITNESS: I don't understand -- you know, there is more to it than that. Right? What is the connection to the microcomputer? So I kind of -- I like parts of what you said, that there would be -- part of the Interface 19 would involve --
(Interruption.)
THE WITNESS: That the Interface 19 would involve some buffer circuit. That's what I was -- that's the kind of thing I was talking about, about translating voltage levels. But there is sort of a

second half to that, which is like, well, okay, so that's taking something that comes off say pins on a DSP chip and interfacing them to something that might be an internal data bus. But then it's like, okay, what do we do with these pins on the DSP chip to connect them to a microcomputer?

BY MR. CRAIN:

Q. Does Main Bus 17 operate at high speed, according to your understanding of Sudo?

A. It's -- you know, the speed of Main Bus 17 is important. It's one of the -- it's part of the -- the speed limit -- you know, the ultimate speed of the whole system, yes. And high speed, you know, what does that mean? But high speed meaning like high speed relative to other systems in the -- relative to other components in the system, yes.

Q. Just to be clear, do you believe that Main Bus 17 is a high-speed bus?

MR. DAS: Objection, asked and answered.

THE WITNESS: We haven't defined high speed. A high-speed bus.

BY MR. CRAIN:

Q. I think you did suggest that speed is important in Sudo. Correct?

A. That's right.

Q. What can you explain to me about the speed of Main Bus 17?

MR. DAS: Objection, form.

THE WITNESS: A system like this, a microprocessor system like this, will have a clock. It has a clock that synchronizes all the different operations. I think Main Bus 17 changes state with every clock cycle, which is probably the most rapid changes that occur in the system.

BY MR. CRAIN:

Q. Describe for me how Interface 19 is connected to Microcomputer 20, according to your understanding of Sudo.

A. It doesn't say.

Q. Do you have any understanding?

A. I understand that the -- there is a microcomputer which is delivering data to the system through that interface. So there must be some form of interface. And as it turns out, the ability to -- I think the microcomputer has the ability to -- has quite a high level of control over the state of the internals of the digital signal processor through this interface and through its control of Main Bus 17.

Q. So based on that, what type of connection do you believe Microcomputer 20 to have with Interface 19 of

DSP 2?

A. I would expect it to have a high-speed connection.

Q. You used the term "high speed" there. So can I also apply that to Main Bus 17?

A. Yes.

Q. So we're going to use that as the benchmark. Okay?

A. Okay.

Q. Tell me, as of 1992, what type of high-speed connections would be in existence that you would have expected to see between Interface 19 and Microcomputer 20.

A. You know, my best estimate would be something like the PCI bus. This was the internal -- the connection that was used to allow you to insert cards into a microcomputer, like an IBM PC or something.

Q. You believe it could have been that?

A. That's the kind of thing I expect it to be.

Q. Do you believe it could have been anything else?

A. It could have been anything else.

Q. Like what? I want you to tell me.

A. You could certainly generate some special purpose interface. You know, you can -- it's not clear. It certainly doesn't have to be that.

Q. What does it have to be?
A. It has to be some -- it has to be able to allow the microcomputer to access the bus in order to perform the functions that it specified.
Q. According to your understanding of what type of high-speed connections were available during the time of the filing of the Sudo patent, what would that menu be?
MR. DAS: Objection, form.
THE WITNESS: You could create --
BY MR. CRAIN:
Q. Let me ask the question again. What would the menu of available options of the interconnection between Interface 19 and microcomputer be to achieve the high speed that you talked about?
A. You could develop -- you could construct some kind of custom parallel connection to do that.
Q. So I would have to create something from scratch?
A. Sure.
Q. Okay. You mentioned a PCI bus.
A. Yes.
Q. Is that an option?
A. Um-hmm. PCI bus requires quite a lot of overhead to manage. But that's the kind of role that would have been used -- that's the -- you know -- so I'm

imagining them building a development -- you know, when you build a card like this -- when you build a chip or a system like this, you typically -- you don't send it out to your customers as a chip. You give them a development board which they can then use for their own experiments to see what they can do with your chip. Very often, those development boards would be PCI bus boards.

Q. What else? That's two.

A. Well, so obviously a custom parallel -- so custom means everything other than some existing standard.

Q. So I've got to make up something.

A. Well, it's often -- if you know exactly what you want, why would you want to use a standard? The purpose of using a standard is to provide interoperability. If this is the only thing you're going to do with it, then you don't need that.

Q. Okay. So I still think you're on two. A PCI bus and some type of custom solution.

A. Okay.

Q. Can you think of a third?

A. No. I can't think of one.

Q. So RS-232 wouldn't be --

A. RS-232 would not be suitable.

Q. Why?
A. Too slow.
Q. Too slow for what?
A. Too slow for the detail of the way that the data transfers occur in this invention.
Q. So to be clear, according to your understanding of Sudo, you do not believe that the connection between Microcomputer 20 and Interface 19 could be an RS-232 connection.
A. Yes.
Q. And it couldn't be a USB connection, because that hadn't been developed yet.
A. That's right. Yeah.
Q. Are there any other serial-type connections that we haven't talked about, that this could be?
A. At this point in technology, serial connections were not fast enough for this.
Q. When was PCI bus developed?
A. The PCI buses identified with the IBM PC AT which came out in like 1984 or something.
MR. DAS: Mr. Crain, we've been going almost an hour and a half now.
MR. CRAIN: Have we?
MR. DAS: If this is a good time for a break.
MR. CRAIN: A couple questions. I'm at a point

here --
BY MR. CRAIN:
Q. Would PC bus -- PCI bus -- let me start again.
Would PCI bus have allowed for a removable connection between Microcomputer 20 and Interface 19?
A. Yes.
Q. Would this undefined custom -- was it a parallel connection?
A. Yes.
Q. Would this undefined parallel connection that was a custom connection also allow for a removable connection between the Microcomputer 20 and Interface 19?
A. Yes.
Q. How?
A. It's a custom. You can build it any way you want.
Q. We don't know, though.
A. I'm trying to think how it would not. Right? It depends on what Microcomputer 20 is. But if it isn't removable, that means that somehow it has to be permanently connected, which would mean that it was, you know, an integral part of the entire system.
Q. What does the circle between Interface 19 and Microcomputer 20 that's in the dashed line box represent to you?

A. It represents the port.
Q. What port?
A. It doesn't represent very much. It's just a -- I just see it as -- it doesn't have any particularly strong interpretation. It represents -- it normally would indicate a transition between -- you know, something like leaving a circuit board.
Q. Could it represent a pin?
A. It could represent a pin. Well, in this case, it could not represent one pin.
MR. CRAIN: All right. We'll take a break.
THE WITNESS: Thanks.
THE VIDEOGRAPHER: This is the end of Media No. 3 in the deposition of Dr. Daniel Ellis. The time is 3:44 p.m. We're off the record.
(Recess taken from 3:44 to 3:55.)
THE VIDEOGRAPHER: This is the beginning of Media No. 4 in the deposition of Dr. Daniel Ellis. The time is 3:55 p.m. We are back on the record.
BY MR. CRAIN:
Q. Would you please turn to Exhibit 13.
A. Okay.
Q. I think you did this earlier. But would you please again identify Exhibit 13.
A. This is my declaration in the matter at hand.

Q. Did you author your declaration?
A. Yes.
Q. Did you type all of the content in your declaration?
A. I didn't type it all. The history -- I'll let you ask the questions.
Q. Well, go on. The history what?
A. (No response).
Q. What were you going to say?
A. I don't know.
Q. You don't know? Did you forget?
A. I didn't finish composing a sentence.
Q. What were you starting to say?
A. I said the history.
Q. And you don't remember what you were going to say after that?
A. Not by now.
Q. Okay. By the way, is there anything with respect to your testimony from earlier today that you would like to change or correct?
A. No. Thank you.
Q. And did you speak with your attorneys during the break?
A. I spoke with them.
Q. Did you speak about the substance of your

testimony to date?
A. No.
Q. What parts of your declaration did you not type?
A. I don't know. I can't identify --
Q. What parts of your declaration do you remember typing yourself?
A. Various parts throughout.
Q. Turn to native page three, QSC page six of your declaration.
A. Yeah.
Q. Do you recall whether or not you composed Section IV(A) of your declaration?
A. Section IV(A)? Yes. I did.
Q. You did compose --
A. I believe so.
Q. Does that include paragraphs ten through fourteen?
A. Yes.
Q. Did you insert a copy of Figure 1 from Sudo onto native page four?
A. Did I insert it?
Q. Yes.
A. I don't think so.
Q. Did you direct it to be inserted?
A. Yes.

Q. Why did you direct it to be inserted?
A. This is what I really liked about Sudo is this picture that makes it very clear there is a separation between the microcomputer and the digital signal processor.
Q. Did you compose paragraph 13 of your declaration?
A. Yes.
Q. Earlier, you seemed to have trouble or you quibbled with me a little bit about the term "hard wired."
A. Yes.
Q. I see the word "hard wired" in paragraph 13.
A. Yes.
Q. So I need for you to explain it to me, what you intend that word to mean so that we can talk about it.
A. In this case, it's in contrast to a removable connection. It's a non-removable connection.
Q. Hard wired means non-removable?
A. Yes.
Q. What does removable connection mean to you?
A. A connection that you can physically separate.
Q. Permanently?
A. A connection that you can physically separate and reconnect multiple times.

Q. What you just said is your understanding of the term "removable connection" in Sudo?
A. "Removable connection" in Sudo or in this paragraph?
Q. Is there a difference?
A. I don't know what "removable connection" in Sudo means.
Q. Is there a difference in what the term "removable connection" in Sudo means and what it means in paragraph 13?
A. I don't believe it appears in Sudo.
Q. I'm sorry. Thank you.
In the '544 patent.
A. Oh, great. Is there a difference in what "removable connection" means? In that extent, I don't believe so, no.
Q. Is the term "removable connection" in Sudo?
A. I think not. I think if it had been, I would have mentioned that.
Q. Does Sudo teach the concept of a removable connection?
A. The subject matter of Sudo is not about those kinds of issues.
Q. Is that a no?
A. Sudo doesn't teach a removable connection. Sudo

is about ways of updating parameter RAM.
Q. In paragraph 13, where you use the term "removable connection," what do you mean?
MR. DAS: Objection, asked and answered.
MR. CRAIN: Well, I didn't understand him the first time, so I've got to ask again.
BY MR. CRAIN:
Q. Let me ask a question. What do you mean by the term "removable connection" in paragraph 13?
A. I mean that the connection between the digital signal processor and the microcomputer was most likely something that could be disconnected and reconnected multiple times with little effort.
Q. Based on what?
A. Based on my understanding of how -- of, you know, the kind of system that was being described and the activities that were involved in developing the patent.
Q. Show me, if you would, in Sudo -- if you have that patent handy --
A. Yes.
Q. Just a moment. I think I've gotten myself confused.
I think we were looking at Sudo. Let's look at something there. I think, before the break, we were

talking about these interfaces. What do you understand A to D numeral one to be?

A. A system for converting an analog input signal to a digital output signal.

Q. What do you understand D to A 22 to be?

A. A system for converting a digital input signal to an analog output signal.

Q. Would you describe for me how your understanding of A to D numeral one is connected to I/O Interface No. 3.

A. We're not given any information. It's not material. That's why we're not given any information. You know, the -- all he's saying is, okay, this is a thing that's connected to an analog input and output. It's a digital processor. So we have to have converters, because we're -- because we're needing to access these things in an ongoing fashion, we'll need some kind of interface to handle the details of the transfer from whatever format it comes from the A to D system into whatever format we need to use internally.

Q. Is A to D No. 1 removably connected from I/O Interface 3? Let me ask it again. I said that wrong.

Is A to D No. 1 removably connectable to I/O Interface 3, according to your understanding of Sudo?

MR. DAS: Objection, form.

THE WITNESS: Again, my understanding of this is

there is some kind of development system, but they're in the business of developing these things. They're going to have existing A-to-D and D-to-A modules, which they're going to use across all their difficult -- many different projects. In that case, yes, it would certainly be removably connected.

BY MR. CRAIN:

Q. So you could unplug it and plug it back as many times as you wanted to?

A. Absolutely.

Q. Identify for me, if you can, any devices that you've had prior experience with where an A to D was removably connectable to the DSP. I'm not talking about in a lab. I'm talking about real devices.

A. Yeah. That's very common. Because the A to D is an extremely delicate piece of equipment. They're commonly manufactured as separate units. So they can be -- you know, you can choose your own A to D, how much you're going to pay, and buy the best one.

Q. So are you saying just because it's a separate component, it's inherently removably connectable?

A. Because it's -- I mean, the idea of it being a separate module, something in a case, that would make it inherently removably connectable, yes.

Q. Is that what you understand Sudo to be telling

us about it?

A. That's not what he's telling us about it. He doesn't talk about it at all. But that's my understanding of what's being represented in this figure.

Q. Draw your focus, please, back to Microcomputer 20.

A. Okay.

Q. I understand, I think, the Sudo patent talks about -- I forget what it calls it -- Hall 1 and Hall 2. I think they may be like functions. Does that sound familiar to you?

A. Sorry. Hall? Oh, Hall 1.

Q. Hall. H-A-L-L. I'm going to show you the language. Look at the bottom of column three of the Sudo patent. Do you see where it says, "Control keys of sound fields, such as Hall 1 and Hall 2, are prepared on the keyboard 21"? You're welcome to read that and continuing on, but I'm asking for your understanding of what Sudo is telling us with respect to how -- what Hall 1 and Hall 2 appear to be to you.

A. I'd just like to point out that is the kind of sentence that led me to feel that this may not have been composed by a native speaker. But -- you don't want to go there. Right?

Q. No. I do. Tell me. Explain to me.

A. "Control keys of sound fields such as Hall 1 and Hall 2 are prepared on the keyboard 21." I don't understand why it's saying that the keys are prepared on a keyboard. What does that mean? I don't know what that means.

Q. You have no understanding of that?

A. I mean, I understand that there may be keys present on a keyboard, but I don't understand why it means they're prepared.

Q. What do you understand "prepared" to mean?

A. Like something is being set up specially.

Q. So you don't understand that to mean that there is a key on a keyboard set up especially for this function of Hall 1?

A. That's not how I would have written it.

Q. But that's not what I asked you.

A. I didn't misunderstand the sentence. It just struck me as strange wording.

Q. It wasn't written the way you would have written it.

A. That's right.

Q. You're certainly able to understand things you didn't write. Correct?

A. That's right.

Q. So getting back to what I was trying to ask --

I'm trying to understand how microprocessor 22 --
A. What?
Q. I'm sorry. Microprocessor -- microcomputer -- let me get my terms right -- how does Microcomputer 20, according to your understanding of Sudo, cause the implementation of Hall 2 sound field?
MR. DAS: Objection, form.
THE WITNESS: Let me just read the following sentences.
BY MR. CRAIN:
Q. Certainly.
A. So it's -- it describes how when the key is pressed, the microcomputer transfers program and coefficient data into the memory of the digital signal processor through the Interface 19.
Q. What is a signal processing function?
A. It's a -- the -- it's a description of the modification you wish to perform, to be performed upon the input signal to generate the output signal.
Q. What are parameters?
A. They are a variety of values that may control aspects of that function -- of that program algorithm procedure.
Q. Is a signal processing function then different from a signal processing function parameter?

A. Yes.

Q. When it's talking about Hall 1 or Hall 2 -- and I think it describes them as sound fields -- do you understand whether or not those correspond to what may be a signal processing function or a signal processing function parameter?

MR. DAS: Objection, compound.

THE WITNESS: He says that the microcomputer specifically reads out the program corresponding to the key and the coefficient data group. I would understand -- the coefficient data group is the sort of thing I would call a signal processing function parameter, and the stuff that's not the coefficient data group could be usefully described as a signal processing function.

BY MR. CRAIN:

Q. Look back at Fig. 1. There is still something I can't get out of my mind here. You were just telling me, if I understood you correctly, that A to D No. 1 is removably connectable, according to your understanding of Sudo.

MR. DAS: Objection, form.

THE WITNESS: What I said was I'm imagining the piece of equipment that's being -- you know, what's being depicted -- the physical realization that's being

depicted here, I'm imagining it as a piece of equipment in the laboratory, including an external A to D converter which is in a box which is removably connected to the remainder of the equipment.

BY MR. CRAIN:

Q. Is that the only way that it could be imagined?

A. No.

Q. What other ways could you imagine it?

A. You could imagine putting the A to D converter as a chip, on a card, that has -- you know, that has other -- has -- you know, the breadboard system that has other components that are being built into the system.

Q. Is that still in a laboratory?

A. Yes.

Q. Can you imagine any implementations of Figure 1 outside of a laboratory?

A. Yes.

Q. What can you imagine?

A. I can imagine this as a -- you know, a development card. I can imagine it as a development card that you could plug into a computer. I can imagine it as a complete system.

Q. In any of those implementations that you can imagine, inside or outside of a laboratory, if you disconnect A to D No. 1, what happens to the audio

signals?

MR. DAS: Objection, form.

THE WITNESS: It depends. But certainly, if you remove the input, then the outputs in a short while are going to cease to reflect what -- I mean, reflect what's going on. So there are two things. It depends what happens -- how the I/O interface would deal with the absence of that input. It could either read it as zeros, or it could stop working altogether, read it as silence.

BY MR. CRAIN:

Q. But it would no longer be processing audio signals. Is that correct?

A. It would be processing whatever it's got in its memory.

Q. But it would no longer be processing the audio signals that were being communicated by A to D No. 1. Correct?

A. If it's not connected, then it won't be getting any information from it.

Q. When on the keyboard, the preset button for Hall 1 or Hall 2 is depressed, what do you understand Microcomputer 20 to do?

MR. DAS: Objection, asked and answered.

THE WITNESS: I understand it to find --

retrieve a corresponding program, a set of instructions and some data, a set of values, and to transfer them into the memory of the digital signal processor -- into the memories of the digital signal processor.

BY MR. CRAIN:

Q. Does that result in the modification of a signal processing function?

A. It would unless it happened to be writing the same program that was already there.

Q. It would unless it was writing the same program that was already there?

A. That's right.

Q. So if Hall 1 was being executed by the DSP and the button for Hall 2 was pressed, what signal processing function would be modified, if any?

A. So, you know, you asked me before about the difference between the signal processing function and the signal processing function parameters.

Q. Yes, I did.

A. And I think I answered it by saying something about signal processing function parameters, and then sort of defining signal processing function relatively as everything that wasn't included in the parameters. It's not that easy to -- it's not like, oh, there is -- there is a very clear distinction between these in all

cases. It's sort of depending on what you -- you know, what you're interested in, what perspective you were taking on the class of problems, the different algorithms. Different parts of that overall algorithm might be considered to be in the parameters or not in the parameters in the function.

Q. Describe for me, Dr. Ellis, your understanding of how, in this example, Hall 1 would be modified as a signal processing function by the depressing of the button for Hall 2.

A. How Hall 1 would be modified as a signal processing function -- how the signal processing function associated with Hall 1 would be modified by pressing the Hall 2 button.

Q. How would it modify the signal processing function for Hall 1?

A. So can I -- so one -- what I've just said about parameters -- what I'm saying is there is a boundary -- we could imagine that here is all the stuff you need to run Hall 1. We can now draw a boundary here and say here are the parameters, here is everything else, which we're going to call the signal processing function.

Q. I'm listening.

A. I'll still using my hands, which I guess is probably -- you told me not to do. There are two parts.

One is the parameters, which is sort of -- we can -- we have some flexibility in how we define it. And for the purposes of this discussion, we're going to define everything else as the function.

It might be that the difference between -- in fact, it's quite likely -- it's quite possible that the difference between Hall 1 and Hall 2 only exists in the parameters, or it could be that the differences exist in both the parameters and the function.

Q. Do you remember my question?

A. How does the signal processing function of Hall 2 get modified -- Hall 1 get modified when you press the button for Hall 2.

Q. Okay.

A. Do you remember my first answer?

Q. I don't. Because it was kind of so long --

A. My first answer was, if it was the same, it wouldn't get modified. It might be the same, in which case it wouldn't get modified.

Q. Does Sudo indicate to us that it would be the same?

A. You know, it was -- that was what it suggested to me. Sudo is, again, not at all -- it's not really talking about these algorithms at all. It's just saying, as an illustration, as a motivation, these are the kind

of things you would do.

Q. What do you mean, it's not talking about these algorithms at all?

A. It's not talking about the algorithms. It's talking about how to update the coefficient Data RAM.

Q. The last answer we have on the transcript is, it's not talking about the algorithms. This is you.

A. Yeah.

Q. It's talking about how to update the coefficient --

A. The coefficient Data RAM.

Q. Data RAM. Yes. Would you explain that.

A. The substance of the invention is a mechanism for updating values in the coefficient Data RAM without interrupting the processing.

Q. So does it, in any way, teach the modification of the algorithm?

A. It starts off by explaining a mechanism -- by describing a scenario in which the algorithm may have been modified.

Q. Where is that?

A. When it says that the --

Q. Where are you looking?

A. Sorry. The bottom of column three. The place we were looking just now. That the microcomputer reads

out the processing program corresponding to the operated sound field control key and transfer -- I'm skipping the comments -- and transfers this data to the DSP through the interface.

Q. Where does that say that it modifies it?

A. It transfers it. There is a program -- the DSP is only running one program at a time.

Q. Right.

A. So when it transfers that program into presumably the program RAM, the understanding is that's then the program that the DSP will be running.

Q. So if Hall 1 is the program that is running, how is Hall 1 modified by the insertion of Hall 2?

A. Yes, there are two possibilities. One is Hall 1 and Hall 2 share the same program. So the program, itself, remains unchanged even though, as it's described, we understand that the program RAM is overwritten. If it's overwritten with the same values, it remains unchanged. In that case, the difference between Hall 1 and Hall 2 would be merely in the coefficients.

Q. What is the other?

A. The other is that Hall 1 and Hall 2 have different programs. So that when it transfers the new program into the program RAM, an entirely new -- a different algorithm is -- begins to be implemented.

Q. In the second scenario that you just described, is the first program changed in any way, other than just not being run anymore?
A. It's obliterated. It's replaced in memory with the second program.
Q. But it's not modified then?
A. No.
Q. And if we want to go back to Hall 1, we'll press the Hall 1 button. That program comes back out of Microcomputer 20 into the RAM. Correct?
A. That's my understanding, yes.
Q. And it would be the same program that was initially running in this hypothetical before we went to Hall 2.
A. Yes.
Q. So it's never modified as an algorithm.
A. That's not -- yes, that's not part of this disclosure.
Q. Now, the first instance is they just happen to be the same.
A. Yes.
Q. Is that a common implementation, in your experience?
A. Yeah.
Q. So Hall 1 and Hall 2 -- understandably, it might

be close, because maybe there are some tweaks -- but what about other types of algorithms or functions maybe for this big football stadium they have down here? Have you heard about this thing? I mean, this thing gets really loud. So if they want to play sound down in this thing, maybe they have to do it in a way that might be different from Hall 1. Would you expect the algorithms to be the same?

MR. DAS: Objection, form.

THE WITNESS: It's interesting, but it turns out that the algorithms that they're suggesting -- right -- which is this -- the couple of times they specify some of AiDi --

BY MR. CRAIN:

Q. Where are you looking?

A. So column one, line 34, it's Greek letter sigma, Greek letter alpha, subscript I, center dot, lower case D, subscript I, all in parenthesis. That's -- they call it -- they give it a name. I can give it a name. The product sum arithmetic operation. So it turns out this is a very well known -- a fundamental operation in signal processing, because you can do a lot of -- you can simulate a very wide range of, for instance, halls with that.

Q. Is that specifically for halls?

A. No.
Q. So it could be stadiums?
A. Yes.
Q. So, in your first scenario, again, the signal processing function is not modified, because it's the same no matter what the --
A. Right.
Q. -- operation is?
A. Yes.
Q. Only the coefficients are different.
A. That's right.
(Exhibit 17 marked for identification.)
BY MR. CRAIN:
Q. Dr. Ellis, I'm going to hand you what has been marked as Exhibit 17. Would you please take a moment to review it.
A. Okay.
Q. Are you able to identify what has been marked as Exhibit 17?
A. Yes. This is an international patent application. It's a patent. It's not a U.S. patent. It's some kind of patent description, which is the reference I referred to as Krokstad in my declaration.
Q. Is it referred to as Krokstad because that appears to be the first named inventor?

A. It appears to be the family name of the inventor.
Q. Correct. Thank you.
Do you believe Exhibit 17 to be an international application published under the Patent Cooperative Treaty?
A. Yes.
MR. DAS: Objection, form.
BY MR. CRAIN:
Q. Have you reviewed -- let's call it the Krokstad reference --
A. Yes.
Q. Have you reviewed the Krokstad reference?
A. Yes.
Q. Do you recall how many times?
A. Three or four times.
Q. Like the others, I'm sure you reviewed it as well this week.
A. That's right.
Q. Would you explain for me what you understand the Krokstad reference to be directed to.
A. It's about a design of a hearing aid, a digital hearing aid, a hearing aid that processes sound using a digital signal processor, using digital signal processing, and various details of other aspects of this

hearing aid to make it good.

Q. Why is it your belief that a person of ordinary skill in the art in 1994 would look to hearing aid technology like what's disclosed in Krokstad for teaching -- let me start that question again.

Why is it your opinion that a person of ordinary skill in the art of the '544 patent would look to the Krokstad reference for teaching and insight?

MR. DAS: Objection, form.

THE WITNESS: Because the use of digital signal processing in hearing aids was a very exciting and important development at the time.

BY MR. CRAIN:

Q. How do you know that?

A. That's my recollection.

Q. Based on what?

A. Based on what I remember about the time. This is -- this is early for a digital hearing aid. I guess that's why they're filing a patent on it. Because it's -- again, as I've described, there is a process by which the digital technology has to become cheap enough to be suitable in the right format. So this is the time at which this -- these -- the hearing aids which had previously been analog were switching to digital, making possible a much greater range of functionalities and

flexibilities, which was -- which was an exciting development.

Q. Do you have any understanding of whether or not the Krokstad reference teaches a removable connection as is claimed in the '544 patent?

A. I think it does.

Q. Would you show me where you believe that to be.

A. So, for instance, in Figure 5a, we actually see -- well, we see firstly a box labeled "RS-232," also labeled "IF," which clearly refers to the serial programming interface described that can be used to update the internal settings of the hearing aid.

We also see a broken line between the box marked RAM 7 and the box marked RAM 2. It's an interrupted arrow, which I believe corresponds to a removable connection between the part of the hearing aid that's inserted in the ear and a case that it is put in when it's not in the ear.

Q. Do you have Exhibit 12 handy? If you want to pull -- reference Exhibit 13, which is your declaration, we can look at both of them. We'll be jumping back and forth.

A. Okay.

Q. So you've got 13 and you've got 12, and then the Krokstad reference.

A. Yeah.
Q. So we'll look at all three of them.
In Exhibit 12, please turn to page 24 -- 23, 24.
A. Yeah.
Q. I was wrong. Make that 25, 26.
A. Yeah.
Q. Let's just start with the last two elements that we see on page 26.
A. Yes.
Q. I believe you also talk about them in your declaration. So we can flip back and forth.
Now, do you see in the left column where it says, "An external programmer"?
A. Yes.
Q. And the right column, it shows -- it actually references Sudo and not Krokstad. Do you see that?
A. Yes.
Q. And we've just been talking about Microcomputer 20.
A. Yes.
Q. So I take it from this that -- let me go back here.
Let's look at your opinion as well.
A. Yes.
Q. Do you see any reference in your opinion, on

pages six, seven, or eight, with respect to Krokstad disclosing or teaching an external programmer?

A. In paragraph 18, I say, "Krokstad also shows the use of an RS-232 input port that is used to program the DSP with functions that are selected for a particular user."

Q. Do you see a reference to an external programmer in that paragraph?

A. Yes.

Q. Is the RS-232 the external programmer?

A. It's the interface to the external programmer. So it's used to program these -- obviously, the RS-232 input port is a port. It's not the port that can program it; it's the thing you connect to the port.

Q. Yeah, you're getting ahead of me. That's right. I think you're right. So where is the thing that connects to the port? Is it in Krokstad is what I'm trying to understand?

A. Oh, he mentions it. Yeah. He mentions the idea of using some kind of audiometry system. That's what's connected through the RS-232 port.

Q. Before you go to that, do you reference what you're trying to find in your port?

A. That's what I'm talking about.

Q. Where are you talking about it, again?

A. I'm talking about there is an RS-232 port that is used to program the DSP.

Q. And you're not suggesting that it is the RS-232 port that's the external programmer. Correct?

A. That wouldn't make any sense.

Q. According to your understanding of Krokstad, what's connected to the RS-232 port?

A. It's a connection between two devices. It's a connection between an external computer, which is used for setting the hearing aid, and it's connecting to the hearing aid circuitry.

Q. So are you then now contending that this computer connected to the RS-232 port would be an external programmer?

A. Yes.

Q. If you look at the next element, it starts out with, "A programming signal input port." We've already talked about Sudo, so I think I'm good with that. That appears to correspond to the first two paragraphs of Exhibit 12. Does that appear to be correct? I only say because see how it references Exhibit 5 and 3?

A. Sorry. You lost me.

Q. Okay. Are you on page 26 of Exhibit 12?

A. Yes.

Q. In the right column, across from the element

that begins, "A programming signal interface port," do you see the paragraph that begins, "Sudo discloses"?

A. Yes.

Q. Do you understand that paragraph to be pertaining to Sudo?

A. Yes.

Q. To what does the second paragraph pertain?

A. Also Sudo.

Q. That's what I was trying to get at. Sorry to confuse you.

A. Yes.

Q. I think that's right.

A. I agree.

Q. Do you understand Krokstad to disclose a programming signal input port?

A. So there are various names given to -- I think there are like three different levels that are distinguished in the '544 patent. And I'm not -- it's not totally clear to me what the distinctions are. But in -- in natural usage, the -- I would say that would be a good way to describe it. The way that a person of ordinary skill would understand a programming signal input port -- a programming signal input port, then that would -- that would apply to the RS-232 port in Krokstad.

Q. So you do believe that Krokstad discloses a programming signal input port, and if I understand you correctly, you represent it to be the RS-232 input port?
A. Yes. RS-232 port.
Q. Is that the only thing it would be?
A. There is this -- there is this second removable connection in Krokstad between -- it's the one I described as the broken line.
Q. What is that?
A. It's this connection between what appears to be a cradle that the hearing aid is put into when not in use and which -- the hearing aid doesn't have an RS-232 port on it. An RS-232 port has a physical size which would be impractical to put on a hearing aid. So there is some kind of box or case that the hearing aid can be put into when it's not in use. And according to the description, there is some electrical connection that's made when it's put in the case.
Q. Is that the programming signal input port?
A. That connection could also be described as the programming signal input port. A programming signal input port.
Q. But is that port removably connectable to the external programmer?
MR. DAS: Objection, form.

THE WITNESS: You know, it depends on what you're defining -- where you're defining the boundary between the external programmer and the digital signal processor.
BY MR. CRAIN:
Q. I'm asking you.
A. Well, you could define either of them. I only mention it because it's a possibility.
Q. What's a possibility, again?
A. That you could define -- you could define the boundary -- you could define the removable connection between the external programmer and the digital signal processor as being the RS-232 port or the broken arrow between those two RAMs in figure -- in the figure I was talking about.
Q. I'm confused. Is it one or the other or is it both?
A. Depending on your taste, you could define it either way.
Q. How are you defining it, is what I'm asking?
A. I'm happy to define it either way.
Q. Okay. Does that mean both?
A. Not at the same time. It depends. You know. I don't see the need to rule out one of them.
Q. What is the external programmer if you're going

to say that the removable connection is -- I take it to be that broken area between RAM 7 and RAM 2.

A. In Figure 5a.

Q. Yes.

A. Yes. Then the external programmer would be everything to the right of that broken line, which would be RAM 7, the RS-232 interface, and the external computer connected to that interface which is not shown.

Q. What does RAM 7 do?

A. I'm not really sure. It seems to be a backup memory that can store parameters.

Q. Is that it?

A. Yeah.

Q. Do you agree with my understanding of Krokstad that it appears to disclose a hearing aid component, a case or I think you said a cradle, and then some type of computing device? Is that a fair characterization?

A. The invention makes reference to the computing device, yes.

Q. As well as the hearing aid, obviously?

A. Yes.

Q. And some type of case?

A. Yes.

Q. Describe for me your understanding of what Krokstad teaches in order to program the hearing aid.

A. That's interesting. He talks about -- you know, that the -- there is a computer connected to the interface, and you can download data through that into the various memories of the hearing aid system to change its function.

Q. Could you get into a little bit more detail. I think that's a very high-level explanation.

A. Yes.

Q. Would you walk me through the steps that you understand. What is the first thing you would do?

A. To do what?

Q. Well, if I want to program the DSP that I presume is in the hearing aid --

A. Yes.

Q. -- what is the first step to do that, that you understand, in Krokstad?

MR. DAS: Objection to form.

THE WITNESS: Well, I don't know -- if the exact sequence doesn't matter, we'd have to establish a connection between the external programmer and the DSP. So that would involve, for instance, plugging the external computer into the RS-232 interface and connecting the ear unit to the case.

BY MR. CRAIN:

Q. Are you suggesting they all have to be connected

at one time?

A. That would be one way. That would certainly be one way of doing it.

Q. Okay.

A. Now, I haven't -- I haven't read Krokstad closely enough. Looking at the picture, it seems like, well, maybe you could write into RAM 7, and then later -- write into RAM 7 when it's not connected to the hearing aid, and then later connect the hearing aid to the case and the data in RAM 7 could be transferred. That's just something that is suggested to me by the figure.

Q. Tell me, if you would -- take a moment to review Krokstad and tell me if either one of those or both of those are suggested in Krokstad.

A. Oh. So yes -- it might be helpful for me to note at this point that in my previous review, I concluded that in that figure -- in Figure 5 -- 5a, I think it is -- Figure 5a, I concluded that what's labeled "RAM 7" was actually meant to be labeled RAM 1, that this was a -- you know, an error in preparing the figure. This is based on comparison with Figure 4a where you see RAM 2, the broken line, and the RS-232 interface.

Q. Are you telling me you put that in your report? Is that in your report?

A. No.
Q. All right. I thought you said that.
So you believe that there is a typo in Figure 5a?
A. Yes.
Q. And I think I interrupted you and I apologize. Explain to me why you believe that RAM 7 is an error.
A. Well, so, you know, one thing is a one and a seven are somewhat similar. You can imagine if this was being transcribed from a hand-drawn figure, that that would be a mistake that could happen. But mainly by comparison of the surrounding units between Figure 4a and Figure 5a, the things on either side of that box are the same, but for some reason, the number inside the box is changed from RAM 1 to RAM 7.
The other thing is that RAM 7 appears in Figure 5b in a completely different place, immediately before RAM 8 within the DSP. There is no interpretation that I could come up with why the other RAMs have corresponding -- RAM 2, which appears in both figures, is in the same place. There is no reason I could think of why RAM 7 would suddenly be moved from downstream of the separation connection in Figure 5a to the internal of the DSP in Figure 5b.
Q. So the question I asked you before that -- I

appreciate that information -- was for you to review Krokstad and tell me if one or both of the two methods are disclosed.

MR. DAS: Objection, form. Objection, compound.

THE WITNESS: So I'm looking at the third paragraph on native page 21. It starts, "The hearing aid can easily be reprogrammed." This describes -- it says, "Reprogramming is performed in that the random access memory RAM 1 in the case or secondary section two is connected via an interface IF of type RS-232 to a computer, e.g. a personal computer which is connected to an audiometer system."

BY MR. CRAIN:

Q. What do you understand that to be teaching?

A. That the -- to reprogram it -- to reprogram the hearing aid, you connect an external computer to the RS-232 interface and transfer data.

Q. So is this the method where the computer, via an RS-232 connection in the case, transfers data into RAM 1?

A. In both of the scenarios I mentioned, this is part of it.

Q. Okay.

A. The data has to be transferred from the computer to RAM 1 to the rest of the hearing aid.

Q. Right. I think you had said that one embodiment might be where they're all connected at the same time, the PC to the case to the hearing aid. And then I think you said another one was, well, you could do it where PC to the case, and then later in time, case to the hearing aid. Did I understand that to be correct?

A. I did say that, yes.

Q. This text you're suggesting -- you're reading to me here, pointing out to me, is that one or the other of the two -- is that one or the other of the two approaches?

A. I can't tell. He only talks about transferring it to RAM 1 in this paragraph. He doesn't talk about what happens to it after it's in RAM 1. It's inherent that it doesn't stay in RAM 1, but has to get to the actual hearing aid. He doesn't say whether it is happening -- whether it could happen later. He doesn't say in that paragraph. I don't know if it says it elsewhere.

Q. In either situation, when a computer is connected via the RS-232 interface to the case and RAM 1, what does Krokstad tell us that is being communicated from the computer to RAM 1?

A. He says it's being reprogrammed to suit altered user conditions and changes in the hearing of the user

or the hearing of another user. So he's telling us that what's being reprogrammed is the particular signal processing functions that the hearing aid can perform.

Q. Would you look on native page 20.

A. Yes.

Q. Do you see the sentence midway through the paragraph that starts on the top, that begins, "Each individual set of filter coefficients"?

A. Yes.

Q. Take a moment, if you would, and read the rest of that paragraph. As you do, it references RAM 7. My question to you is going to be, which RAM 7 is that? Go ahead and read the paragraph.

A. Yes.

Q. So is that RAM 7 referring to what we see in 5b, according to your understanding, and not what we see in Figure 5a?

A. Yes.

Q. Do you have any understanding of what he means when he talks about a set of filter coefficients?

A. I think so.

Q. What do you understand that to mean?

A. Coefficients that control the behavior of a digital filter.

Q. Would these be similar to parameters?

A. Yes.
Q. What do you understand a specific response function for the hearing aid to be?
A. A complete specification of the response of the hearing aid to different sound inputs.
Q. Do you understand Krokstad to be teaching us -- no matter which of the two connection methods may be implemented -- that coefficients may be communicated from the computer to the hearing aid?
A. He certainly -- I think he explicitly says coefficients.
Q. Do you see where he talks about modifying any response functions?
A. That would be the point of -- of having a programmable hearing aid is to allow you flexibility in the response functions.
Q. Well, remember when we were talking about Sudo, how we had like Hall 1 function and Hall 2.
A. Yes.
Q. And we talked about a couple of different approaches to those. But I think in neither one of the two approaches in Sudo, the function was being modified. It was either the same function, with different coefficients; or two different functions, where one was replacing the other. Do you recall that discussion? In

Sudo.

A. Yes. And in the second case, the function is being modified.

Q. Well, I think we talked about how --

A. Oh, the function -- okay. You were drawing a distinction between like a modification meaning a slight change to the function. Right.

Q. Do you see an instance that teaches a modification of any of the response functions -- I believe it uses that term -- in Krokstad?

A. The only sensible interpretation of this is that modifying the filter coefficients would be a part of modifying the response function. The response function includes the -- if you change the filter coefficients, you're going to change the overall response function. That's one way to change the overall response function.

Q. But does it change the algorithm?

A. Changing the filter coefficients does not change the algorithm.

Q. Do you see any discussion in Krokstad where it changes the algorithm for the function?

A. I don't know, but my understanding would be there would be no reason to -- the most likely thing would be to give the interface the ability to change all the software -- all the data stored in the processor.

It would be -- you know, just -- it would be a strange engineering decision to prevent yourself from changing -- to limit -- to make it so that it was limited to only changing the filter coefficients and not the program.

Q. Well, this application was published in 1991. So show me in Krokstad where it teaches or suggests exactly what you just said.

MR. DAS: Objection, form.

THE WITNESS: I don't know if it does, but I'm saying that it would be obvious to a person of ordinary skill, that that would be the most simple way to implement it.

BY MR. CRAIN:

Q. Would you like to take a moment to review Krokstad to see if you can find such a suggestion?

A. No.

Q. Why not?

A. Because I don't think -- you know, I don't think he does -- there is not going to be -- I don't expect to find anything in there which is going to be, well, here he's clearly talking about modifying the program.

Q. But he does talk about modifying coefficients; doesn't he?

A. He talks about modifying the response function,

using the external programmer to change the response function.

Q. Well, that's -- and changing the coefficients?

A. One way to do that would be to change the coefficients.

Q. What is the other?

A. The other way would be to change the coefficients and the program.

Q. Show me where it talks about changing the program.

A. Well, as I said, when it says you're changing the response function, that can be understood to be referring to changing the program.

Q. Where are you looking?

A. "The hearing aid can easily be reprogrammed to suit altered user conditions and changes in the hearing of the user or the hearing of another user."

So he's talking about the ability of the -- the ability to change the overall behavior of the device. It's interesting that he uses the word "reprogrammed."

Q. We are talking about a hearing aid. Correct?

A. That's right.

MR. CRAIN: Let's go off the record.

THE VIDEOGRAPHER: We're going off the record. The time is 5:08 p.m.

(Recess taken from 5:08 to 5:25.)
THE VIDEOGRAPHER: This is the beginning of Media No. 5 in the deposition of Dr. Daniel Ellis. The time is 5:25 p.m. We're back on the record.
BY MR. CRAIN:
Q. So, Dr. Ellis, is there any testimony that you've given, either in the last session or earlier today, that you would like to change or correct in any way?
A. No.
Q. Did you have an opportunity to consult with QSC's counsel during the break?
A. I spoke to them.
Q. Did you consult or confer with QSC's counsel regarding the substance of the testimony that you have given already in this deposition?
A. No.
Q. Did you consult or confer with QSC's counsel regarding the substance of any testimony anticipated to be given?
A. No.
Q. Including any redirect testimony?
A. No.
Q. During the break, did counsel for QSC suggest to you the manner in which any questions should be answered?

A. No.

MR. CRAIN: At this time, we tender the witness.

MR. DAS: We'll take a short break.

MR. CRAIN: Okay.

THE VIDEOGRAPHER: We're going off the record. The time is 5:26 p.m.

(Recess taken from 5:26 to 5:44.)

THE VIDEOGRAPHER: We're back on the record at 5:44 p.m.

E X A M I N A T I O N

BY MR. DAS:

Q. Dr. Ellis, could you turn to Exhibit 14.

A. Okay.

Q. Could you remind us what Exhibit 14 is.

A. Exhibit 14 is the '544 patent.

Q. That's the issue of the petition on which you're being deposed. Correct?

A. Yes.

Q. Now, turn to the second to last page of that and look at claim one, and let me know when you've finished reviewing it.

A. Okay.

Q. So claim one is in column eight. If you look at the paragraph that's column eight, around line 35 -- do

you see that?
A. Yes.
Q. It says, "A programming signal input port for receiving at least one programming signal from the external programmer, the external programmer being removably connectable to the programming input signal port for modifying at least one of a signal processing function and a signal processing function parameter defined in said signal processing circuit." Did I read that correctly?
MR. CRAIN: Object to form.
MR. DAS: You can answer.
THE WITNESS: No, you transposed two words.
BY MR. DAS:
Q. Which words?
A. You said -- I think you said "input signal port" when you meant -- when it says "signal input port."
Q. I apologize. But you see that paragraph. Correct?
A. Yes.
Q. How would a person of ordinary skill in the art of the '544 patent understand the clause, "modifying at least one of a signal processing function," as used in this claim one?
MR. CRAIN: Object to form.

THE WITNESS: It means changing the function that's being performed by the signal processing circuit.
BY MR. DAS:
Q. Which means?
A. Which means changing -- that is, substituting a different function.
Q. So would that necessarily require actually changing the existing algorithm off a function that exists on the DSP or could it be just replacing it with an entirely new function?
MR. CRAIN: Object to form.
THE WITNESS: My understanding is that it would only mean replacing the entire code. It would be very difficult in practice to -- I mean, it would be fiddly in practice to have an algorithm in memory where you could go in and change just a few parameters. You would already have to have the ability to access the memory. So it would be much simpler and more -- I guess, more straightforward to just go ahead and rewrite the entire piece of program code. I can't think of any reason why you would want to modify only part of an existing program code. You already -- you know, the programmer already knows what the programming code is, so -- and it's already writing to memory. So you just go in and write the whole thing. That would be the only way I

could imagine it being done.
BY MR. DAS:
Q. Now, during your cross-examination, you were asked a number of questions about Exhibit 16, which is Sudo.
A. Um-hmm.
Q. One of the questions -- again, I may not get the exact wording correct -- was something along the lines of why would a person of ordinary skill in the art of the '544 patent not understand Interface 19 as being a buffer circuit. Do you remember being asked a question along those lines?
A. Yes.
Q. Now, what is your understanding of a person of ordinary skill in the art of the '544 patent?
MR. CRAIN: Object to form.
THE WITNESS: This is covered in my declaration.
BY MR. DAS:
Q. And that's Exhibit 13?
A. Exhibit 13. In Section III, paragraph seven, eight, and nine, I explain what I mean by a level of ordinary skill in the art -- a person of ordinary skill in the art.
Q. And in paragraph eight of your declaration, it says, "In my opinion, a person of ordinary skill in the

art for this '544 patent would have had a master's degree in electrical or electronics engineering and master's-level course work, along with practical experience designing and testing electronic amplifiers and the associated signal processing functions." Do you see that?

A. Yes.

MR. CRAIN: Object to form.

BY MR. DAS:

Q. And in your opinion, is that the only definition of a person of ordinary skill in the art?

MR. CRAIN: Objection to form. Beyond the scope.

THE WITNESS: No. My intention in making that definition was to provide an example of the kind of person I was thinking about when I was making statements about obviousness. The deeper thing I was trying to get at was the idea that someone who has training in electrical engineering, like a bachelor's degree; and who has gone on to do some further study, indicating that they have, you know, correctly understood the bachelor's engineering; and then they're working in the area that's relevant to the patent, so that, for instance, if they have this practical experience. But there could be many other people who I would regard as a

person of ordinary skill in the art for this patent.
BY MR. DAS:
Q. So can you give us some other examples of people who would be persons of ordinary skill in the art for this '544 patent.
MR. CRAIN: Object to form, beyond the scope.
THE WITNESS: So this is about, you know, basic electrical engineering topics, and then the use of digital signal processors in a system. So anyone who had that kind -- a good grasp of those topics. So someone with a Ph.D. in electrical engineering and who had -- who had covered signal processing topics would be someone I would consider a person of ordinary skill. Someone who had a master's degree and had worked with digital signal processing would meet that -- would meet my definition.
BY MR. DAS:
Q. Why did you not --
A. Sorry. Would not meet my definition. Would also be the kind of person that I'm thinking about as corresponding to a person of ordinary skill.
Q. Why did you not include those other examples in paragraph eight?
MR. CRAIN: Object to form. Beyond the scope.
THE WITNESS: I was -- I was just trying to give

a sufficient example of the kind of skill that I was -- the kind of person I was talking about. I was not trying to indicate the -- you know, the necessary -- the conditions that could not be omitted.

BY MR. DAS:

Q. So one of the persons of ordinary skill, I thought you said, was a person with a Ph.D. in electrical engineering and who had covered signal processing topics. Correct?

A. Yes.

MR. CRAIN: Object to form, leading. Object to form, beyond the scope.

BY MR. DAS:

Q. Would you consider such a person to be a person of ordinary skill in the art of the '542 patent?

A. Yes.

MR. CRAIN: Object to form. This is beyond the scope. This entire line is beyond the scope.

THE WITNESS: Yes.

BY MR. DAS:

Q. Okay. You also identified a person of ordinary skill in the art could be someone with a master's degree in electrical engineering who had worked with digital signal processing would be another person of ordinary skill in the art of the '544 patent. Correct?

A. Yes.

MR. CRAIN: Object to form, leading. Object to form, beyond the scope.

You can't lead your own witness, KM. You know that.

MR. DAS: I'm not leading my witness.

MR. CRAIN: Read the transcript. You did.

MR. DAS: No.

BY MR. DAS:

Q. Would you consider that person to also be a person of ordinary skill in the art in the '542 patent?

A. Yes.

MR. CRAIN: Object to form, beyond the scope.

MR. DAS: We have no further questions at this time.

MR. CRAIN: Go off the record.

THE VIDEOGRAPHER: We're going off the record. The time is 5:53 p.m.

(Recess taken from 5:53 to 5:56.)

THE VIDEOGRAPHER: We're back on the record. The time is 5:56 p.m.

E X A M I N A T I O N

BY MR. CRAIN:

Q. Dr. Ellis, just a couple more questions. Thank

you.

After I finished my cross-examination, before Mr. Das asked you any questions, you remember we took a break.

A. Um-hmm.

Q. Did you have the opportunity to consult with your counsel during that particular break?

A. Yes.

Q. Did you speak -- let me ask this again.

Did you consult or confer with QSC's counsel regarding the substance of the testimony that you would give during your redirect examination?

MR. DAS: Again, I would instruct you, if you can answer that question without getting into privileged communications, you can answer.

MR. CRAIN: What's the privilege?

MR. DAS: The privilege is that --

MR. CRAIN: So it's established you did talk with him about the redirect testimony?

MR. DAS: It's attorney-client privilege what we discuss with him.

BY MR. CRAIN:

Q. So can you answer the question. Did you talk with your attorneys -- let me start again.

Did you talk with QSC's attorneys before your

redirect examination about your redirect examination?
A. And what's the privilege?
MR. DAS: Well, again, do you need to consult on this to answer the question?
BY MR. CRAIN:
Q. I want to know what you talked about with regard to the redirect examination.
MR. DAS: I will instruct you not to talk about what we talked about during that break. Okay?
BY MR. CRAIN:
Q. Did you talk about the substance of any testimony that you would give on redirect examination?
MR. DAS: I object, privilege, and I instruct you not to answer that question.
BY MR. CRAIN:
Q. Can you not answer that question because it would cause you to reveal a communication between yourself and QSC's counsel? That's a yes or no.
A. It's an interesting thing, because at some point, you know, you're asking me -- it's doing the same thing. It's still revealing privilege.
Q. I'm not asking you for the substance of it. I'm not asking you for what you talked about. That would be a whole other area. I'm asking, did you speak with QSC's counsel before your redirect testimony about the

substance of your redirect testimony?

MR. DAS: And I instruct you not to answer that on the basis of privilege.

MR. CRAIN: So you won't even let him tell me whether he did or didn't.

MR. DAS: You can ask him if he spoke to us.

MR. CRAIN: About the substance of the testimony he would give. I'm not asking for what the substance was. That's not privileged.

MR. DAS: It is privileged.

MR. CRAIN: What's the basis?

MR. DAS: The basis of the privilege is that it goes into attorney-client communications, what the substance of the communication is.

MR. CRAIN: I didn't ask for the substance.

MR. DAS: Yes. You're asking him about whether he spoke about the substance of his redirect testimony. That is going directly to the substance of the communication.

MR. CRAIN: Absolutely not. I'll absolutely take that to the board.

MR. DAS: Yes.

BY MR. CRAIN:

Q. So you're not going to answer the question that is clearly in the Trial Practice Guide, Appendix D,

Section 6, about whether or not you did or did not consult with QSC's counsel regarding the substance of the testimony that you would give on redirect examination. You're not going to answer that. Right?

MR. DAS: I'm going to instruct you not to answer that question on the basis of privilege.

THE WITNESS: I'm following the advice of my counsel.

BY MR. CRAIN:

Q. Did you consult with QSC's counsel or confer with QSC's counsel, prior to your giving the redirect examination, after the conclusion of my cross-examination, regarding the substance of the testimony that was anticipated to be given during the redirect portion of your testimony?

MR. DAS: I will instruct you not to answer that question on the basis of privilege.

THE WITNESS: I'm taking the advice of my counsel.

BY MR. CRAIN:

Q. So you will not even tell me whether or not you did or didn't, irrespective of whatever the substance was. Is that correct?

MR. DAS: Again, I would instruct you not to answer that question on the basis of privilege.

THE WITNESS: I'm taking my counsel's advice.
BY MR. CRAIN:
Q. During the break, after the conclusion of my cross-examination, prior to the commencement of redirect by Mr. Das, did QSC's counsel suggest to you the manner in which you should answer any questions that would be posed to you on redirect examination?
MR. DAS: Again, I would instruct you not to answer that question on the basis of privilege.
MR. CRAIN: You've got to be kidding me. Golly, KM.
BY MR. CRAIN:
Q. Can you answer?
MR. DAS: I would instruct you not to answer that on the basis of privilege.
THE WITNESS: I'm taking the advice of my counsel.
MR. CRAIN: Wow.
BY MR. CRAIN:
Q. I've asked you this question similar times, or these questions, about consulting with QSC's attorneys, after breaks, today and yesterday; haven't I?
A. Yes.
Q. This is the first time that you have refused to answer those questions based on the advice of counsel;

is it not?

A. Yes.

MR. CRAIN: We are concluded.

THE VIDEOGRAPHER: This is the end of Media No. 5 in the deposition of Dr. Daniel Ellis. The time is 6:02 p.m. We are now off the record.

(Deposition adjourned at 6:02 p.m.)

(Signature reserved.)

S I G N A T U R E

I declare under penalty of perjury under the laws of the State of Washington that I have read my within deposition, and the same is true and accurate, save and except for changes and/or corrections, if any, as indicated by me on the CHANGE SHEET flyleaf page hereof.

Signed in _____, Washington, this _____ day of _____ 20___.

_____

DANIEL P.W. ELLIS, Ph.D.

Taken: Friday, June 27, 2014

Re: QSC Audio vs. Crest Audio
Cause No.: IPR2014-00131
Donald W. McKay, RMR, CRR, CCR

C E R T I F I C A T E

STATE OF WASHINGTON)
) ss
COUNTY OF KING)

I, the undersigned Washington Certified Court Reporter, hereby certify:

That the foregoing deposition upon oral examination of the witness named herein was taken stenographically before me and transcribed under my direction;

That the witness was duly sworn by me pursuant to RCW 5.28.010 to testify truthfully;

That the transcript of the deposition is a full, true and correct transcript to the best of my ability;

That I am neither an attorney for, nor a relative or employee of any of the parties to the action or any attorney or counsel employed by the parties hereto, nor financially interested in its outcome.

I further certify that in accordance with CR 30(e), the witness was given the opportunity to examine, read, and sign the deposition, within 30 days upon its completion and submission, unless waiver of signature was indicated in the record.

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WITNESS NAME: Daniel P.W. Ellis, Ph.D., 06/27/2014

PAGE	LINE	CHANGE	REASON

I, Daniel P.W. Ellis, Ph.D., have read the foregoing deposition and hereby affix my signature that same is true and correct, except as noted above.

_____

Daniel P.W. Ellis, Ph.D.

Sworn to and Subscribed before me

_____, Notary Public.

This_____day of _____, 20____.

My Commission Expires:

F

G

H

J

K

P

Z