UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF TEXAS
HOUSTON DIVISION

PEI-HERNG HOR,	§	
	§	
Plaintiff,	§	
	§	
v.	§	**CIVIL ACTION NO. 4:08-cv-3584**
	§	
CHING-WU "PAUL" CHU,	§	
	§	
Defendant.	§	

AMENDED MEMORANDUM AND ORDER
ENTERING FINDINGS OF FACT AND CONCLUSIONS OF LAW

During a period of several months spanning the end of 1986 and the beginning of 1987, a group of scientists that included Plaintiff Pei-Herng Hor, Intervenor Ruling Meng, and Defendant Ching-Wu "Paul" Chu, working primarily in the High Pressure Low Temperature ("HPLT") laboratory at the University of Houston, made several pathmarking advances in superconductivity. Two patents issued as a result. On this much, all parties agree. More than two decades later, however, little else is especially clear.

The HPLT lab was run by Dr. Chu and it employed Dr. Hor and Ms. Meng. The patents-in-suit here, U.S. Patent No. 7,056,866 (the "'866 Patent") and U.S. Patent No. 7,709,418 (the "'418 Patent"), named Dr. Chu as the sole inventor when they issued in 2006 and 2010, respectively. Believing themselves co-inventors, Dr. Hor ("Plaintiff") and Ms. Meng ("Intervenor") brought suit in 2008 for correction of inventorship under 35 U.S.C. § 256.

The Court held an eight-day bench trial in January 2014. Post-trial, it invited the parties to submit proposed findings of fact and conclusions of law and to brief whether Plaintiff's and Intervenor's claims are barred by the doctrine of equitable estoppel. Having considered testimony and evidence presented at trial, as well as all subsequent submissions, the Court

concludes that Plaintiff and Intervenor have failed to meet their burden of showing inventorship by clear and convincing evidence. Because it decides in Defendant's favor on the merits, the Court declines to reach his argument for equitable estoppel.

I. PROCEDURAL BACKGROUND

Dr. Pe-Hreng Hor filed suit against Dr. Ching-Wu "Paul" Chu in December 2008, alleging that Dr. Chu had improperly failed to name Dr. Hor as a co-inventor on the '866 Patent. (*See* Doc. No. 1.) He asked that the Court, pursuant to the authority granted to it by 35 U.S.C. § 256, to order the Director of the United States Patent and Trademark Office ("PTO") to issue a certificate correcting the patent's named inventors. (*See id.*) After successfully moving to intervene in February 2010, Ms. Meng asked in her first Complaint in Intervention for the same relief. (*See* Doc. No. 37.)

The '418 patent issued in May 2010, prompting both Plaintiff and Intervenor to amend their complaints. (*See* Doc. Nos. 43, 56.) Months of motions practice followed, ultimately resulting in a January 2011 Memorandum and Order from this Court granting Defendant's Motion to Dismiss or in the Alternative for Summary Judgment Upon Intervenor Meng's and Plaintiff Hor's Unclean Hand Defenses. With respect to laches, the Court held that "the laches period of delay may begin when a plaintiff knew or should have known that the defendant filed a patent application covering his alleged inventive contributions and failed to name him as an inventor, regardless of whether such notice occurred prior to the patent's issuance." (*Id.* at 21.) Believing that both Hor and Meng knew or should have known about their claims by the early 1990s, if not sooner, the Court applied the presumption of laches triggered by a delay of greater than six years. (*Id.* at 24.) Without an adequate justification for that delay, and because "its ability to judge the facts has been significantly undermined by the passage of more than twenty

years," the Court held that presumption could not be overcome and that Plaintiff's and Intervenor's claims were thus barred by laches. (*See* Doc. No. 105-1 at 28.) The Court also held that, "although not raised by Chu, the Court is convinced that, in addition to laches, the doctrine of equitable estoppel applies to bar Hor's and Meng's claims of inventorship." (*Id.* at 31.)

The Federal Circuit affirmed in part, reversed in part, vacated in part, and remanded. *See Hor v. Chu*, 699 F.3d 1331 (Fed. Cir. 2012). With respect to laches, the court "h[e]ld that the laches period for a § 256 correction of inventorship claim begins to run when the omitted inventor knew or should have known of the issuance of the patent, regardless of whether the omitted inventor knew or should have known of the omitted inventorship while the patent application was pending before the PTO." *Id.* at 1336-37 (internal quotation marks omitted). Because Dr. Hor and Ms. Meng brought their claims within six years of the issuance of the patents-in-suit, no presumption applied, and the judgment in favor of Dr. Chu based on his laches defense was in error. As for equitable estoppel, the court of appeals concluded that it was legal error to *sua sponte* grant summary judgment on that basis, at least without affording Plaintiff and Intervenor some notice, and thus vacated that portion of this Court's order. *See id.* at 1837-38.

On remand, Defendant moved for summary judgment based on equitable estoppel, and partial summary judgment on the basis that Plaintiff and Intervenor lacked corroboration. (Doc. Nos. 141, 142.) The Court held a hearing on those motions, which it denied orally. (*See* Minute Entry for 12/11/2013.) The Court reasoned that it would benefit from the more complete record that a trial would produce and that Defendant would be free to re-press his equitable estoppel argument in post-trial briefing.

The Court held a bench trial in January 2014. The Court then entered an order for post-trial briefing, allowing the parties to submit proposed findings of fact and conclusions of law, as

well as briefing on whether equitable estoppel should bar Plaintiff's and Intervenor's claims. This order follows.[1]

II. FINDINGS OF FACT[2]

A. The Inventorship Period Begins

The discoveries that ultimately led to the two patents-in-suit took place between November 1986 and March 1987 ("the Inventorship Period"). On how the parties found themselves in the HPLT lab in November 1986, and on how the Inventorship Period began, there is general agreement.

Dr. Chu supervised the HPLT laboratory. He was the group leader and Principal Investigator of the physics research group. Dr. Hor came to the HPLT lab as a graduate student in 1981 or 1982. (Doc. No. 184 at 74.) Dr. Chu served as Dr. Hor's dissertation advisor. (*Id.* at 73)

Ms. Meng, a material scientist, came to the lab in 1984, having already worked for some twenty years as a research assistant in China. (Pl. Trial Ex. 18.) Dr. Chu visited Ms. Meng's lab at China's Academy of Science in 1979 and ultimately invited Ms. Meng to join him in the United States as a visiting scholar. (Doc. No. 189 at 34-35.) She arrived in the United States later that year, becoming one of the first Chinese scholars to visit the United States. (Doc. No. 189 at 36.)

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[1] Any findings of fact that are more properly conclusions of law are so deemed. Any conclusions of law that are more properly findings of fact are so deemed.

[2] It has been unavoidable in this case that the Court has had to grapple with the science that underlies the patents-in-suit. That science is complicated. Thanks largely to the assistance of the parties, the Court has gained enough knowledge about superconductors to compose these Findings. But, the Court does wish to acknowledge that some of its explanations of the scientific concepts at issue may seem inadequate to practitioners in the field. On a related note, the Court apologizes for the startling number of abbreviations it uses herein.

When Ms. Meng arrived, Dr. Chu's lab did not yet have material synthesis capabilities. (Doc. No. 189 at 36.) She spent the next two years establishing them. (Doc. No. 189 at 37-38.) Ms. Meng spent some of 1981 in Germany and all of 1982-1984 in China, but she continued collaborating with Dr. Chu. (Doc. No. 185 at 208-09, Doc. No. 189 at 41.) She returned to the United States in 1984 at Dr. Chu's invitation. (Doc. No. 185 at 209.)

From November 1986 until March 1987, Ya Qi Wang served as a Visiting Scholar from China and worked in the HPLT lab. (Doc. No. 185 at 52, 215.) Like Ms. Meng, Dr. Wang's background was in material science. (Deposition of Y.Q. Wang ("Wang Dep.") at 21.)

Superconductivity is a phenomenon characterized by zero electrical resistance and the exclusion of the interior magnetic field, which is known as the Meissner Effect. (Doc. No. 184 at 97, 106-07.) A compound must display both zero electrical resistance and the Meissner effect in order to be classified as a superconductor.[3] (*Id.* at 106.) The HPLT lab focused on researching materials that would become superconducting at relatively high temperatures. (*Id.* at 75-77.) Superconductors with temperatures higher than the boiling point of liquid nitrogen were considered especially important because liquid nitrogen is particularly available for industrial use. (*Id.* at 105-106.)

The lab was characterized by long hours, seven days a week. (*Id.* at 78.) Those working in the lab would speak to each other in Chinese. (*Id.*) Ultimately, the group was just as much family as it was workplace. (*Id.*) Dr. Chu served as a mentor and role model for Dr. Hor and Ms. Meng. (*Id.* at 80-81.) Dr. Hor characterized Dr. Chu as a "father figure." (*Id.* at 81.) For her part, Ms. Meng considered Dr. Chu one of her best friends. (Doc. No. 186 at 73.)

[3] All temperatures referred to herein are measured on the Kelvin ("K") scale. Because the Kelvin scale begins at absolute zero, or about -460˚ Fahrenheit, even the "high" temperatures discussed herein are extremely low. (Doc. No. 184 at 99.)

Dr. Chu took a temporary position in Washington, D.C. as Program Director for Solid State Physics at the National Science Foundation ("NSF"), beginning in September 1986. (Doc. No. 186 at 123.) Though the NSF position was full-time, Dr. Chu returned regularly to continue his work in the HPLT lab. (Doc. No. 192 at 33.) In October, Dr. Chu asked that Dr. Hor be appointed Alternate Principal Investigator ("API") for the HPLT lab. (Pl. Trial Ex. 100.) Dr. Hor accepted the position in December. (Pl. Trial Ex. 101.)

Once he assumed his position at NSF, Dr. Chu did in fact continue to return to Houston almost every weekend and he stayed in fairly constant contact with the lab, speaking most frequently to Ms. Meng. (Doc. No. 184 at 96; Doc. No. 186 at 24; Doc. No. 190 at 114.) Ms. Meng testified that she and Dr. Chu would often speak twice daily. (Doc. No. 186 at 24-25.) Dr. Hor and Dr. Chu, in contrast, would speak less frequently. (Doc. No. 184 at 96.)

On or about November 7, 1986,[4] Ms. Meng was alerted by her Chinese Mentor to an article titled "Possible High Tc Superconductivity in the Ba-La-Cu-O System," written by J.G. Bednorz and K.G. Müller. (Doc. No. 185 at 223; Doc. No. 189 at 44; Doc. No. 190 at 6.) Ms. Meng sent a student to the library to obtain a copy and read the article that evening. (Doc. No. 189 at 44.) The article described a compound consisting of Barium, Lanthanum, Copper, and Oxygen ("LBCO") that exhibited superconducting characteristics at a temperature near 30 K. The authors prepared their sample using a coprecipitation method, which involved mixing the compound in a water-based solution before heating it. (Doc. No. 189 at 46-47.) Meng left a copy of the article on Dr. Chu's desk for him to review upon his next visit to Houston from Washington. (Doc. No. 189 at 44; Doc. No. 185 at 224.)

[4] Dr. Hor puts the date at November 14. (*See* Doc. No. 184 at 113.)

B. November 1986: The Lab Seeks to Replicate Bednorz & Müller

1. Plaintiff's and Intervenor's Version

On Saturday, November 8, Ms. Meng and Dr. Chu met to discuss the article. (Doc. No. 185 at 224.) They agreed to attempt to reproduce the results described therein. (Doc. No. 189 at 47.) Ms. Meng was the only material scientist in the HPLT lab and so synthesis duties ordinarily fell to her. (Doc. Mo. 185 at 88-90.) Because Ms. Meng was not familiar with the coprecipitation the article described, Ms. Meng proposed using the solid state reaction method. (Doc. No. 189 at 48.) Ms. Meng believed that the coprecipitation method had its shortcomings, including its cost, the time required, and the likelihood of failure. (*Id.* at 49.) Dr. Chu, in contrast, proposed that Ms. Meng use that very method. (*Id.* at 48.) Ultimately, Ms. Meng won out and came to an agreement with Dr. Chu: Ms. Meng would use the solid state reaction method. (*Id.* at 50.) This decision, on how to replicate Bednorz & Müller, is part of the reason that Ms. Meng believes herself to be a co-inventor.

On November 16, Ms. Meng prepared the LBCO compound as described in the Bednorz & Müller article using the 5-5-5 nominal formula.[5] (*Id.*) Though the group observed the transition temperature (T_c) that the article had described, the scientists did not know the chemical formula of the superconducting compound. (Doc. No. 184 at 119-120.)

[5] A nominal formula is the starting point for creation of a new compound. Each nominal formula was typically given a formula number so that it could be tracked through the synthesis and testing process. (Doc. No. 190 at 91-94.)

2. Dr. Chu's Response

Dr. Chu offered a different take on the first attempt to replicate the Bednorz & Muller result. He asserts that it was his idea and decision for Ms. Meng to use the solid state reaction method. (Doc. No. 192 at 22.) He suggests that it was Ms. Meng who preferred to use the co-precipitation method, which she had not previously used. (*Id.*) Ms. Meng's statements during the *Wu* interference[6] are consistent with Chu's version of events (*See* Pl. Trial Ex. 27 at 1-11), though Ms. Meng has since repudiated any statements she made there. (Doc. No. 1898 at 52-53.) More generally, Dr. Chu disagreed that using the solid-state reaction method had any bearing on whether the patents issued, as it is the standard method for preparing compounds. (Doc. No. 192 at 21-22.) That technique was well known in the field and had previously been used in Dr. Chu's lab. (Doc. No. 189 at 109-110.)

C. December 1986: The Research Ramps Up

1. Plaintiff's and Intervenor's Version

At a Material Research Society meeting in December, Dr. Chu learned that the 2-1-4 phase of LBCO was the superconducting phase and that the partial substitution of Barium for Lanthanum was necessary to create a superconductor. (Doc. No. 184 at 120-121.) At that same meeting, Chu met with his former student, Dr. M.K. Wu of the University of Alabama, and suggested that Dr. Wu collaborate with Dr. Chu's group.[7] (Doc. No. 185 at 104.)

[6] Claims of inventorship of YBCO 1-2-3 by Dr. Wu prompted interference proceedings before the USPTO Board of Patent Appeals and Interferences, which issued a decision in 1999. (Pl. Trial Ex. 75.) Several declarations prepared for that event are referred to herein as being made in the course of the Wu interference.

[7] Dr. Chu does not join issue with his colleagues on the events described in this paragraph.

When, at Dr. Chu's urging, the group applied substantial pressure to the 2-1-4 LBCO compound, they did indeed observe a record-high T_c. (Doc. No. 184 at 122-124.) As a result, on December 15,[8] Chu submitted an article to the prestigious Physical Review Letters ("PRL") entitled "Evidence for Superconductivity Above 40k in the [LBCO] Compound System." (Pl. Trial Ex. 103) When the article was ultimately published, on January 26, 1987, Dr. Hor and Ms. Meng were listed as co-authors, along with Dr. Chu. (*Id.*)

Because the high pressure result in the LBCO system had little real-world application, the group next (also in December) began efforts to replace Barium with smaller Strontium and Calcium ions. (Doc. No. 184 at 127-131.) The chemical substitution was designed to mimic physical pressure. (Doc. No. 185 at 105.) The Strontium substitution was found to increase the T_c, but calcium led to a reduction. (Doc. No. 184 at 131; Doc. No. 185 at 130; *see also* Pl. Trial Ex. 53; Pl. Trial Ex. 65.) Much of the work on the Strontium substitution was performed by Dr. Wu. (Doc. No. 184 at 129-132.) Neither Dr. Hor nor Ms. Meng dispute that it was Dr. Chu who conceived of replacing Barium with Strontium. (Doc. No. 184 at 129; Doc. No. 185 at 101, 104-05; Doc. No. 186 at 91, 93-94, 107.)

Dr. Hor asserts that, "[i]n December of 1986, no scientist in the field of superconductivity would use a magnetic element such as Ytterbium to create superconducting compounds" as "[i]t was thought that magnetic elements would not produce a superconductor. A scientist would not substitute magnetic Gadolinium into a compound and expect to get a high temperature

[8] Also on December 15, Dr. Chu wrote a letter recommending Dr. Hor's appointment as a research associate. Dr. Chu stated that Dr. Hor "contributed significantly to the understanding and creation of high temperature superconductivity" and that the "discovery of world record, high temperature (>40.2K) superconductivity" was "largely to [Dr. Hor's] credit." (Pl. Trial Ex. 102; Doc. No. 190 at 77-78.) Later that month, Hor was appointed to serve as a research associate, a position which ordinarily required a PhD. (Doc. No. 184 at 125-126; Doc. No. 187 at 87-88.)

superconductor." (Doc. No. 198 at 9 (citing Doc. No. 185 at 108, 112-14 and 173; Doc No. 190 at 142-143).) Dr. Hor and Ms. Meng also contends that Dr. Chu did not ask Ms. Meng to substitute Yttrium for Lanthanum in the 214 phase in December 1986. (Doc. No. 185 at 219.)

2. Dr. Chu's Response

Dr. Chu breaks ranks with his colleagues in significant ways with respect to events of mid-December and the conception of Yttrium ("Y"), Ytterbium, and Lutetium. He asserts that, in mid-December, he decided to substitute smaller atomic elements for Lanthanum in the Bednorz LBCO. (Doc. No. 192 at 78.) Dr. Chu's calendar reflects that, on December 18, he wrote "complete replacement of La by smaller Y, Yb Lu---", which he believes "indicates that he was anticipating the substitution experiments using all various rare-earth elements."[9] (Doc. No. 203 at 9 (quoting and citing Doc. No. 192 at 70); *see also* Def. Trial Ex. 447A.)

Dr. Chu's plan was scuttled by an empty supply cabinet. On December 19, Dr. Chu wrote on his calendar "No, Y . . ." (Def. Trial Ex. 447A.) He says that he had already asked Ms. Meng to order rare earth oxides and that he asked her if they had any on that day, to which she replied in the negative. (Doc. No. 192 at 73.)

Dr. Chu says that he contemplated using the 2-1-4 nominal formula for YBCO in the substitutions. (*Id.* at 46.) He believes that his "conception was a definite and permanent idea of Y." (Doc. No. 203 at 9 (citing Doc. No. 192 at 120).)

Then, after the high pressure work on LBCO 2-1-4 had been completed (Doc. No. 192 at 70-76, 120), on December 26, Dr. Chu wrote on his calendar "Y, Lu have to work fast" and on

[9] Hor argues that Dr. Chu's calendar "did not surface until Dr. Hor filed his grievance with UH in 2007," that "[t]he calendar was not produced during the Wu Interference or any of the other interferences even though it is a document that would have been helpful to UH's attorney." (Doc. No. 198 at 44.)

January 2, he added "[t]hink about patent-Cu-Nb, Zr, V, Ta, W; La-Sc, Y, Yb, Lu; and Ba-Sr, Ca." (Def. Trial Ex. 447A.) Dr. Chu says he wanted to try Yttrium and Lutetium because their atoms are smaller than Lanthanum and substituting smaller atoms would perhaps introduce chemical pressure.[10] (Doc. No. 192 at 78.) Dr. Chu selected Yb because he knew it was "weakly magnetic" and he "was also thinking about the magnetic elements for probing the superconductivity at the time." (Doc. No. 192 at 72-73.) He selected Copper because it was "close to a transition metal" and he selected other elements because they had previously been involved in lower temperature work. (Doc. No. 192 at 75.)

With respect to his notation, "think about patent," he says that colleagues Roy Weinstein and Scott Chafin had asked that he write a patent, prompting Dr. Chu to delay his return to DC and prepare the patent disclosure that was ultimately filed on January 9. (Doc. No. 192 at 76; *see also* Pl. Trial Ex. 82.)

D. January 1987: A Meeting in the Lab

1. Plaintiff's and Intervenor's Version of Events

In early January 1987, Dr. Hor initiated a conversation with Dr. Wu,[11] Ms. Meng and Li Gao, another University of Houston graduate student, about how the research should proceed. In that meeting, with his periodic table close at hand, Dr. Hor conceived of the idea of replacing

[10] While Chu at first stated during trial that he had no recollection, independent of his calendar, of the conception of the Y substitution, he later said that he had not understood and that he 'recalled everything." (Doc. No. 192 at 128-9.)

[11] How Dr. Wu learned of the Yttrium substitution is the topic of some disagreement. At trial, Dr. Chu testified that he told Dr. Wu of his conception of the Yttrium substitution in a telephone call in December 1986. (Doc. No. 190 at 41-43.) His sworn declaration in the Wu interference indicated otherwise. (Pl. Trial Ex. 63.) There, Dr. Chu explained that he did not discuss the Yttrium substitution with Dr. Wu prior to January 29, 1987, but that Dr. Hor or Ms. Meng likely informed Dr. Wu of the idea sometime between December 27, 1986 and January 4, 1987. (Pl. Trial Ex. 63 at 6; Doc. No. 190 at 55-59.)

Lanthanum with Yttrium, pursuant to a 2-1-4 formula. (Doc. No. 184 at 132-34; *see also* Doc. No. 185 at 219-221, 229-30; Doc. No. 186 at 5, 57-58.) Ms. Meng suggested that Dr. Wu begin working on that substitution at the University of Alabama because the HPLT lab did not have Yttrium in stock. Meng believed that Dr. Wu could obtain Yttrium from NASA once he returned to Alabama. (Doc. No. 184 at 131-35; Doc. No. 185 at 230-231; Doc. No. 186 at 6.)

At the HPLT lab, it was standard operating procedure for Ms. Meng to order chemicals and other rare earth oxides. (Doc. No. 186 at 13.) Ms. Meng says that Dr. Chu did not ask Ms. Meng to order Yttrium. (*Id.* at 7-8.) Ms. Meng says she ordered Yttrium oxide for the HPLT as soon after the early January meeting as was possible, but not until January 12, because the school was on winter break at the time of the meeting. (Doc. No. 184 at 135-137; Doc. No. 186 at 10-14; Pl. Trial Ex. 6; Pl. Trial Ex. 17.)

By substituting Yttrium for Lanthanum, Dr. Wu was able to create a YBCO compound that exhibited superconductivity above 77 K. (Doc. No. 184 at 141, 150-52; Doc. No. 186 at 15-16; Doc. No. 192 at 48-49. *See also, e.g.*, Doc. No. 184 at 152; Pl. Trial Ex. 13.) Ms. Meng recorded formulas for conducting the Yttrium substitution on or around January 13. (Pl. Trial Ex. 8.)

Dr. Chu was not at the meeting with Dr. Hor, Ms. Meng, and Dr. Wu and would not learn about what had been discussed at that meeting until speaking to Dr. Hor on January 29. (Doc. No. 190 at 54.) Dr. Hor did, however, inform Dr. Chu of his decision to try a Yttrium substitution in early January; at that time, Dr. Chu did not tell Dr. Hor that he had already conceived of a Yttrium substitution. (Doc. No. 184 at 137.)

Dr. Chu then prepared a patent disclosure on January 9, 1987. (Pl. Trial Ex. 82.) Ms. Meng notes that Chu used the word “we” throughout, in order to signify the group effort. (*Id.*;

Doc. No. 189 at 60-63.) Dr. Chu acknowledged that Ms. Meng was responsible for helping him describe the synthesis process. (Doc. No. 192 25-26; *see also* Pl. Trial Ex. 82.) Ms. Meng asserts that the "method used in preparing the compound was critical to the production of the superconductor." (Doc. No. 200 at 8 (citing Doc. No. 192 at 31).)

On or around January 12, Dr. Chu filed a patent application claiming the Yttrium substitution. (Def. Trial Ex. 401.) Dr. Chu was listed as the sole inventor. *Id.*

2. Dr. Chu's Response

a. Y Substitution and Ordering Materials

With respect to the early January meeting between Dr. Hor, Ms. Meng, Dr. Wu, Li Gao, and another student, James Ashburn, Dr. Chu notes that "there is no pre-2006 evidence that Hor *alone* first suggested the Y substitution in the Wu meeting."[12] (Doc. No. 203 at 12.) Instead, Dr. Chu asserts that only Ms. Meng, an interested and biased party, supports Dr. Hor's version of events. (Doc. No. 203 at 12.) The declarations signed by Dr. Hor and Ms. Meng during the Wu Interference did not directly assign credit to anyone for first conceiving of the Yttrium substitution. (Doc. No. 185 at 55-57, 188; Doc. No. 186 at 57-58; *see also* Pl. Trial Exs. 5, 28.)

Dr. Chu argues that the lab records also fail to fully support Dr. Hor's version of events. Though Dr. Hor said that he conceived of the Yttrium substitution after Calcium failed to have the desired effect, the lab notebook shows tests involving Calcium much later in January, after the much-discussed early January meeting, which makes little sense if Dr. Hor already knew that Calcium was not helpful. (Doc. No. 185 at 130-134.) On the other hand, there are no records of

[12] Dr. Hor notes that Dr. Chu relied upon the meeting between Dr. Hor, Ms. Meng, Dr. Wu, and Mr. Gao as proof that the HPLT lab had conceived of YBCO prior to Dr. Wu. (Doc. No. 198 at 10 (citing Ex. 25, Ex. 27, Ex. 28).

unsuccessful Calcium tests prior to the date on which Dr. Hor asserts that he conceived of the Yttrium substitution. (*Id.* at 136-38.)

With respect to the ordering of materials in January 1987, Dr. Chu asserts that, contrary to testimony from Dr. Hor and Ms. Meng, but consistent with documentary evidence, the University of Houston was on vacation only until January 2 (Def. Trial Ex. 412 at 7) and the UH chemical supply room was open as early as January 4 (*id.*), which would have been just a few days after Dr. Hor claimed to have suggested the Yttrium substitution. Dr. Chu posits that "Meng's order on January 12, 1987, does not directly correlate to Hor's alleged suggestion of Y at the Wu meeting, since, if urgent, Meng or her students could have ordered a week earlier." (Doc. No. 203 at 14.) To the contrary, Dr. Chu contends, the evidence is consistent with his version of events: he conceived the Yttrium substitution on December 18, realized the lab did not have Y on December 19, and asked Ms. Meng to order Yttrium on January 11, just before his return to Washington. (Doc. No. 190 at 115-117.) Dr. Chu further adds that, after he completed the Patent Disclosure on January 9, he asked Ms. Meng whether rare-earth elements had been ordered and she admitted not having done so. (Doc. No. 190 at 117.) Dr. Chu says that he told her again to order "soon and quick." (Doc. No. 190 at 117.) Dr. Chu adds that addition rare-earth oxides were ordered, at his instruction, on January 17, because he was beginning an investigation into the role of Yttrium and Lanthanum on superconductivity. (Doc. No. 192 at 81-82.)

b. Patent Disclosure

Dr. Chu explains that he prepared a Patent Disclosure on January 9 and delivered it to his attorney at Arnold, White & Durkee before returning to DC. (Doc. No. 190 at 40-41, 117.) That disclosure described the "complete or partial substitution of the La-atoms . . . by the smaller

atoms Lu . . . or Y . . .” in addition to describing the complete or partial substitutions of Sr, Ca or Mg for Ba. (Pl. Trial Ex. 82 at 1.) Dr. Hor admits that the formula described in the Patent Disclosure matches the one Wu brought to UH much later, on January 30. (Doc. No. 184 at 150-51; Doc. No. 185 at 155-56.) The same formula was the subject of two papers Dr. Chu wrote in February. (Def. Trial Exs. 409, 410.)

Arnold, White & Durkee filed U.S. Patent Application No. 07/002,089 (“the ‘089 application”) on January 12. (Def. Trial Ex. 401.) That application described Dr. Chu’s conception of the Y substitution for La in the LBCO-214 composition. (*Id*. at 2.) Dr. Chu notes that he disclosed 2-1-4 as his nominal formula for all substitutions. (Def. Trial Ex. 82.) The University’s new patent attorneys filed a continuation in part on January 27. (Def. Trial Ex. 402.) In that continuation, Dr. Chu again characterized himself as the sole inventor; the only material changes included more fully describing the inventions and slightly broadening the range of chemical compositions covered by the application. (*Id*.)

E. Late January 1987: The Group Makes Additional Substitutions

1. Plaintiff’s and Intervenor’s Version

The group’s next move was to begin substituting other elements for Lanthanum in order to find other superconductors. For instance, on January 29, Dr. Wu reported observing superconductivity at 77 K in a mixed-phase compound in which Yttrium was substituted for Lanthanum.[13] (Doc. No. 184 at 143.)

In reporting this development, Dr. Wu told Dr. Hor that he had accomplished “what we discussed previously,” referring to the early January meeting in Houston. (Pl. Trial Ex. 49 at 808.) Because Dr. Chu was unaware of what had been discussed in that meeting, he asked Dr.

[13] Dr. Hor asserts that Dr. Wu did not in fact tell Dr. Chu which compound had led to the T_c of greater than 77 K. (Doc. No. 190 at 103-104.)

Hor to write down the formulas he had discussed with Dr. Wu. Those formulas included the Yttrium and Scandium substitutions for Lanthanum. Though Ms. Meng tried to duplicate the result with Yttrium that evening, she was unsuccessful. (Doc. No. 1:143, 150; 2:138; 3:16-17; 6:105-109; P. Ex. 21 (H-50).) Dr. Hor's formulas were then recorded by Ms. Meng in her lab notebook. (Doc. No. 1:148-149; Pl. Trial Ex. 21 at 942.)

Dr. Wu brought a sample to Houston on January 30. The sample used a 2-1-4 formula. Dr. Hor tested it to determine that it was a genuine superconductor; the sample's T_c exceeded 77 K. (Doc. No. 184 at 150-151; Pl. Trial Ex. 51 at 9-10.) Dr. Wu's sample was a mixed phase sample, which meant that it had a black, superconducting phase, and a green phase as an insulator. (Doc. No. 184 at 154; Doc. No. 190 at 90-91.) The HPLT lab next endeavored to isolate the black phase. (Doc. No. 184 at 155-156.)

Dr. Chu immediately drafted an article, submitted to PRL on February 6, called "Superconductivity at 93K in a Mixed Phase Y-Ba-Cu-O [("YBCO")] Compound System at Ambient pressure." (Pl. Trial Ex. 48.) The article was published on March 6. Both Hor and Meng were listed as authors. (*Id.*) Dr. Wu was listed as an author as well. (*Id.*) Dr. Wu was listed first among Alabama authors and Dr. Hor was listed first among Houston authors.[14] (*Id.*) Also on February 6, Dr. Chu filed a continuation-in-part patent application prompted by Dr. Wu's YBCO sample, as it was important to get an application on file before submitting a scientific paper. (Doc. No. 186 at 199-209; Pl. Trial Ex. 90.)

[14] The general custom in the field was to list first the person who had made the most significant contribution. (Doc. No. Doc. No. 184 at 82-83, 153; Doc. No. 187 at 19, 83-85.) Dr. Chu testified that his custom was to name himself first in the first paper in a new field, but thereafter to list himself last in subsequent papers. (Doc. No. 190 at 75.)

At the time, the exact chemical composition and structure of the YBCO superconductor were still unknown; the HPLT lab lacked the X-Ray diffraction equipment that would be necessary to make that determination. (Doc. No. 185 at 8; Doc. No 190 at 87.)

2. Dr. Chu's Response

Dr. Chu explains that Dr. Wu called him on January 29 and told him that he had observed a resistive drop above 77 K, but did not have the magnetic susceptibility measurements necessary to confirm it. (Doc. No. 184 at 141.) Dr. Wu agreed to come to Houston the next day to test for Meissner effect. (*Id.* at 143.) In conversation with Dr. Wu, Dr. Chu learned of the previous meeting between Dr. Hor, Ms. Meng, and Dr. Wu. (Doc. No. 190 at 104-105; Doc. No. 192 at 83.) Dr. Chu did indeed ask Dr. Hor to write down the formulas that had been discussed at that meeting. *Id.*

When Dr. Wu arrived, he told Dr. Chu he wanted to file a patent, but Dr. Chu informed him that Dr. Chu had already done so, on January 12. (Doc. No. 192 at 82-83.) Dr. Chu showed Dr. Wu the patent and Dr. Wu admitted that "[t]here's no point to file anything." (*Id.*)

Dr. Chu prepared two manuscripts to be submitted to PRL on January 31. The manuscripts described YBCO 2-1-4 and the presence of black and green phases in the compound. Both manuscripts contained footnotes disclosing the January 12 Patent Application. *Id.* Dr. Chu showed both papers to Dr. Hor and Ms. Meng. (Doc. No. 192 at 88.) Dr. Hor did not see the footnotes announcing the patent application. (Doc. No. 185 at 193-194.)

Dr. Chu did indeed file U.S. Patent Application No. 07/012,205 on February 6, describing the YBCO composition that exhibited superconductivity above 77 K. Dr. Chu was named as the sole inventor. (Def. Trial Ex. 403.) The patent ultimately issued as the '418 patent. (Def. Trial Ex. 444.)

F. February-March 1987: Searching for the Black Phase

1. Plaintiff's and Intervenor's Version

Throughout January and February of 1987, Dr. Chu and his group continued to reproduce Dr. Wu's results, endeavoring to identify the exact structure of the superconducting phase. (Doc. No. 185 at 8.) Dr. Chu asked Dr. David Mao and, later, Dr. Robert Hazen of Washington's Carnegie Institute to assist, asking Ms. Meng to help by preparing and selecting samples to be sent to Carnegie. (*Id.* at 94; Doc. No. 190 at 123.) As a part of that process, Ms. Meng separated the black phase from the green phase in order to create a purer black phase sample for Dr. Hazen. (Doc. No. 189 at 58; Doc. No. 189 at 89-95.) Ms. Meng says that her work on the black and green phases is reflected in the '866 patent. (Pl. Trial Ex. 13 at col. 8; Doc. No. 189 at 95.)

Tasked with figuring out the chemical composition of YBCO, Dr. Hazen did not receive a sample from the Houston lab until February 20. (Doc. No. 190 at 126-127.) A week later, Dr. Hazen informed Dr. Chu of his preliminary findings as to YBCO's chemical composition. (Doc. *Id.* at 128.) On February 28,[15] Dr. Chu informed Ms. Meng that Dr. Hazen had identified the superconducting phase as a cubic structure with an atomic ratio of 1-2-3. (Doc. No. 189 at 93; Doc. No. 185 at 9-10; Hazen Dep. 64-65, 154-155.) In a notebook, Ms. Meng noted the call and other possible substitutes for Yttrium. (Doc. No. 189 at 93; Pl. Trial Ex. 35 at H557-H559.)

Ms. Meng spent much of this time period working with Christopher Kinalidis, who operated the scanning electron microscope for the electrical engineering department. (Doc. No. 189 at 7.) Ms. Meng and Mr. Kinalidis worked together to become more familiar with the properties of the samples and to improve their ability to identify phases, which in turn helped Ms. Meng to produce better samples. (Doc. No. 189 15, 87.)

[15] Dr. Chu asserts it was February 27. (Doc. No. 192 at 92-93.)

On March 5, Dr. Hazen offered his preliminary results as to the crystal structure. (Doc. No. 6:130-131; Deposition of George Hazen ("Hazen Dep.") at 76-78.) The crystal structure was determined to be a square-planar structure. (Hazen Dep. at 159-161.) On March 8, 1987, Dr. Hazen prepared a report on the structure and phase for YBCO-123. (*Id.* at 84-86; Pl. Trial Ex. 85.) Even with this information, however, it was unknown why the compound functioned as a high-temperature superconductor. Dr. Hor continued to work to find that out. (Doc. No. 185 at 10.)

The chemical formula and crystal structure of the YBCO superconductor was identified by the Carnegie Institute's group led by Dr. Hazen and Dr. Mao. (*Id.* at 9-10; Doc. No. 190 at 122-124; Hazen Dep. 20-21, 33, 39-54.)

2. Dr. Chu's Response

Dr. Chu explains that, in February, he determined that he needed to know the chemical composition and structure of high T_c YBCO-214. (Doc. No. 192 at 89.) He had determined that the samples were not pure phase and that the samples had intertwined black and green phases, as well as that the superconducting phase was not likely to display the 2-1-4 structure (*Id.* at 89-90.) Chu further knew that the superconductivity likely came from the black phase, not the green phase. (*Id.* at 90.) As Dr. Hor and Ms. Meng assert, Dr. Chu enlisted the help of Dr. Mao and Dr. Hazen. (Doc. No. 190 at 90-91.)

Dr. Chu points out that, while Ms. Meng worked with Mr. Kinalidis to try to determine the chemical composition of the black phase, it was Dr. Hazen who ultimately figured out the precise formula for the black phase. (Doc. No. 186 at 31, 135.) Dr. Hazen "provided the chemical composition of the superconducting black phase as well as the atomic structure of all elements, except the position of the oxygen atoms, based upon the first sample provided by Chu

before Hor or Meng attempted to make a more refined sample with more black phase." (Doc. No. 203 at 23-24.)

G. March 1987: Rare Earth Experimentation Continues

1. Plaintiff's and Intervenor's Version

On or about March 11 or 12, Dr. Hor asked Ms. Meng to replace Yttrium in the YBCO-123 with the magnetic rare-earth element Gadolinium. (Doc. No. Doc. No. 185 at 11-14, 164-165; Pl. Trial Ex. 37 at 1585-86.) Ms. Meng too testified that Dr. Hor asked her to try the Gadolinium substitution. (Doc. No. 186 at 83-84.) Jeff Bechtold also testified that Dr. Hor had discussed with him the Gadolinium experiment in early 1987. (Deposition of Jeff Bechtold ("Bechtold Dep.") at 190-196; 225-26.) The Gadolinium experiment was conducted on or around March 15. (Doc. No. 185 at 16-18, 165-166; Bechtold Dep. at 66-73, 76-82; Pl. Trial Ex. 44; Pl. Trial Ex. 93; Pl. Trial Ex. 110; Pl. Trial Ex. 119.) The Gadolinium compound was found to be a high-temperature superconductor with a T_c in the 85-90 K range, similar to that of YBCO.

Surprised by this result, Dr. Hor decided to substitute other rare earth elements for Yttrium in the 123-phase. (Doc. No. 185 at 21-22.) He asked Ms. Meng to complete the substitutions and ultimately several new superconductors were discovered. (Doc. No. 185 at 23-29; Doc. No. 181.) According to available lab records, formulas were calculated, and tests were conducted, for 1-2-3 phase compounds including Cerium, Terbium, Neodymium, Erbium, Dysprosium, Holmium, and Ytterbium. (Doc. No. Pl. Trial Ex. 121-125, 127-129.) The lab notes reflect a host of calculations and formulas for magnetic rare earth compounds made between March 12 and March 16. (Pl. Trial Exs. 121-125, 127-129.) The compounds displayed T_c ranging from 70 to 95 K. (Doc. No. Doc No. 185 at 30-33, 130-135.)

Once again, Dr. Chu almost immediately submitted a PRL paper, which was ultimately published on May 4, 1987. (Doc. No. 185 at 33-34; Pl. Trial Ex. 60.) The article was submitted and received on March 16, immediately after Dr. Hor's work on magnetic rare earth substitutions in YBCO 1-2-3. The article, which lists Dr. Hor as its first author and Ms. Meng as its second, addresses complete substitution of the magnetic rare earth elements in the 1-2-3 phase. (*Id.*) The article did not discuss partial substitution of the magnetic rare earth elements for Yttrium. (*Id.*)

On March 26, Dr. Chu prepared another continuation-in-part application, within ten days of the work Dr. Hor claims to have completed. (Def. Trial Ex. 404.) The continuation-in-part added the magnetic rare earth superconductors. (Doc. No. 186 at 210-211; Pl. Trial Ex. 92.)

2. *Dr. Chu's Response*

Dr. Chu asserts that the evidence clearly establishes that his partial substitution with the most magnetic rare-earth element, Gadolinium, in late February led to his work the next month to test other rare-earth elements, discoveries which are reflected in the '866 Patent. (Doc. No. 203 at 24.) He explains that mid-January orders for rare-earth elements demonstrates that he conceived of using them as substitutes for La. (Doc. No. 192 at 79-80.) He first ordered Gadolinium because it was the most magnetic of the rare earths. (*Id.*) He explained that, on January 12, he had Ms. Meng order Yttrium and Lutetium in order to introduce chemical pressure, and Gadolinium, for a pair-breaking experiment. (*Id.* at 65, 79-80.) He added that he had the lab order other magnetic rare earth elements throughout January 1987. (*Id.* at 65-66, 79-80; *see also* Pl. Trial Exs. 6, 7, 17; Def. Trial Ex. 442 at H1869, H1878-79, H1887.) Dr. Chu argues that, while it follows logically from the mid-December conception of Yttrium, Ytterbium, and Lutetium to want to order rare earths, it makes no sense for Ms. Meng, who claims to have

ordered the rare earths based on what she learned in the Bednorz paper in November, to wait until January. (Doc. No. 203 at 27 (citing Doc. No. 186 at 37-39).)

Dr. Chu also notes that his conception of partially substituting Gadolinium for Yttrium in YBCO was recorded on February 22. (Pl. Trial Ex. 37 at H131; *see also* Doc. No. 190 at 132-34; Doc. No. 192 at 96.) Because it was the most magnetic of the rare-earth elements, Dr. Chu tested a partial substitution of Gadolinium for Yttrium in YBCO on February 24. (Doc. No. 192 at 96-97, 134-35.) From there, Dr. Chu figured that, because the partial substitution of Gadolinium did not suppress superconductivity, the magnetic rare-earths could be completely substituted for Yttrium in YBCO or Lanthanum in LBCO. (*Id.*) Dr. Chu notes that Ms. Meng recorded as much on February 27 and 28. (Doc. No. 192 at 99-100 (citing Pl. Trial Ex. 35 at H 557, H559-60).) Dr. Chu says he formulated and tested complete substitutions of the magnetic rare earths in March 1987. (Doc. No. 190 at 46-47; Doc. No. 192 at 113-14.)

Dr. Chu explains that it was he who directed his lab to perform pair-breaking experiments in late February. (Doc. No. 192 at 79-82.) He said he made several partial substitutions of rare-earths and drew conclusions that Dr. Hor did not draw for several more weeks. (Doc. No. 192 at 97, 111-12, 134-35; *see also* Pl. Trial Ex. 37 at H 131; Pl. Trial Ex. 93 at H1340; Pl. Trial Ex. 44 at H431.) Dr. Chu explains that it was his decision to partially substitute Gadolinium on February 24 and the subsequent observation that superconductivity was not compromised that spurred him to make complete replacements of Y with each magnetic rare-earth element. (Doc. No. 192 at 97-99, 101, 149.)

Though Dr. Hor has suggested that the lab tested Gallium, and not Gadolinium, on February 24, Ms. Meng and Dr. Chu have both suggested otherwise. (Doc. No. 186 at 178-80;

Doc. No. 192 at 97-98.) Documentary evidence also lends support to Dr. Chu's position. (Pl. Trial Ex. 37 at H 131; Pl. Trial Ex. 44 at H431; Pl. Trial Ex. 31 at H1340.)

Meng's testimony regarding the events of February 27, when Dr. Chu says that he instructed the lab to make partial substitutions with all magnetic rare-earth elements, was conflicting at trial and contradicted by her prior testimony. (Doc. No. 186 at 158; Doc. No. 189 at 163-65; *id.* at 167-68.)

Once Dr. Chu had learned from Dr. Hazen that the superconducting black phase boasted a 1-2-3 formula, Dr. Chu says he decided to perform experiments to confirm his earlier findings made during partial substitutions of Gadolinium. (Doc. No. 192 at 108-09.) Dr. Chu says that on March 7, for instance, he tried Europium and continued to similarly experiment with rare-earth elements from March 11 to March 15. (*Id.* at 114-15.) Chu says that it was he who had the lab perform the complete substitutions. (Doc. No. 190 at 146-147; Doc. No. 192 at 113-14.) When all was said and done, the lab had tested Europium, Samarium, Gadolinium (again), Neodymium, and Erbium. (*See* Doc. No. 192 at 113-16; Pl. Trial Ex. 47 at H52021; Pl. Trial Ex. 37 at H 151-165; Pl. Trial Ex. 93 at H1274-1279; Pl. Trial Ex. at 93.)

As for Dr. Hor's claims that he first instructed Ms. Meng to undertake the complete substitution of Gadolinium for Yttrium on March 11 or 12 (Doc. No, 185 at 15-16), Dr. Chu contends that he had conceived of rare earth elements as superconductors three weeks prior. (Doc. No. 192 at 133-155.)

Dr. Chu disputes that Mr. Bechtold can corroborate Dr. Hor's claims to have conceived the complete substitution of Gadolinium. (Doc. No. 203 at 35.) He notes that Dr. Hor claimed that only a complete substitution of Gadolinium for Yttrium in YBCO was scientifically correct, and yet Mr. Bechtold specifically recalled that Dr. Hor discussed with him only a partial

substitution. (Bechtold Dep. at 178-181, 194-97, 207-11.) Dr. Hor, for his part, could not recall discussing the Gadolinium substitution with Mr. Bechtold. (Doc. No. 185 at 182-184.)

Once Dr. Chu had completed various complete substitutions of the magnetic rare-earth elements in YBCO, he drafted and submitted a paper to PRL on March 16. (Doc. No. 190 at 149-153.) Similarly, the '866 patent, filed on March 26, claimed partial and complete substitutions of Gadolinium, Neodymium, Samarium, Europium, Dysprosium, Holmium, Erbium, Thulium, and Ytterbium, as well as Yttrium, Lanthanum, and Lutetium. (Doc. No. Ex 13, claim 1.)

3. Dr. Hor's Rejoinders

Dr. Hor notes that the lab records reflect calculations, using a 2-1-4 nominal formula, for preparation of compounds with a small fraction replacement of Yttrium with magnetic Gadolinium on February 22 and March 3. (Doc. No. 190 at 136-146; Pl. Trial Ex. 37 at H131-141.) But, there is no evidence as to how the compounds were synthesized or even whether they were actually made or tested.[16] (*Id.* at 6:137, 141; Pl. Trial Ex. 44.)

The lab records likewise reflect calculations, also using the 2-1-4 nominal formula, for small-fraction substitutions of magnetic rare earth elements for Lanthanum, but not for Yttrium, dated between March 3 and 6. (*Id.* at 137-141; Pl. Trial Ex. 37 at H 132-142.) Again, there is no evidence showing synthesis conditions or that the compounds were made or tested. (Doc. No. 190 at 141.)

Dr. Hor notes that the lab records on which Dr. Chu relies to establish that he conceived of the magnetic rare earth line of superconductors show continued use of the nominal 2-1-4-formula, even after Dr. Hazen had informed Dr. Chu of the 1-2-3 chemical composition of

[16] There are different methods to synthesize a compound from a nominal formula. Varying the synthesis conditions can change the resulting compound. (Doc. 190 at 93-94.)

YBCO on February 27, and that there would be no reason to use the 2-1-4 formula after YBCO-123 was known.[17] (Doc. No. 190 at 136; Hazen Dep. At 64-65; 154-156; Pl. Trial Ex. 37 at H131-141).) He points out that, to the contrary, Dr. Hor's magnetic rare earth pair-breaking experiments used a 1-2-3 nominal formula. (Pl. Trial Ex. 121-125, 127-128.)

Dr. Hor posits that the formulas on which Dr. Chu relies did not, as Dr. Chu insists, involve Gadolinium substitution, but rather substitutions of the non-magnetic element Gallium. (Pl. Trial Ex. 44 at H455; Bechtold Dep. at 185-186.) In fact, Dr. Hor notes that none of Dr. Chu's academic writings has ever claimed credit for coming up with the Gadolinium substitution. (Doc. No. 190 at 184.)

Dr. Hor contends that "[t]he only documentary evidence of small fraction partial substitution of magnetic rare earths for Yttrium is contained in formulas which were written by Y.Q. Wang in one of the lab notebooks." (Doc. No. 198 at 27.) In fact, Dr. Hor appears to doubt whether Dr. Chu ever made any partial substitution rare earth compounds. (Doc. No. 198 at 28.) Dr. Hor further contends that several of Dr. Chu's publications indicate that the magnetic rare earth substitutions were not undertaken until after Dr. Hazen had passed along information as to the chemical formula and structure of YBCO 1-2-3. (Doc. No. 198 at 28-29.) Dr. Hor posits that "[a]ll of Dr. Chu's written accounts of the discovery of the magnetic rare earth superconductors are consistent with Dr. Hor's conception of the magnetic rare-earth superconductors in Mid-March 1987." (Pl. Trial Exs. 49, 65- 67.)

Dr. Hor disputes whether, as Dr. Chu testified, partial substitution of magnetic rare-earth elements in YBCO established the viability of the magnetic rare earth elements as superconductors. (Doc. No. 198 at 29.) Rather, he asserts that "without complete replacement of

[17] Dr. Chu testified that he continued to use the 2-1-4 formula in this time period because the lab did not know how to make YBCO-123 yet. (Doc. No. 192 at 141-42.)

Yttrium there is always a possibility that some pure high T_c YBCO-123 will be present in the newly synthesized compound and that it will be responsible for the detection of superconductivity." (Bechtold Dep. at 213-217.)

With respect to the March 26 continuation, Dr. Hor emphasizes Dr. Chu's claims to have begun pair-breaking experiments using magnetic rare-earth elements in February and his contemporaneous discovery of the magnetic rare earth superconductors, as well as his demonstrated ability to quickly file patent applications. With that in mind, he argues that "it is unreasonable to infer that Dr. Chu would have waited over a month from mid-February to March 26, 1987 to file a continuation-in-part patent application that included the magnetic rare-earth superconductors." (Doc. No. 198 at 25-26 (citing Doc. No. 185 at 171-72).)

H. Relevant Post Invention Period Events

1. Meeting with Attorneys

In 1987 or so, Dr. Hor, Dr. Chu, and Ms. Meng met with Mr. Cox, the patent attorney, at University of Houston. (Doc. No. 185 at 38; Doc. No. 186 at 39.) Going into that meeting, Dr. Hor did not yet know that Dr. Chu had already filed patent applications. (Doc. No. 185 at 46.) Dr. Hor believed that the purpose of the meeting was to work together to draft a patent application for YBCO-123 and other rare earth superconductors. (*Id.* at 38-39.) As Dr. Hor recalls the meeting, Mr. Cox inquired as to who had proposed the Yttrium substitution; Dr. Chu pointed to Ms. Meng and asked if she recalled that he had called her and told her to try a Yttrium substitution.[18] (*Id.* at 39; Doc. No. 186 at 39-40; Doc. No. 190 at 197.) Dr. Hor was taken aback by the statement; Ms. Meng, unwilling to embarrass and hesitant to anger Dr. Chu, said that she

[18] Dr. Chu argues that, "[c]learly, at the time of the meeting, Chu still recollected his conception of Y in mid-December 1986, and through his question to Meng during the meeting, informed Hor and Meng that he had conceived Y weeks before Hor and Meng jointly suggested Y to Wu." (Doc. No. 203 at 11.)

did not remember. (Doc. No. 186 at 42, 118.) For largely the same reasons, Dr. Hor also said he did not remember. (Doc. No. 185 at 41, 62, 174.) Mr. Cox then stated that it seemed no one remembered who first conceived of the Yttrium substitution; for his part, Dr. Chu said that Dr. Hor and Ms. Meng were co-inventors and should be so recognized. Mr. Cox responded that a "pair of hands" could not be listed as an inventor. (Doc. No. 185 39-43 and 174-77; Doc. No. 186 at 39-42 and 114-120.)

Dr. Chu acknowledges that he asked why everyone could not be named an inventor on the '866 patent. (Doc. No. 190 at 198; 186 at 228.) Mr. Cox testified that he did not interpret Dr. Chu's question as a serious suggestion that Dr. Hor and Ms. Meng were co-inventors. (Doc. No. 186, at 228-33.)

Unsettled by what had just transpired, Dr. Hor left the meeting. (Doc. No. 185 at 43, 176.) Dr. Chu followed him and apologized by telling Dr. Hor that Mr. Cox was "only a lawyer" and did not "know anything." (*Id.* at 44.) According to Dr. Hor, Dr. Chu pledged to straighten things up with Mr. Cox. (*Id.* at 43-44; Doc. No. 190 at 197-199.) In the end, however, Dr. Chu did not follow up with Mr. Cox and Dr. Hor did not discuss the matter again with Dr. Chu "because he trusted him and because in his public writings on the discovery of YBCO and the magnetic rare earth superconductors, Dr. Chu was very fair to everybody." (Doc. No. 198 at 33 (citing Doc. No. 186 at 61-62).)

Ms. Meng later told Mr. Cox that Dr. Hor was the one who had conceived of the Yttrium substitution; Mr. Cox responded that Dr. Chu should receive such recognition as the public face of the university and research group and to avoid UH losing its patent. (Doc. No. 186 at 46-50, 101-103.) Contrary to what Ms. Meng and Dr. Hor appear to believe, Mr. Cox said that he generally understood how the lab functioned. (Doc. No. 186 at 216; Doc. No. 187 at 169.)

2. DuPont License

DuPont licensed the technology associated with the then-existing patent applications in 1988. (Doc. No. 192 at 14.) Dr. Chu agreed to share the proceeds of that agreement evenly with the university and then split his portion with Dr. Hor, Ms. Meng, and Dr. Wu, giving about $137,000 to each. (Doc. No. 185 at 48-49, Doc. No. 190 at 26-27, Doc. No. 192 at 15-16; Pl. Trial Ex. 11; Pl. Trial Ex. 73.) Dr. Chu has acknowledged that the payments were made in recognition of the outsized contributions made by Dr. Hor, Ms. Meng, and Dr. Wu. (Doc. No. Doc. No. 190 at 28-29.) Dr. Hor argues that the payments "raise[] an inference that Dr. Hor's and Ms. Meng's contributions to the '816 and '418 patents were substantial." (Doc. No. 198 at 30.)

3. Wu Interference

As introduced above, claims of inventorship of YBCO 1-2-3 by Dr. Wu required that the USPTO Board of Patent Appeals and Interferences issue a decision in 1999. (Pl. Trial Ex. 75.) In its decision, the Board recognized that the "technology embraced by the subject matter of the invention is so new and unpredictable" and seemed, according to Ms. Meng, to imply that conception of the invention could not take place until actual reduction to practice. (*Id.* at 7-8.)

Dr. Chu filed a declaration claiming to have conceived of the Yttrium substitution in mid-December 1986 and to have told Ms. Meng about his idea. (Pl. Trial Ex. 63.) In his declaration, Dr. Chu did not state that he personally told Dr. Hor of the Yttrium substitution. (*Id*.) At trial, however, Dr. Chu suggested that he had told Dr. Hor of his idea prior to January 29, 1987, but could not recall when. (Doc. No. 190 at 108-11.)

Mr. Cox prepared a declaration on Dr. Hor's behalf, in which he was to state that he and Ms. Meng had discussed the Yttrium substitution for Lanthanum with Dr. Wu. (Pl. Trial Ex. 5.)

Dr. Hor notes that his statement was "consistent with his understanding that he was at least a co-inventor of YBCO-123 and that it was a group effort." (Doc. No. 198 at 37 (citing Doc. No. 185 at 57).) Dr. Hor was not told that his declaration would be used to support Dr. Chu's claim to sole inventorship. (Doc. No. Doc. No 187 at 145-146; Doc. No. 185 at 57-58.)

Ms. Meng filed a declaration supportive of the University of Houston as to claims by the University of Alabama, but Ms. Meng did not believe that she had conceded her position that she was a coinventor. (Doc. No. 189 at 105-06; Doc. No. 192 at 126-128.) Dr. Hor notes that Ms. Meng has since recanted on her statements in the Wu interference. (Doc. No. 186 at 56-57.)

As Dr. Hor notes, "it was not critical to UH who conceived of Yttrium substitution as long as it was not Wu. Dr. Chu's defense in the Wu interference focused on showing that Dr. Wu did not conceive of Yttrium substitution first and that he got the concept of Yttrium substitution from someone at UH." (Doc. No. 198 at 35.)

4. Dr. Chu Writes Recommendations

In 1992, Dr. Chu wrote a recommendation on Dr. Hor's behalf, recommending that he be given promotion and tenure, noting the "[h]e and his colleagues working under his direction discovered the whole series of the so-called 123 compounds [involving rare earth elements] — the most important HTS compound system to date for both scientific study and large-current applications above 77K." (Pl. Trial Ex. 59.) Dr. Chu said that he did not lie when giving Dr. Hor credit. (Doc. No. 190 at 162.)

III. CONCLUSIONS OF LAW

A. Legal Framework

The parties generally agree as to the law that governs here. Patents are presumed valid, 35 U.S.C. § 282, and the presumption of validity extends to inventorship; "each patent . . . receives the presumption that its named inventors are the true and only inventors." *Acromed Corp. v. Sofamor Danek Grp., Inc.*, 253 F.3d 1371, 1379 (Fed. Cir. 2001) (citing *Hess v. Advanced Cardiovascular Sys., Inc.*, 106 F.3d 976, 980 (Fed. Cir. 1997)). "[T]o rebut this presumption, a party challenging patent validity for omission of an inventor must present clear and convincing evidence that the omitted individual actually invented the claimed invention." *Id.* (citing *Environ Prods. v. Furon Co.*, 215 F.3d 1261, 1265 (Fed. Cir. 2000)). In the event that Plaintiff and/or Intervenor does so, 35 U.S.C. § 256 grants this Court the authority to order the PTO to add the omitted inventor to the patent-in-suit. *See Ethicon, Inc. v. U.S. Surgical Corp.*, 135 F.3d 1456, 1461 (Fed. Cir. 1998).

1. The Law of Inventorship

"Determining 'inventorship' is nothing more than determining who conceived the subject matter at issue." *Sewall v. Walters*, 21 F.3d 411, 415 (Fed. Cir. 1994). Inventorship is a question of law. *Univ. of Pittsburgh of Commonwealth Sys. of Higher Educ. v. Hedrick*, 573 F.3d 1290, 1297 (Fed. Cir. 2009). "'Inventorship' in the law of patents arises from conception, not development or reduction to practice." *PerSeptive Biosystems, Inc. v. Pharmacia Biotech, Inc.*, 225 F.3d 1315, 1324 (Fed. Cir. 2000). That is, "[c]onception is the touchstone of inventorship, the completion of the mental part of invention. . . . It is 'the formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention, as it is hereafter to be applied in practice.'" *Burroughs Wellcome Co. v. Barr Labs., Inc.*, 40 F.3d 1223,

1227-28 (Fed. Cir. 1994) (quoting *Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1376 (Fed. Cir. 1986)). Consequently,

> [T]he test for conception is whether the inventor had an idea that was definite and permanent enough that one skilled in the art could understand the invention; the inventor must prove his conception by corroborating evidence, preferably by showing a contemporaneous disclosure. An idea is definite and permanent when the inventor has a specific, settled idea, a particular solution to the problem at hand, not just a general goal or research plan he hopes to pursue. . . . The conception analysis necessarily turns on the inventor's ability to describe his invention with particularity. Until he can do so, he cannot prove possession of the complete mental picture of the invention. These rules ensure that patent rights attach only when an idea is so far developed that the inventor can point to a definite, particular invention.

Id. at 1228.[19]

2. Joint Inventorship

With respect to joint inventorship, "[a] contribution to one claim is enough." *Falana v. Kent State Univ.*, 669 F.3d 1349, 1357 (Fed. Cir. 2012) (internal quotation marks omitted); *see also Gemstar-TV Guide Int'l, Inc. v. Int'l Trade Comm'n*, 383 F.3d 1352, 1381 (Fed. Cir. 2004). "A joint invention is the product of collaboration between two or more persons working together to solve the problem addressed. . . . The inventors need not work physically together or contemporaneously to be joint inventors; nor must each inventor contribute equally or to each claim of the patent." *Univ. of Pittsburgh of Commonwealth Sys. of Higher Educ. v. Hedrick*, 573 F.3d 1290, 1297 (Fed. Cir. 2009) (citing 35 U.S.C. § 116 (2006)). Rather, "each person claiming to be a joint inventor must have contributed to the conception of the invention." *Acromed Corp. v. Sofamor Danek Grp., Inc.*, 253 F.3d 1371, 1379 (Fed. Cir. 2001) (citing *Fina Oil & Chem. Co.*

[19] The Federal Circuit has cautioned that it did not mean to "suggest that a bare idea is all that conception requires." *Burroughs*, 40 F.3d at 1229-30. Rather, "[t]he idea must be definite and permanent in the sense that it involves a specific approach to the particular problem at hand. It must also be sufficiently precise that a skilled artisan could carry out the invention without undue experimentation. And, of course, the alleged conception must be supported by corroborating evidence." *Id.* at 1229-30.

v. Ewen, 123 F.3d 1466, 1473 (Fed. Cir. 1997)). Put another way, joint inventorship arises where "collaboration or concerted effort occurs," such that "the inventors have some open line of communication during or in temporal proximity to their inventive efforts." *Eli Lilly & Co. v. Aradigm Corp.*, 376 F.3d 1352, 1359 (Fed. Cir. 2004).

"The determination of whether a person is a joint inventor is fact specific, and no bright-line standard will suffice in every case." *Fina Oil*, 123 F.3d at 1473. An alleged co-inventor's contribution must not be "insignificant in quality, when that contribution is measured against the dimension of the full invention." *Acromed*, 253 F.3d at 1379 (internal quotation marks omitted). Undoubtedly, "[t]he line between actual contributions to conception and the remaining, more prosaic contributions to the inventive process that do not render the contributor a co-inventor is sometimes a difficult one to draw. Contributions to realizing an invention may not amount to a contribution to conception if they merely explain what was 'then state of the art' . . . if they are too far removed from the real-world realization of an invention . . . or if they are focused solely on such realization." *Eli Lilly*, 376 F.3d at 1359 (internal citations omitted).[20]

[20] Quoting the District of D.C., the Federal Circuit has on another occasion eloquently explained the concept of joint inventorship:

> A joint invention is the product of *collaboration* of the inventive endeavors of two or more persons *working toward the same end* and producing an invention by their *aggregate* efforts. To constitute a joint invention, it is necessary that each of the inventors work on the same subject matter and make some contribution to the inventive thought and to the final result. Each needs to perform but a part of the task if an invention emerges from all of the steps taken together. It is not necessary that the entire inventive concept should occur to each of the joint inventors, or that the two should physically work on the project together. One may take a step at one time, the other an approach at different times. One may do more of the experimental work while the other makes suggestions from time to time. The fact that each of the inventors plays a different role and that the contribution of one may not be as great as that of another does not detract from the fact that the invention is joint if each makes some original contribution, though partial, to the final solution of the problem.

"[A] person is not precluded from being a joint inventor simply because his or her contribution to a collaborative effort is experimental." *Fina Oil*, 123 F.3d at 1473 (citing *Burroughs*, 40 F.3d at 1229). That said, "experiments conducted at the request of an inventor by another party may inure to the benefit of the inventor for purposes of establishing a reduction to practice." *Cooper v. Goldfarb*, 154 F.3d 1321, 1331-32 (Fed. Cir. 1998) (citing, e.g., *Burroughs*, 40 F.3d at 1230); *see also Consol. Aluminum Corp. v. Foseco Int'l Ltd.*, No. 82 C 2792, 1988 WL 391250 (N.D. Ill. Oct. 31, 1988) ("A person who merely follows the instruction of another in performing experiments is not an inventor."), *aff'd*, 716 F. Supp. 316 (N.D. Ill. 1989), *aff'd*, 910 F.2d 804 (Fed. Cir. 1990). In the field of chemistry, courts have made clear that, "[i]n some circumstances, the method of making a compound will require nothing more than the use of ordinary skill in the art. In those circumstances, the contribution of that method would simply be 'the basic exercise of the normal skill expected of one skilled in the art' and would not normally be a sufficient contribution to amount to an act of joint inventorship." *Falana*, 669 F.3d at 1358 (alteration omitted) (quoting *Fina Oil*, 123 F.3d at 1473). Of course, the reverse is also true: "Where the method requires more than the exercise of ordinary skill . . . the discovery of that method is as much a contribution to the compound as the discovery of the compound itself." *Falana*, 669 F.3d at 1358. In short, it is a "well-known principle that conception of a compound requires knowledge of both the chemical structure of the compound and an operative method of making it." *Id.*

Kimberly-Clark Corp. v. Procter & Gamble Distrib. Co., Inc., 973 F.2d 911, 916-17 (Fed. Cir. 1992) (quoting *Monsanto Co. v. Kamp*, 269 F. Supp. 818, 824 (D.D.C. 1967)).

3. The Corroboration Requirement

The requirement that one claiming co-inventorship must produce corroborating evidence is important. The corroboration requirement "addresses the concern that a party claiming inventorship might be tempted to describe his actions in an unjustifiably self-serving manner in order to obtain a patent or to maintain an existing patent." *Singh v. Brake*, 222 F.3d 1362, 1367 (Fed. Cir. 2000). The alleged co-inventor's testimony "cannot, standing alone, rise to the level of clear and convincing proof." *Ethicon, Inc. v. U.S. Surgical Corp.*, 135 F.3d 1456, 1461 (Fed. Cir. 1998) (internal quotation marks omitted). "Thus, an alleged co-inventor must supply evidence to corroborate his testimony." *Id.* (citing *Price v. Symsek*, 988 F.2d 1187, 1194 (Fed. Cir. 1993)). Courts use a "rule of reason" analysis to determine "[w]hether the inventor's testimony has been sufficiently corroborated." *Id.* "Under the 'rule of reason' standard for corroborating evidence . . . the trial court must consider corroborating evidence in context, make necessary credibility determinations, and assign appropriate probative weight to the evidence to determine whether clear and convincing evidence supports a claim of co-inventorship." *Id.* at 1464.

Corroborating evidence can present itself in numerous manifestations. "Documentary or physical evidence that is made contemporaneously with the inventive process provides the most reliable proof that the inventor's testimony has been corroborated. . . . Because documentary or physical evidence is created at the time of conception or reduction to practice, the risk of litigation-inspired fabrication or exaggeration is eliminated." *Sandt Tech., Ltd. v. Resco Metal & Plastics Corp.*, 264 F.3d 1344, 1350-51 (Fed. Cir. 2001) (citing *Woodland Trust v. Flowertree Nursery, Inc.*, 148 F.3d 1368, 1373 (Fed.Cir.1998)). "Circumstantial evidence about the inventive process may also corroborate. . . . Additionally, oral testimony of someone other than

the alleged inventor may corroborate." *Ethicon*, 135 F.3d at 1461 (internal citations omitted). "Typically, the 'testimony of one co-inventor cannot be used to help corroborate the testimony of another.'" *Weaver v. Houchin*, 467 F. App'x 878, 880 (Fed. Cir. 2012) (quoting *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1171 (Fed. Cir. 2006)). The Federal Circuit has provided a list of factors that can help the Court in evaluating oral testimony. Those factors are:

> (1) delay between event and trial, (2) interest of witness, (3) contradiction or impeachment, (4) corroboration, (5) witnesses' familiarity with details of alleged prior structure, (6) improbability of prior use considering state of the art, (7) impact of the invention on the industry, and (8) relationship between witness and alleged prior user.

Juicy Whip, Inc. v. Orange Bang, Inc., 292 F.3d 728, 741 (Fed. Cir. 2002). Worthy of emphasis is the inclusion of "interest of the witness." The Federal Circuit has explained that "[a] review of the relevant [Supreme Court and Federal Circuit] case law reveals a clear requirement that [cross-corroboration] by interested parties must be corroborated by documentary testimony." *Lacks Indus., Inc. v. McKechnie Vehicle Components USA, Inc.*, 322 F.3d 1335, 1350 (Fed. Cir. 2003).

B. Ultimate Conclusions

The documentary evidence here is inconclusive. And while the Court cannot "conclude that the witnesses . . . were not credible," "the guidance of precedent caution[s] against the reliance on oral testimony alone." *Juicy Whip*, 292 F.3d at 743. As such, the Court concludes that "that the evidence of record did not provide the clear and convincing evidence necessary" to warrant correction of inventorship.

1. Conclusions as to Intervenor

a. Intervenor's Contentions

Ms. Meng asserts that she "was responsible for the operative method of making the superconducting compounds described in Claims 1 through 10 of the '866 patent, and

synthesized these compounds (reducing them to practice) using her methods." (Doc. No. 200 at 13 (citing 5:69-84).) Meng further argues that "[c]laims 11 through 15 of the '866 patent describe a 'method for making a superconducting metal oxide'" for which she was responsible. (Doc. No. 200 at 14 (citing Doc. No. 189 83-90, 95-97; Pl. Trial Exs. 35, 37, 45).) Meng adds that "[e]very data point used to support the claims in the patents came from work done in Meng's synthesis lab and is reflected in her laboratory notebooks." (*Id.* (citing Doc. No. 189 at 64-65).) As for the '418 patent Ms. Meng contends that she "was responsible for the operative method of making the compounds described in Claims 1 through 8 and reducing them to practice." (*Id.* at 15 (citing Doc. No. 189 at 97-100; Pl. Trial Ex. 44).)

Ms. Meng contends that conception in this case requires actual, not conceptual, reduction to practice. (*Id.* at 24.) To bolster that assertion, Ms. Meng points to a finding issued by the Board of Patent Examiners in the *Wu v. Chu* interference indicating that "'the technology embraced by the subject matter of the [superconductivity inventions] is so new and unpredictable,' conception of the invention at issue cannot take place until there has been an actual reduction to practice — in other words, conception proceed simultaneously with the work of reduction to practice." (*Id.* at 21 (citing Pl. Trial Ex. 75).) Consequently, Ms. Meng argues that she is entitled to be a named inventor here because she "developed the methods by which the superconducting compounds described in the '866 and '418 patents were synthesized." (*Id.* at 23.) She asserts that her "development of methods, through extensive experimentation and analysis, required more than the exercise of ordinary skill." (*Id.*) She adds that "[w]hen Chu provided Meng with instructions, they were only general instructions, void of 'minute details' or specific steps to carry out." (*Id.*) Rather, "Meng's work was, in general, left to her independent,

significant expertise as a material scientist." *Id.* In short, she took Dr. Chu's abstract ideas and brought them to life.

b. Conclusions

Ms. Meng's testimony is hopelessly at odds with that of Dr. Chu on how it came to be that they used solid state reaction method, which the evidence suggests was a widely used technique. Ms. Meng has not presented enough factual evidence for the Court to find that she suggested the solid state reaction method. And, even if it could make that finding, the evidence is not clear and convincing enough for the Court to find that suggesting that method was anything beyond that of ordinary skill in the profession. Ms. Meng has not managed to tie what is written in the lab notebook to her own contributions, distinct from a general catalog of what had occurred in the lab.[21]

2. Conclusions as to Plaintiff

a. Plaintiff's Contentions

Dr. Hor asserts that he was responsible for conceiving of the Yttrium substitution for Lanthanum and the substitution of the magnetic rare-earth elements for Yttrium. (Doc. No. 198 at 42-43.) Dr. Hor relies on the fact that he was listed first on all relevant scientific publications; the lab records detailing the discovery of YBCO-123; the lab records regarding Dr. Hor's conception of the magnetic rare-earth superconductors in Mid-March 1987; Dr. Chu's past statements crediting Dr. Hor with the creation of YBCO and the magnetic rare-earth superconductors; and Dr. Chu's references to "our patent" when communicating with Ms. Meng

[21] There were some vague references during trial, and allusions in the briefs, to Ms. Meng claiming credit for certain substitutions as well, but she does not press those claims in her post-trial filing.

(Doc. No. 186 at 21, 71). For corroboration, Dr. Hor relies upon Ms. Meng's testimony, lab records, the scientific papers, and the statements giving credit to Dr. Hor.

As for circumstantial evidence that Dr. Hor believes corroborate his contributions to the patents-in-suit, he points to the payments from the DuPont proceeds, the timing of the January 1987 Yttrium order, the timing of Dr. Chu's patent application, the timing of Dr. Chu's writing his scientific paper on magnetic rare earth superconductors; Dr. Hor being listed as the first author on the relevant papers; and lab records. (Doc. No. 198 at 43.)

b. Conclusions

Dr. Hor has not provided enough corroborating evidence to meet the clear and convincing standard. Ms. Meng's testimony is only mildly persuasive, as she is an interested party. The lab notebooks do not conclusively point one way or the other, and the authorship order, letters of recommendation, and DuPont payments are just not especially convincing.

Dr. Hor bases his inventorship on his suggestion to Dr. Wu in late December 1986 or early January 1987 that Y be substituted for La in LBCO 214, but he has failed to offer enough corroborating evidence, especially considering that he relies in large part on Ms. Meng, who is in interested party and has even, at times, hinted that she herself conceived of that idea. On the other side of the ledger, Dr. Chu has brought forward his calendar entries, his patent disclosure, and some of Ms. Meng's past statements. Dr. Chu's evidence at the very least places the issue in equipoise, which requires the conclusion that Plaintiff has not met his burden of proving inventorship with clear and convincing evidence.

As for the complete substitution of rare earth elements for Yttrium, the evidence as to what was tested when, and by whom, is so conflicting that the Court cannot deem it clear and convincing. That other elements appear to have been tested prior to Gadolinium undercuts Dr.

Hor's suggestion that he conceived of the rare earth substitutions when he tested Gadolinium. Dr. Chu's claim to inventorship, and supporting proof, is at least as credible, which again requires that the Court conclude that Plaintiff has not met his burden.

IV. CONCLUSION

In view of the testimony heard, and the evidence received, during trial, the Court concludes that neither Plaintiff nor Intervenor has carried the burden of showing inventorship to a clear-and-convincing standard. Judgment is therefore rendered in favor of Defendant. A Final Judgment will follow in a separate document. Defendant's Motion for Judgment Based on Equitable Estoppel (Doc. No. 199) shall be terminated as moot. So too all still-pending Motions in Limine (Doc. No. 162).

IT IS SO ORDERED.

SIGNED at Houston, Texas, on this the twenty-first day of January, 2015.

KEITH P. ELLISON
UNITED STATES DISTRICT JUDGE