M. TRIANTAFYLLOU

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PETROLEUM GEO-SERVICES INC.

Petitioner

v.

WESTERNGECO LLC

Patent Owner

Case No. IPR2014-01475, -01476, -01477, -91478

Patent No. 7,162,520 B2

Patent No. 7,162,967 B2

Patent No. 7,080,607

DEPOSITION OF DR. MICHAEL TRIANTAFYLLOU

Volume 2

Alexandria, Virginia

August 28, 2015

Reported by: Mary Ann Payonk

Job No. 96926

M. TRIANTAFYLLOU

August 28, 2015
8:37 a.m.

Deposition of DR. MICHAEL TRIANTAFYLLOU, Ph.D., Volume 2, held at the offices of Oblon, McClelland, Maier & Neustadt, 1940 Duke Street, Alexandria, Virginia, pursuant to Notice before Mary Ann Payonk, Nationally Certified Realtime Reporter and Notary Public of the District of Columbia, Commonwealth of Virginia, States of Maryland and New York, CA-CSR No. 13431.

M. TRIANTAFYLLOU
APPEARANCES:
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CHRISTOPHER RICCIUTI, ESQUIRE
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1940 Duke Street
Alexandria, VA 22314

ALSO PRESENT:
Kevin Hart, Petroleum Geo-Services,
Inc. (By phone)

M. TRIANTAFYLLOU
MICHAEL TRIANTAFYLLOU,
recalled as a witness, having been duly
sworn, was admonished of his former
oath, examined and testified as follows:
EXAMINATION (Cont'd.)
BY MS. BERNIKER:
Q. Doctor, you understand that you're still under oath from yesterday?
A. Thank you.
MR. KIKLIS: Can we just make a note for the record that we have a new attendee, Mr. Suarez.
MS. BERNIKER: Mr. Suarez is here today and I think Mr. Swafford is not here today, both from Williams & Connolly.
BY MS. BERNIKER:
Q. All right. Doctor, at any point since we began the deposition, have you communicated with the attorneys for WesternGeco about the deposition?
A. No.
Q. Okay. I would like to talk for a minute about hydrophone noise. Can you explain

M. TRIANTAFYLLOU
to me why hydrophone noise is a concern in marine seismic surveying?
A. Okay. So let's start with the principle of hydrophones. The only way of communicating under water is through sound, because the ocean is opaque to electromagnetic waves. So, for example, there's no GPS below let's say 5 centimeters below the ocean surface, which causes a great problem to any -- underwater, you have to use acoustics, there's no other means of communication at a distance.
On the other hand, the acoustical waves, the water in general is an excellent conductor of acoustic waves. They can travel fast. They can travel far if the frequencies are low. They can travel short distances at high frequency, providing great accuracy, and so on and so forth.
So what is important in acoustical waves is the frequency -- if you take whatever sound waves are analyzed, there will be components of high frequency, low frequency and so on and so forth. There will be a range of frequencies. So when you do seismic

M. TRIANTAFYLLOU

exploration, you need to travel far, signals have to penetrate the bottom of the ocean, be reflected by the layers underneath. So you work in a certain frequency range which allows you to do this.

At the same time, for short communications, you want higher accuracy, so you go to higher frequencies. So you're trying immediately to divide your hydrodynamic acoustical signals by the purpose they have so you can use them for exploring the underground deposits with certain lower frequencies, and use higher frequencies to find positions and the like.

But then you have sources of noise. And let's restrict ourselves to hydrodynamic noise as your question addressed. So the -- if you have something which is perfectly streamlined, streamlined means that it has a shape like we envision a fish or an airplane or a torpedo. It produces relatively small amounts of noise, except where there are protrusions, there are sharp cutoffs and the like. You put them at an angle of attack, you

M. TRIANTAFYLLOU

turn them, and then the noise increases.

So, for example, a streamer, if you tow it perfectly aligned, the only sources of noise would be any -- anything that is attached on it. That would be the primary source of noise. There is some noise anyway because of the boundary layer, which is characteristic of anything that is in the flow and moves. It's a layer adjacent to the body called the boundary layer.

But the main source of sound comes from what is called flow separation, when the flow, instead of hiding the body, splits and generates eddies. That's a major topic for many people, including the hydrodynamic noise they cause.

So what happens when that separation happens, you create turbulent flow. Turbulence is a vague term, but in essence, it means you have hundreds of scales, meaning small, large, depending on the size of the object that makes them, but they range in scale from, let's say if you have a body which is half a meter, they will go from half a meter, the size of the

M. TRIANTAFYLLOU

body, down to what's called the Kolmogorov scale, which is submillimeter, the size of those eddies in the turbulent flow.

And so when you take a -- a power spectrum of that, when you find the frequency analysis, you have a very wide frequency range, and that noise interferes with the signals. In other words, when you measure what you are interested in, whether it is position of a body with high frequencies, so the short distance signals, or the long distance, lower frequency signals, these have a dynamic noise because it comes from turbulence, which is a chaotic phenomenon with many, many time scales, produces a wide band noise.

So, for example, a foil that will stall, let's take the DigiFIN or the DigiBIRD. You create an angle of attack which is 25 degrees because you want a big force. It will stall and then it will create -- if it's half a meter, it will create eddies from half a meter down to submillimeter, and all these are going to create a lot of hydrodynamic noise. And this noise will interfere with the accuracy

M. TRIANTAFYLLOU

of anything that you do. So as a result, it is imperative that whatever works around hydrophones be of limited generation of such hydrodynamic noise.

Q. I want to make sure I understood your answer. I'm obviously not going to go through every sentence you said, but is the hydrodynamic noise -- actually, let me take a step back.

Is the hydrophone noise -- that's important during data acquisition; right?

A. And it can be also during positioning of -- determining the position of the streamers, positioning the streamers, trying to determine the position of the streamers.

Q. So it can be important when you're trying to determine the position of the streamers and it can be important when you're acquiring seismic data; is that right?

A. Yes.

Q. Okay. And why in your view is it important when you're determining the position of the streamers?

A. Because again, if the frequencies

Page 365

M. TRIANTAFYLLOU

interfere with the frequencies of the positioning devices, then that increases the noise at the same frequencies. In other words, if I have a signal which consists of two frequencies different, so if the noise is high frequency and my signal is low frequency, I use a Kalman filter and just shoot it out. Nothing is left. But if the noise is at the same frequency as my signal, then it's very difficult or impossible sometimes to distinguish. Often it's impossible to distinguish the two, unless there's some special trick you can do to distinguish the two signals. So it poisons basically the signal, the measurements.

Q. How long has it been known that hydrodynamic noise -- I'm sorry, that hydrodynamic noise is something that you'd try to avoid as much as possible near the hydrophones?

A. It is generally known that you should not have noise around any acoustical device. The least amount of noise around acoustical devices. So it's not limited to streamers,

Page 366

M. TRIANTAFYLLOU

side scan sonars, which we use a lot. You go to extreme measures to make sure that the noise is not there.

Q. Was that known as far back as the '80s?

MR. KIKLIS: Objection, scope.

A. It is a consideration for any acoustical device that you should not have noise of the same frequencies around it.

BY MS. BERNIKER:

Q. Yeah. And I'm just trying to get a sense for how long people have known that. Can you give me an estimate?

A. The fact that hydrodynamic noise is important dates back to the '50s in some applications, you know.

Q. And --

A. And certainly the military know it for much longer than that.

Q. Yeah, okay. Is that one of the reasons that -- I think you said in your expert report, but apologies if I'm not quite construing that right -- is that one of the reasons that you would want, if you were going

Page 367

M. TRIANTAFYLLOU

to position streamer positioning devices along the length of a streamer, you'd want them to be small?

MR. KIKLIS: Objection, form, misstates.

A. It's not so much small that it's the -- the important item is a combination of things. It's the shape and the size, of course, because the noise will increase with size. But it will increase more -- much more with shape than with size. And also, those go hand in hand because when you design something which is big, it has to be strong, and so it further accentuates the problems.

And also, the operating envelope, meaning if you put a small foil, small -- too small, so let's say, when it's sitting there, will make practically no noise, but the minute you start tilting it, it will start producing noise. So if you're continuously operating at high envelopes because it's so small that in order to -- to avoid it stalling, they will produce a lot of noise. So it's a balance of things. It's not a recipe that smaller,

Page 368

M. TRIANTAFYLLOU

better.

BY MS. BERNIKER:

Q. Is a foil, is that like a wing or is that different?

A. Foil, wing. We use them interchangeably.

Q. Is that -- does that -- is it also the case then, given what you explained, that you would want to try to keep the number of protrusions like wings to a minimum?

A. If you are talking protrusions in general, the wing actually is one of the least offensive of the devices because it's streamlined naturally. Other protrusions, like if you attach something that is bulky and put it on, then that will make quite a bit of noise continuously, which is even worse. But also foils, if -- you have to use them at large angles of attack, because they will stall.

Q. Sounds like generally speaking protrusions are something that, to the extent possible, you'd avoid in order to avoid hydrophone noise?

A. Yes.

Page 369

M. TRIANTAFYLLOU

Q. So I want to direct your attention to the '520 patent specification. Do you have that patent in front of you?

A. Which patent you are talking about?

Q. The '520.

A. I have the '520.

Q. If you could look at column 4, please.

A. Yes.

Q. It says -- do you see in column 4 around, starting at line 40, there's a sentence? Are you with me?

A. Yes.

Q. Okay. It says: "Because the movement of the seismic streamer 12 causes acoustic noise (both from seawater flow past the bird wing structures as well as cross current flow across the streamer skin itself), it is important that the streamer movements be restrained and kept to the minimum correction required to properly position the streamers."

Do you see that?

A. Yes.

Q. Do you understand the '520 patent to

Page 370

M. TRIANTAFYLLOU

say that you should be keeping use of the streamer positioning devices to a minimum to the extent possible?

A. You should -- you should -- what it says, it's the -- that the streamers should be kept to -- the streamers should not move laterally.

Q. To the extent you can avoid it?

A. Yes. So the -- there are some priorities. So it says it is important that the streamer movements be restrained. Okay. Why? Because as I said, if you tow the streamer straight, it produces a certain amount of noise. But once it starts creating kinks or moves, then the noise goes way up, because you have cross-flow drag, which causes this -- these effects. And at the same time, when you move the birds -- he says minimum correction required -- the birds when they move to angles of attack, they will increase the noise.

So the first order of business is you should restrain the movement of the streamers, but also try to keep the correction required to a minimum.

Page 371

M. TRIANTAFYLLOU

Q. Okay. So he is taking noise into consideration when he tells you how to go about the method of his patent; right?

A. He mentions, yes, the importance.

Q. Right. And he says you should balance the noise that's created with -- you should balance the noise that's created by using the streamer positioning devices to correct the positioning of the streamers with the rest of what you're doing in figuring out how to go about your survey; right?

MR. KIKLIS: Objection, form.

A. This is -- he puts the considerations that they are there. And when you design a control system, you use what is called the penalty on what you want to control, and the penalty on what you want -- on the control force you are going to put. Because if you design a control system and you don't put restrictions on how much force you are going to put, the answer will be infinite control. If you tell your controller do whatever you want, the answer is infinite. If you tell your son or daughter to go and buy a car and say go and

Page 372

M. TRIANTAFYLLOU

buy a car, they go and buy a Maserati.

So you have to put some restrictions. So the instructions here are to a control person, and what they are told is that one of the considerations you have to put is take into account the noise so when you penalize, as it's called in control, keep in mind that the noise is an issue on this. Because the other issue would be power. But the electronics engineer may say we have plenty of power, we pass it through the wires, why don't we do a good job. We have powerful thrusters to really wiggle around.

So this instruction here says ah, you're going to minimize the control base and considerations. Now, you have to -- what it is, of noise. And then what you are going to control is the motion of the streamers. Again, the motion of the streamers influences the hydrodynamic noise.

So these are two considerations which he says have to enter into the table. There are other considerations too. Okay?

BY MS. BERNIKER:

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