UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

URT UMWELT UND RECYCLINGTECHNIK GMBH,

Petitioner,

v.

DUESENFELD GMBH,

Patent Owner.

Case No. IPR2024-00887
U.S. Patent No: 11,050,097

DECLARATION OF VANI DANTAM IN SUPPORT OF DUESENFELD GMBH'S PATENT OWNER RESPONSE

I, Vani Dantam, of Fishers, Indiana, declare that:

I. ASSIGNMENT

1. I have been retained by Robins Kaplan LLP on behalf of Duesenfeld GmbH ("Duesenfeld") as an expert with regard to this matter. I understand that Petitioner URT Umwelt und Recyclingtechnik GmbH ("URT" or "Petitioner") is requesting that the Patent Trial and Appeal Board ("Board") institute *inter partes* review (IPR) of U.S. Pat. No. 11,050,097 ("the '097 patent") (Ex. 1001).

2. In my capacity as an expert, I have been asked to provide my independent analysis and opinions regarding the '097 patent, the prosecution history of the '097 patent and related applications as applicable, the alleged prior art relied upon by Petitioner, the meaning of various claim terms from the '097 patent from the perspective of a person of ordinary skill in the art ("POSITA"), and the opinions offered by Petitioner's expert, Volker Spies, in his declaration ("Spies Declaration") (Ex. 1003). My opinions and conclusions are fully discussed in later sections of this declaration.

3. I am an independent consultant, and I am not, and have never been, an employee of Duesenfeld or URT. I received no compensation for this declaration beyond my normal hourly compensation ($250/hr) based on my time actually spent analyzing the '097 patent, the prosecution history of the '097 patent and related

applications, the prior art publications relied upon by Petitioner, the Spies Declaration, and other related materials. I will not receive any added compensation based on the outcome of any IPR or other proceedings involving the ’097 patent.

II. BACKGROUND AND QUALIFICATIONS

4. My Curriculum Vitae (“CV”) is attached as **Appendix A**. Additional confidential work history is in Exhibit 2035 (Confidential **Appendix C).** I highlight here a few experiences in my career that are particularly germane to my opinions discussed herein, which give a basis of my opinions of a person of ordinary skill in the art at the time of invention (*i.e*., approximately 2015).

5. In 1979, I obtained a Bachelor of Technology degree with a focus in Metallurgical Engineering from the Indian Institute of Technology – Banaras Hindu University (Varanasi, Uttar Pradesh, India), graduating with high honors at the top of my class.

6. In 1982, I obtained a Master’s of Science (MS) degree in Mechanical Engineering from Vanderbilt University, under a U.S. Navy Scholarship.

7. In 1987, I obtained a Master’s in Business Administration (MBA), specializing in Finance and International Business from Kelley School of Business, Indiana University, under a GM Fellowship.

8. I have certifications and continuing education, including QES Quality Engineering Certification, GM Quality Institute, Kettering University (Flint, MI).

9. From 2008 - 2010, I worked as the Director of Global Sales at Remy Electric, managing sales of Hybrid/EV motors/generators. These motors/generators operated using energy supplied by lithium ion batteries. Through my work at Remy Electric, I became familiar with the performance characteristics of different lithium ion batteries. Lithium ion batteries had just begun to proliferate in the industry.

10. From 2010 - 2012, I worked with the Indiana-based company EnerDel as their VP of Sales. EnerDel is a company that pioneered Lithium ion battery technologies. Through my capacity as VP of sales, I developed a thorough understanding of lithium ion battery technology and the materials that went into these batteries. I managed the design of battery modules and packs for different applications, based on customer inputs. Because of my technical background, I was able to talk to a customer, and translate those needs into a proposed module and pack design. I also worked as a team member scaling up the production of cells/modules/packs from the pilot plant in Fishers, IN to a GWh scale production plant in Greenfield, IN.

11. From 2012 - 2015, I worked for Axion Power as its Senior Vice President of Sales, Business Development, and Marketing. Axion Power is a company that specialized in manufacturing lead-carbon batteries, which is a technology that competed with lithium ion batteries. At Axion Power, I supervised Application Engineering and Module and Pack Development to reflect the customer

needs. As I competed for business, my work at Axion Power helped me understand the tremendous advantages lithium ion batteries have, how advanced the material and process technology was set to become, and the areas where additional work was needed—from a customer perspective. Customers would show us their lithium ion battery packs, and asked us to design a lead-carbon battery that could outperform the lithium-ion battery, and I would supervise the application engineering personnel. Through this experience I became increasingly well-versed in both kinds of battery technologies.

12. In 2015, I joined Landis+Gyr (a division of Toshiba, Japan) as their V.P. of North American Sales. I managed the sales of LTO batteries (LTO batteries use Lithium Titanate anodes and LFP or NMC cathodes). During my five-year employment with Landis+ Gyr, I often visited Toshiba headquarters in Tokyo and their plant in Kashiwazaki (north of Tokyo) and received coaching and training from my colleagues in Japan on different battery chemistries and material preparation as well as production line design. One area of my focus was understanding the electrode preparation and how the plant prepared the rejects for recycling by recruiting special material recyclers for plant waste and returned battery packs.

13. Starting in 2019, I worked for Lucas TVS (Chennai, India) and 24m Technologies (Cambridge, MA) as their Chief Project Consultant, focusing on

feasibility, finance, Engineering, Procurement, and Construction ("EPC"), operations, and customer development. In this role, I managed plant feasibility studies regarding production of semi-solid state lithium ion battery technology conducive to Indian ambient conditions. Through this capacity I helped design a plant directed to produce new cell formats for batteries using LFP/NMC chemistries, BMS integration and module/pack/charging infrastructure design and architecture.

14. From 2022 - 2023, I served as the Chief Operating Officer of Nextech Batteries in Carson City, Nevada. I was responsible for all functional areas, including logistics, engineering, and production, which included setting up global manufacturing facilities for lithium sulfur chemistry-based cells.

15. From 2023 - 2024, I was Chief Executive Officer and Chairman of the Board for Nevada Technology Corporation, which specializes in lithium ion battery recycling, including repurposing used batteries into second life batteries and developing advanced cell technologies to overcome current rechargeability, cost, and life limitations.

16. From 2022 - 2024, I was the Chief Advisor to Lohum Americas, which is a provider of advanced recycling technologies for lithium ion batteries using principles of Hydrometallurgy. They currently operate a recycling plant in India with a capacity of 800MWh. This will be scaled up to over 2GWh in the next

2-3 years. They also signed agreements to establish recycling facilities in the Middle East, Eastern Europe and Africa.

III. LEVEL OF SKILL IN THE ART AND BASIS FOR OPINIONS

17. For purposes of this Declaration, I do not dispute the level of skill for a POSITA as set forth on page 14 of the Petition and in ¶¶62-63 of the Spies Declaration (*i.e.*, a B.S. degree in electrical engineering, materials science, chemical engineering, or an equivalent field, as well as at least 2 to 3 years of academic or industry [experience] in the recycling or processing of lithium-ion batteries.).

17.1 I also understand that the Board, in its Institution Decision, adopted this definition. Institution Decision at 7. I continue to not dispute this determination of level of skill in the art. This definition is appropriate, because I understand that the named inventors on the ’097 patent were graduate students at the Technical University of Braunschweig in Germany when they conceived of the inventions, and so they would not yet have had advanced degrees at the time.

18. I believe that I am qualified to render opinions regarding the technology described and claimed in the ’097 patent, based on my experience and education. Based on my expertise and qualifications, I believe that I am qualified to provide opinions as to the state of the art and what a POSITA would have understood, known, or concluded as of the filing date of the ’097 patent (*i.e.*, April 28, 2015). I have been working in the lithium battery field, including supervising

the processing of lithium ion batteries, since 2012. My career has continued in the battery recycling field, and I have participated in various industry organizations relating to battery recycling technologies. I have familiarized myself with the state of the art at the time of invention as it relates to battery recycling technology, as set forth herein. I have provided my declaration herein from the perspective of a person of ordinary skill in the art in the time frame of the invention of the '097 patent, *i.e.*, as of April 28, 2015.

19. In reaching my opinions and conclusions, I have relied upon my education, my work experience in the relevant field, and my training, and considered and relied upon my review and analysis of the materials listed in **Appendix B.**

IV. RELEVANT LEGAL PRINCIPLES

20. For the purposes of this declaration, I have been informed about certain aspects of the law that are relevant to my analysis and opinions. I have applied these legal principles in rendering my opinions below.

A. Claim Construction

21. I understand that the ordinary and customary meaning of a claim term is the meaning that the term would have to a POSITA at the time of the invention.

22. In the absence of an express intent on the part of the inventor to give a special meaning to the claim terms, the words are presumed to take on the ordinary and customary meanings attributed to them by a POSITA.

23. I understand that it is the use of the words in the context of the written description, and as customarily used by those skilled in the relevant art, that accurately reflects both the ordinary and the customary meaning of the terms in the claims.

24. I understand that the basis for a term's ordinary and customary meaning may be derived from a variety of sources, including the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art at the time of the invention.

25. I have been instructed that dictionary definitions or definitions from technical references can be used to inform or confirm the ordinary and customary meaning of words found in a claim, but that in construing claim terms, the general meanings gleaned from reference sources, such as dictionaries, must always be compared against the use of the terms in the context of the claim itself.

26. I understand that a patent applicant is entitled to be his or her own lexicographer (in other words, provide his or her own meaning to a word or phrase) and may rebut the presumption that claim terms are to be given their plain and

ordinary meaning. To do so, the applicant must clearly set forth a definition of the term that is different from its ordinary and customary meaning. Where the applicant provides an explicit definition for a term, that definition will control interpretation of the term as it is used in the claim in which it appears. I understand that the specification can also be relied on for more than just explicit lexicography to determine the meaning of a claim term. For example, I understand that the meaning of a particular claim term may also be determined by implication, that is, according to the usage of the term in the context of the specification.

B. Obviousness

27. I understand that under U.S. patent law, 35 U.S.C. §103, a claim is invalid as obvious if the differences sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

28. I am informed that an obviousness analysis requires an assessment of the scope and content of the prior art, the differences between the art and the claims at issue, and the level of ordinary skill in the art. I am told that it is against this backdrop that obviousness is assessed.

29. I am informed that a POSITA is a hypothetical person who is presumed to be aware of all the pertinent prior art. I am also informed that an

obvious analysis may take account of the inferences and creative steps that a POSITA would employ.

30. I am informed that assessing which prior art references to combine and how they may be combined to match the challenged claim may not be based on hindsight reconstruction or *ex-post* reasoning. Hindsight reconstruction is using the challenged patent itself as a road map for recreating the invention. In assessing obviousness, only what was known before the invention was made can be considered. I also understand that a guard against such hindsight reconstruction is a determination whether a person of ordinary skill in the art would have been motivated, taught, or suggested to combine the relevant teachings of the prior art to duplicate the challenged claim at the time of the filing of the application on the patented invention.

C. Anticipation

31. I am informed that under U.S. patent law, 35 U.S.C. §102, a claim is invalid as anticipated if a single prior art reference discloses each and every limitation of the claimed invention.

32. I am informed that a reference is anticipatory if it contains the claim elements in the same order as claimed, regardless of whether the prior art and the claimed invention are directed to achieving the same purpose.

33. I am informed that a prior art reference may anticipate a claim without expressly disclosing a feature of the claimed invention if that missing feature is necessarily present, or inherent, in the single anticipating reference.

34. I am informed that inherency requires more than the probability or possibility that a claimed feature is present in the prior art, but rather that the feature or characteristic is a necessary part of the prior art. I also am informed that recognition of the inherency by a POSITA— at the time— is not required.

D. Enablement

35. I am informed that under U.S. patent law, a petitioner attempting to invalidate a patent for anticipation or obviousness, must establish enablement. I understand that without a showing of enablement, a petitioner cannot establish a reasonable likelihood of a patent being invalid for anticipation or obviousness.

36. I am informed that the test for enablement is whether one reasonably skilled in the art could make or use the invention from the disclosures in the prior art, coupled with information known in the art without undue experimentation.

37. I am informed that the more that is known in the prior art about the nature of the invention, how to make, and how to use the invention, and the more predictable the art is, the less information needs to be explicitly stated in the specification.

38. I am informed that what is known in the art at the time of invention can provide evidence as to the question of predictability.

V. TECHNOLOGY BACKGROUND: EV BATTERIES

39. The technology at issue in this case relates to the recycling of electric vehicle "EV" batteries. To appreciate the state of the art at the time of invention, an understanding of the structure of EV batteries is important.

40. Figure 1 below is an image of an EV battery, as published in 2009. Ex. 2006 at 5. At the bottom right of this diagram is a cutaway cross-section of a battery cell, showing the layers of electrodes and separators making up the cell. To the left is an illustration of the primary components of the cell.

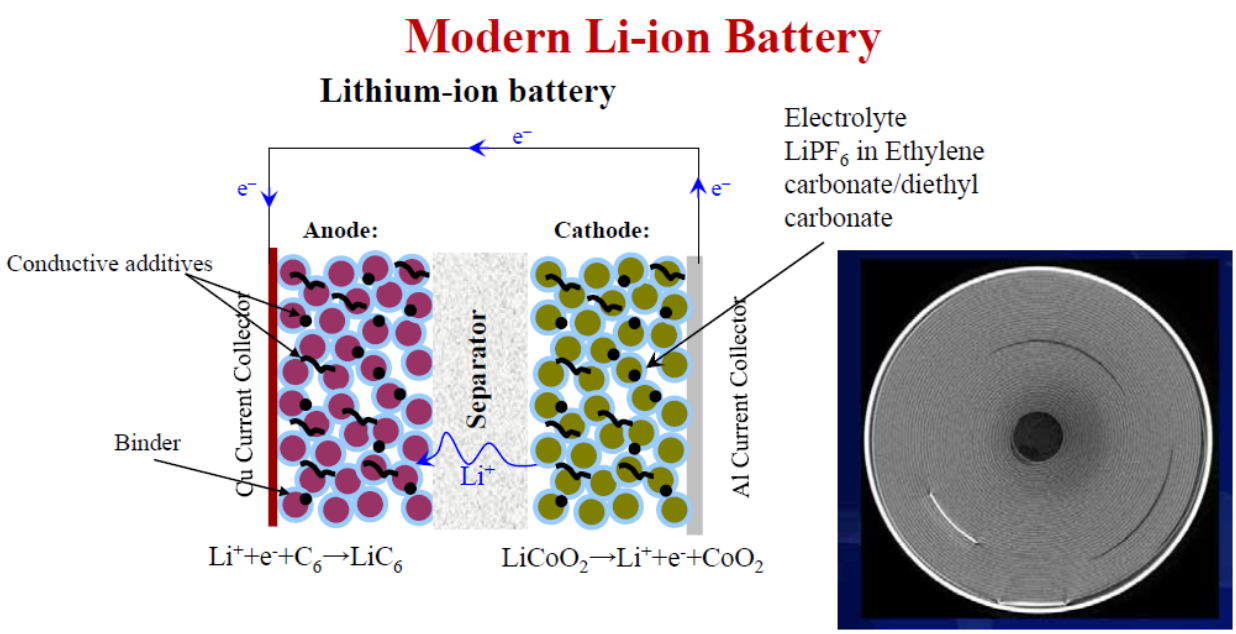


Figure 1: Diagram of lithium ion battery components.

Ex. 2006 at 5.

41. The cathode is the positive electrode. Ex. 2006 at 5. The cathode is formed on a support, which is typically aluminum foil. *Id.* Metal oxides are pasted onto the support foils. *Id.* These metal oxides include lithium cobalt oxide (LCO), lithium iron phosphate ($LiFePO_4$), or nickel manganese cobalt oxide (NMC) or nickel manganese aluminum oxide (NMA). Ex. 1020 at 4 ("On the cathode side, for example, lithium nickel manganese cobalt oxide, lithium nickel aluminum oxide and lithium iron phosphate."). A binder (light blue line shown in Figure 1) is used to affix the metal oxides onto the copper foil support. Ex. 2006 at 5.

42. The anode is the negative electrode. Ex. 2006 at 5. The anode is formed on a support, which is usually copper foil. *Id*. Onto the copper foil is pasted graphite, again using a binder. Ex. 2006 at 5.

43. Between the cathode and the anode there is a thin membrane called a "separator." Ex. 2006 at 5. This separator is porous, allowing lithium ions to pass back and forth between the anode and cathode. *Id.* Without the separator, there would be a short circuit from contact between the anode and cathode. The lithium ions need to be dissolved in a liquid solvent in order to be able to flow between the electrodes during discharging and recharging processes.

44. The lithium ions are dissolved in a solvent, which is commonly one or more of the following: ethylene carbonate, dimethyl carbonate, ethyl methyl carbonate, propylene carbonate or diethyl carbonate. Ex. 2006 at 5. The form of

lithium used is typically lithium hexafluorophosphate ($LiPF_6$). *Id*. When the lithium is dissolved in the solvent, the lithium is referred to as an "electrolyte." The lithium ions in the electrolyte transit back and forth between the positive cathode and the negative anode as the battery is charged and discharged. *Id.*

45. The metal oxides are affixed onto the foils by means of a binder. Ex. 2006 at 5. The binder is a polymer, and frequently polyvinylidene fluoride (PVDF) is used. Ex. 1020 at 4 ("The binder can, for example, be polyvinylidene fluoride (PVDF)"). The binder embeds the metal oxide particles and fixes them onto the foils, which provides for the structural integrity of the electrodes. Ex. 1020 at 1 ("The galvanic cell includes an active material, a support for the active material and a binder for bonding the active material and the support."). The binder is chemically stable, and helps the battery maintain its durability over the battery's chemical environment and the mechanical stresses undergone by the battery over its lifetime.

46. The most valuable components of the battery are the metal oxides in the cathode. However, these metal oxides are embedded in the binder, which must be dissociated in order to liberate the metal oxides. Ex. 1020 at 3 ("The invention is based on the finding that heating the cell fragments to the decomposition temperature would theoretically have to be sufficient to destroy the binder to such an extent that the active material is released, but that the active material is still

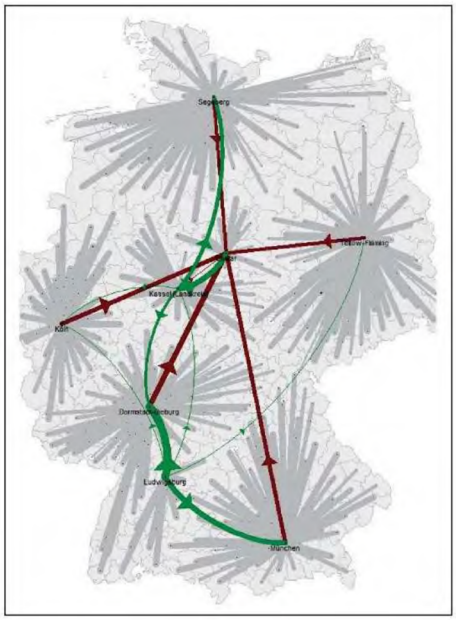
difficult to remove from the support."). Because of the stability of the binder, a high heat furnace/oven may be used to decompose the binder. Temperatures on the order of 350ºC to 800ºC may be sufficient to decompose the binder. Ex. 1020 at 5 ("The decomposition temperature is preferably at least 350°C and at most 800°C. It has been found that the binder is reliably decomposed at these temperatures."). Once the binder is decomposed, the metal oxides in shredded material are reduced to black powder along with pieces of metal foil substrate pieces.

47. The high temperatures of these furnaces/ovens can generate unwanted by-products. For example, $LiPF_6$ and PVDF may decompose into a toxic gas, including hydrogen fluoride ("HF"). Ex. 2001 at 1:22-27 ("In addition, when $LiPF_6$ reacts with water, $LiPF_6$ is hydrolyzed and generates toxic hydrogen fluoride."). Hydrogen fluoride may corrode glass, break seals on industrial machinery, and if inhaled, can be fatal.

48. In order to facilitate the breakdown of these batteries, it is advantageous to shred them. The term "comminuting" is used to describe the shredding of batteries. By shredding the batteries, the individual components are exposed, to better allow the extraction of the underlying materials. Ex. 1016 at 177 (noting as a part of the discussion on cell disassembly that, "[a]fter excluding the alternatives, one possible process path remains, which includes mechanical destruction of the cells using a shredding process and physio-mechanical electrode

separation"). Shredding the batteries yields an unstructured bulk of fragments of battery components. *Id.* A hazard arises when there are residual charges left in the batteries. Ex. 2004 at 2:0004 ("When crushing electrolytic cells under normal atmosphere, the electrolyte or a solvent containing electrolyte can easily ignite due to released electrical charges and associated arcing. In the case of lithium-ion cells, such a fire is accompanied by a release of hydrogen fluoride."). These residual charges may spark, triggering a chemical reaction. Ex. 2002 at 1:29-31 ("The danger lies in the charge that some of these cells may still contain, which could lead to causing a fire."). Explosions and fires may result. Ex. 2004 at 2:0004. A fundamental problem with the recycling process is the difficulty of transporting batteries to a central facility for processing. Ex. 1016 at 21 ("Lithium batteries are generally subject to the transportation regulations for dangerous goods."). To extract the metal oxides and other materials from the batteries, high heat furnaces/ovens have conventionally been used. Ex. 1016 at 1 ("Most conventional battery recycling processes focus on the recovery of the valuable metals cobalt and nickel using an essentially pyrometallurgical process, which must be combined with hydrometallurgical processes to recover the lithium."). These high heat furnaces/ovens make sense to build in centralized locations. However, the spent batteries will be coming from a wide region, including from individual automobile

owners whose cars are spent or wrecked. Ex. 1016 at 51-53. Figure A-15 below highlights the highly decentralized nature of battery inflow.



Ex. 1016 at 53.

Thus, there is a logistics problem of getting these used batteries transported to a centralized facility for processing. Ex. 1016 at 33 ("Used batteries must be transported between collection points, any interim storage facilities and the dismantling and processing plant(s).").

49. The transportation problem is heightened by the toxic nature of the used batteries (whether shredded or whole). Ex. 2004 at 2:0002 ("However, if electrolytic cells are damaged, chemical compounds with high environmental and health hazards can develop form the electrolyte in interaction with the electrodes, the housing, and/or ambient air."); *see id.* ("Similar hazards can emanate from aged

electrolytic cells."); Ex. 1016 at 33 ("Both the storage of damaged used batteries and the prolonged storage of undamaged used batteries are potentially associated with fire and explosion hazards."). Many countries and local governments had laws restricting the transport of these materials, in view of their toxic nature. Ex. 1016 at 21. Thus, there was a need to "inactivate" the batteries prior to transportation. Ex. 1016 at 33 ("The danger posed by defective batteries must be eliminated by suitable measures before transportation (deactivation).").

50. Many companies had experimented with techniques to inactivate spent or shredded batteries. These prior art techniques typically relied on adding foreign substances to the batteries as a way to neutralize their chemical hazards, such as using fire retardants, brines, pressurized fluids, etc. These prior art approaches include the following:

51. **Ecobat.** In 2007, Ecobat LLC filed for patent protection on a technique for safely handling shredded lithium-ion batteries. Ex. 2011. Ecobat focused on flushing the electrolyte out of the batteries using a pressurized solvent. *Id.* at 3:3-5. According to this invention, batteries are sealed in a high-pressure extraction container, which is then filled with an extraction fluid, such as CO_2. *Id.* at 5:41-45. Various additives are then added to the fluid to enhance extraction of electrolyte. *Id.* at 6:1-14. The pressure and temperature of the fluid are then increased until the battery casings are breached. *Id.* at 6:39-46. The fluid then

enters the breached cell and begins to dissolve the electrolyte. *Id.* at 7:10-15. Once the electrolyte is dissolved, the solution is moved to a precipitation vessel for further extraction of electrolyte components. *Id.* at 8:3-10.

52. **LiMotive.** In 2009, LiMotive Company Ltd. filed for patent protection on a method for safely preparing batteries for disposal. Ex. 2008 at 2:23-25. A true and correct copy of the LiMotive patent (in German) is attached hereto as Exhibit 2007. A certified English translation of the LiMotive patent is attached hereto as Exhibit 2008, upon which I rely for my opinions. LiMotive's technique teaches shredding the batteries in the presence of a metal flame retardant and one binding agent. Ex. 2008 at 3:6-8. According to the invention, lithium-ion batteries are shredded through a stream of high-pressurized water containing abrasive materials. *Id.* at 6:7-10. Adding water is used in conjunction with fire retardant agents to prevent, suppress, reduce, or extinguish fire during the shredding process. *Id.* at 3:6-20. Fire retardants are used to put out localized fires in order to prevent thermal runway (explosion). Ex. 2008 at 3:9-11. In view of the likelihood of HF formation, the method discloses sequestering the emerging HF with a binding agent (*i.e.*, calcium oxide (CaO), calcium chloride (CaCl), and/or calcium hydroxide ($Ca(OH)_2$). *Id.* at 3:11-15. Any hydrolyzed discharge from the shredding process is filtered off to remove the insoluble components of the discharge of the liquid

components during the shredding process. *Id.* at 12:11-13. The filtrate is then dried to reduce the weight of the filtrate before transport. *Id.* at 12:16-18.

53. **Electrocycling.** In 2009, Electrocycling GmbH filed for patent protection on a technique for processing batteries for transport. Ex. 2004. A true and correct copy of the Electrocycling patent (in German) is attached hereto as Exhibit 2003. A certified English translation of the Electrocycling patent is attached hereto as Exhibit 2004, upon which I rely for my opinions. The Electrocycling patent disclosed two alternative embodiments for deactivation of batteries: one by aqueous solution, another via a deactivating powder. Ex. 2004 at 5:0034-0035. According to the first embodiment of the invention, crushed lithium-ion battery cells fragments are filled into a plastic drum pre-filled with aqueous lithium hydroxide (LiOH) solution. *Id.* at 3:0017; 5:0034. In another embodiment of the invention, shredded cells are dusted with deactivation powder before they reach the collection drum. *Id.* at 3:0018; 3:0035.

54. **Hayashi**. In 2013, Hiroshi Hayashi, Koichiro Hirata, Hidenori Tsurumaki, and Hisashi Hoshina filed for patent protection on a method for processing fluorine-containing electrolyte solution in lithium-ion batteries. Ex. 2001. According to Hayashi's method, a whole battery is first depressurized and immersed in an oil heater for 2 hours. Ex. 2001 at 11:13-17. The organic components of the battery are then volatilized by heating the electrolyte past the

boiling point of the organic ingredients. Ex. 2001 at 4:38-45. Hayashi's method purposefully decomposes and gasifies lithium hexafluorophosphate to release the hydrogen fluoride gas. Ex. 2001 at 4:45-47. The method teaches adding water or mineral acids (such as sulfuric acid) to the electrolyte before heating to accelerate the gasification and the decomposition reactions. Ex. 2001 at 5:18-52. The released gasses are then captured and separated: the organic solvent components are recovered while the fluorine compound is immobilized as calcium fluoride. Ex. 2001 at 5:64-67.

55. **Dunagan**. In 2014, Dennis Dunagan and Teague Ostrander filed for patent protection for a system for recycling volatile battery sources. Ex. 2002. Dunagan's process teaches neutralization of comminuted lithium batteries in a neutralizing brine solution. Ex. 2002 at 5:4-11. The comminuted material must remain in the neutralizing brine for at least 24 to 48 hours, until the "chemical reactions are substantially neutralized." Ex. 2002 at 5:18-25; *id.* at 5:31-34. The wet comminuted material is then air dried before the second round of comminution. Ex. 2002 at 5:31-34; *id.* at 5:40-42. The second comminution step transforms the shredded batteries into a homogenous material, which allows workers to take a sample of the material to identify the potential value of the precious metal oxides in the material. Ex. 2002 at 5:63 – 6:5. The homogenous material is then transported to a processing plant for reclamation of battery components. Ex. 2002 at 5:63 – 6:5.

56. There was a drawback to using foreign substances to inactivate the batteries. Adding these additional compounds introduced further contaminants into the battery material, thus complicating the recycling process. *See* Ex. 1001 at 2:6-12 (teaching that avoiding the addition of foreign substances has great benefits because it "decreases the complexity of the battery processing, reduces the weight of the inactivated comminuted material and increases the purity in the subsequent separation and recycling steps"); *see also id.* ("In particular, in potential subsequent hydrometallurgical processing steps, a high degree of product purity that does not require the input of foreign ions is advantageous."). Additional hazards could result; for instance, treatment with aqueous solutions risks partial electrolysis, which could lead to the formation of hydrogen fluoride gas.

VI. THE ADVANCE OF THE '097 PATENT

57. The '097 patent describes an important advance for inactivating shredded batteries for transportation. Instead of introducing foreign substances to inactivate the shredded batteries, the '097 patent is directed to inactivating the shredded batteries by simply drying them under vacuum, particularly at a maximum pressure of 300 hPa. Ex. 1001. The method of the '097 patent avoids the use of high temperatures during the drying process as a way to avoid the formation of toxic gases, especially HF. Ex. 1001 at 2:5-12.

58. Through this process, the technique of the ’097 patent results in dried, shredded battery material, which is chemically inert and safe for storage and transport. Ex. 1001 at 1:63-2:4 (“The comminuted material is therefore largely inert and can be transported.”); *see also id.* at 4:5-7 (“The comminuted material is preferably dried until an electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible.”).

59. Once inactivated, the shredded battery material can be shipped to a centralized facility for additional processing steps, like decomposing the binder and harvesting the metal oxides from the support foils. *Id.* at 6:27-31.

60. The ’097 patent describes and claims methods and installations that provide a method for recovering spent battery material and rendering it safe for transport by inactivating the comminuted battery material using a vacuum drying process.

61. Claim 1 of the ’097 patent is as follows:

1. A method for the treatment of used batteries, comprising the steps:

(a) comminuting the batteries such that comminuted material is obtained;

(b) inactivating the comminuted material such that an inactivated comminuted material is obtained, wherein the inactivating step is performed during or after the comminuting step; and

(c) filling a transport container with the inactivated comminuted material;

wherein the inactivating step is performed by drying the comminuted material, and

wherein the drying occurs at a maximum pressure of 300 hPa.

Ex. 1001, 10:44-59.

62. Claim 12 of the ’097 patent is as follows:

12. A battery processing installation for treatment of used batteries, comprising:

(a) a comminution unit configured to comminute the batteries such that comminuted material is obtained;

(b) an inactivation device comprising a drying device configured to inactivate the comminuted material, wherein the inactivation device is configured to perform the inactivating step during or after the comminuting step of the comminution unit;

(c) a filling device configured to fill a test transport container with the inactivated comminuted material; and

(d) a vacuum installation connected to the drying device and configured to generate a vacuum in the drying device.

Ex. 1001 at 11:50-62.

63. The ’097 patent specification teaches how to obtain inactivated comminuted material suitable for safe transport. *Id.* at 1:64-2:12.

64. The ’097 patent teaches drying under low pressure, while avoiding high temperatures to avoid formation of HF. *Id.* at 3:7-9 (“It is beneficial if the drying occurs at a maximum pressure of 300 hPa, in particular a maximum of 100 hPa.”); *see id.* at 3:5-7 (“The size of the vacuum is preferably selected such that the vapour pressure of dimethyl carbonate at 80°C., especially at 70° C., is not reached.”).

VII. OVERVIEW OF ASSERTED PRIOR ART

A. LithoRec

65. *LithoRec – Recycling Lithium Ion Batteries* (“LithoRec”) is a report of a two-year study of EV battery recycling techniques by a group of researchers from TU Braunschweig, along with several EV industry partners (“LithoRec Partners”). Ex. 1016.

66. LithoRec arose from a project funded by the German government to consider better ways to recycle EV batteries. When the project began in about 2009, the EV battery recycling industry was in its infancy, as the market for electric vehicles was just beginning to emerge. There were very few EV batteries available to experiment with, in order to develop methods for their recycling. Ex. 1016 at 112 (“no materials from recycled batteries were available at the start of the project”); *see id.* at 2 (“Recycling of automotive lithium-ion (Li-ion) batteries is

more complicated and not yet established because few end-of-life batteries will need recycling for another decade.”).

67. LithoRec investigated fundamental questions about the feasibility of EV battery recycling, including economic and scientific considerations. Some of the areas of focus of LithoRec are the following:

- **Supply and demand**. The LithoRec Partners considered whether they could obtain an adequate number of batteries to be recycled, and whether there would ultimately be a demand for the recycled materials. Ex. 1016 at 21-23.
- **Storage and transport.** The LithoRec Partners investigated the concept of centralized versus decentralized end of life battery collection, with an eye toward compliance with the local regulations on hazardous chemicals. Ex. 1016 at 32-33.
- **Disassembly.** The LithoRec Partners considered how to discharge the batteries to strip off the casing materials before the cells could be recycled. Ex. 1016 at 1-2.
- **Separation of the metal foils from the active material**. The LithoRec Partners experimented with methods of removing the precious metal oxides from the collector foils – a precursor step to

hydrometallurgical recovery of valuable materials. Ex. 1016 at 101.

- **Hydrometallurgical processing**. The LithoRec Partners investigated whether they could use solvent-based (*i.e.*, hydrometallurgical) methods, as opposed to thermal (*i.e.*, pyrolytic) methods, for extracting the precious metal oxides from the foils. The researchers concluded that a hydrometallurgical process was a promising approach for recovering the metal oxides. Ex. 1016 at 110-124.
- **Synthesis of new electrodes from recycled materials**. The LithoRec Partners investigated whether they could synthesize new electrodes from metal oxides recovered through the hydrometallurgical process. They concluded that it would be possible to manufacture new electrodes from recycled materials. Ex. 1016 at 143-150.
- **Comparison of electrodes from recycled materials versus those manufactured from virgin materials**. The LithoRec Partners ran tests to determine whether electrodes made from recycled materials were as functional as those that were manufactured from virgin materials. They were satisfied that the electrodes manufactured

from the recycled materials were just as high performance (and in some instances more so). Ex. 1016 at 155.

68. After determining that a recycling program might be feasible, the LithoRec Partners contemplated how to build a pilot plant for extracting the metal oxides and other materials from spent batteries. Ex. 1016 at 222-236. This proposed pilot plant was hypothetical. The relevant section of LithoRec is entitled "Conceptual design of a recycling pilot plant." *Id*. at 222. The report states that "a possible recycling plant was conceptualized." *See id.* The authors were explicit that this would be a new and untested concept. *See id.* ("The entire facility is a new design, i.e., no existing facility is being converted or extended, but a completely new facility is being built on a greenfield site."). The authors offered only a sketch of a potential plant, not based on data. *See id.* at 226 ("As there is currently no reliable data on the substances contained in the battery cells that would allow drying to be reliably designed, only a rough estimate of drying can be made at this point."). The authors attempted to buttress their proposal by obtaining quotes from dryer manufacturers, but no company responded to their requests. *Id*. ("The manufacturers of drying systems could not be persuaded to submit an offer under the given circumstances.").

69. The study states that the most appropriate drying apparatus to be used is a vibratory fluidized bed dryer. *Id.* at 227. A vibratory fluidized bed dryer is a

thermal processing apparatus that utilizes high-velocity heated gas, typically air or nitrogen, to simultaneously agitate and dry the materials, described below.

70. LithoRec explains that a vibratory fluidized bed dryer is used in order to impart "mechanical stress" on the dried material. *Id*. at 227. LithoRec states that a flow of gas (nitrogen) is needed to "ensure material transport by exciting the flow bottom." *Id*. That is, the gaseous flow is used to agitate the material, which "will also contribute to further rubbing of the active material [the precious metals] from the films." *Id*. A person of skill in the art would have understood LithoRec to be describing a flow of gas to drive this agitation and convective heat transfer and the consequent drying of the shredded material.

71. LithoRec references a table of recommended equipment, specifically Table G-7, Row 3.08, under the heading "Drying System." Ex. 1016 at 235. The specified system is characterized by the following parameters: "2000 m^3/h; incl. pulse jet filter, blower, and condenser; explosion-proof incl. pressure relief devices." *Id.* These components, described below, are consistent with LithoRec's recommendation to use a vibratory fluidized bed dryer.

72. The figure "2000 m^3/h" specifies the volume of air that is moved or circulated by a device (such as a fan, blower, or ventilation system) per hour. *Id.* This measurement is typically used to indicate the efficiency and capacity of the system in providing adequate ventilation, cooling, or air circulation in a given

space. An air flow rate of 2000 m^3/h in a vibratory fluidized bed dryer would ensure effective fluidization, efficient heat transfer, and continuous removal of moisture from the drying of the material.

73. The "pulse jet filter" is a type of dust collector that removes fine particulate matter from the air stream. As the drying process involves the evaporation of moisture, particles can become airborne. The pulse jet filter captures these particles, preventing them from escaping into the environment. It ensures that the air leaving the dryer is clean, which is important for maintaining air quality and complying with environmental regulations. It also helps in recycling the filtered air back into the system, improving energy efficiency.

74. The "blower" is responsible for generating the air flow required to fluidize the particles in the bed. It provides the necessary air flow rate (*e.g.*, 2000 m^3/h) to lift and suspend the particles, ensuring uniform drying and heat transfer. The blower maintains continuous air circulation, which is vital for the drying process. This blower facilitates the movement of the air and directs air flow into the dryer. The schematic diagram G-1 on page 230 in LithoRec does not show the location and/or the presence of the "blower."

75. The "condenser" cools the gas stream leaving the dryer, causing the solvent vapors to condense into liquid form. By condensing the evaporated solvents from the gas stream, the condenser prevents the buildup of solvents and any

potential moisture in the drying chamber, which could otherwise reduce drying efficiency. It also allows for the recovery and potential reuse of the condensed vapors, which can be an important aspect of resource management in industrial processes. Additionally, removing solvents and any potential moisture from the gas stream helps maintain a consistent drying environment and prevents re-absorption of vapors by the dried particles.

76. I understand the "explosion-proof" notation refers to the overall design. Generally, by using materials and construction methods that can withstand explosions, the design ensures that the dryer can safely handle potentially explosive materials or conditions. This is particularly important in industrial processes where flammable solvents or dust may be present. The explosion-proof design helps in maintaining the safety of both the equipment and the operators.

77. The "pressure relief devices," such as rupture discs or relief valves, are safety mechanisms that release excess pressure from the system. In the event of abnormal pressure increases, the pressure relief devices activate to release the excess pressure safely, thereby protecting the integrity of the dryer and preventing catastrophic failures. A person of skill in the art would understand that pressure relief devices are used to ensure that the pressure in a system does not exceed a threshold and is generally used to regulate high pressure systems. If a pressure in a

system exceeds a threshold, then the valve of the pressure relief device would open to expel the excess pressure.

B. Perry

78. Perry's Chemical Engineers' Handbook is a reference book. Ex. 1006 at. The section of Perry cited in the Petition is entitled "*Batch Through-Circulation Dryers*." Ex. 1006 at 12-44. This section is dedicated to batch drying. This section of Perry does not discuss continuous drying systems.

79. Within this context, Perry distinguishes between two categories of through-circulation batch dryers.

80. Perry describes a category of batch dryer in which "heated air passes through a stationary permeable bed of wet material placed on removable screen-bottom trays suitably supported in the dryer." Ex. 1006 at 12-44. Perry describes various shelving arrangements in such a "hot-air-circulating system." Perry describes that these systems are suitable for "food-drying plants," for example. *Id.* Table 12-11 of Perry describes parameters for drying three categories of materials: granular polymer, vegetable, and vegetable seeds. *Id*. at 12-45.

81. By contrast, Perry provides a separate section directed to vacuum-shelf dryers. Perry describes these as "indirect-heated batch dryers consisting of a vacuum-tight chamber usually constructed of cast iron or steel plate, heated, supporting shelves within the chamber, a vacuum source, and usually a condenser."

Id. Perry explains that the "material to be dried is placed in pans or trays on the heated shelves." *Id.* Perry states that vacuum shelf dryers are "used extensively for drying pharmaceuticals, temperature-sensitive or easily-oxidized materials, and materials so valuable that labor cost is insignificant." Ex. 1006 at 12-44. Perry further explains that vacuum shelf dryers are useful for handling "small batches" of materials wet with toxic solvents. *Id.* Perry mentions "semiconductor parts" as another example of a material suitable for vacuum shelf drying.

82. Perry does not address application of the systems found in the cited section to EV battery recycling. Perry does not discuss evaporating the kind of solvents addressed in LithoRec. Perry does not discuss the use of vibratory fluidized bed dryers that use blowers to agitate battery material. The portion of Perry relied upon by Petitioner does not discuss the continuous processes recommended by LithoRec.

C. DIN 28400

83. DIN 28400 is a German glossary of terms related to vacuum technology. Ex. 1018. DIN 28400 lists the different ranges of vacuum pressures, from low to ultra-high vacuum. Ex. 1018 at 1 DIN 28400 Part 1, Section 1.

84. The section of DIN 28400 relied upon in the Petition is Section 1, entitled "*Fundamental Concepts, vacuum ranges and units*." *See* Pet. at 25; Ex. 1018 at 1 DIN 28400 Part 1, Section 1.

85. Specifically, the cited Section 1.1, entitled "*Vacuum*," states:

> Vacuum refers to the state of gas when the pressure of the gas, and thus the number density of molecules, in a container is lower than outside, or when the pressure of the gas is lower than 300 mbar, i.e., lower than the lowest atmospheric pressure on the Earth's surface. Note: the correlation between pressure p and number density of molecules n *is*
>
> $p = nkT$ (strictly speaking, this formula is only valid for ideal gases)
>
> k = *Boltzmann constant*
>
> T = *thermodynamic temperature.*

See id.

86. The parameters set forth in Section 1.1 are the basis of the table on the same page of DIN 28400, *i.e.*, "Table 1. Ranges of vacuum." Ex. 1018 at 1 DIN 28400 Part 1, Section 1, Table 1. Section 1.3 uses the formula provided in Section 1.1 *(i.e.*, $p = nkT$) to calculate vacuum ranges/ranges of pressures at t = 20°C.[1] Ex. 1018 at 1 DIN 28400 Part 1, Section 1.3. Section 1.3 provides:

> Ranges of vacuum are ranges of pressure or number densities of molecules into which the vacuum is subdivided according to convention. The rounded limits of these ranges are listed in Table 1 in pressures or equivalent number density of molecules. The stated number densities of molecules apply for a temperature of t = 20°C.

See id.

[1] This temperature is considered "room temperature."

87. The pressure ranges in Table 1 (below) are subdivided into rough (low), medium, high, and ultra-high vacuum pressures at t = 20°C. Ex. 1018 at 1 DIN 28400 Part 1, Section 1, Table 1.

Table 1. **Ranges of vacuum**

Symbol	Unit	Rough (low) vacuum	Medium vacuum	High vacuum HV	Ultra-high vacuum UHV
p	Pa	$1 \cdot 10^{5}$ to $1 \cdot 10^{2}$	$1 \cdot 10^{2}$ to $1 \cdot 10^{-1}$	$1 \cdot 10^{-1}$ to $1 \cdot 10^{-5}$	$< 1 \cdot 10^{-5}$
p	mbar	$1 \cdot 10^{3}$ to 1	1 to $1 \cdot 10^{-3}$	$1 \cdot 10^{-3}$ to $1 \cdot 10^{-7}$	$< 1 \cdot 10^{-7}$
n	m^{-3}	$2.5 \cdot 10^{25}$ to $2.5 \cdot 10^{22}$	$2.5 \cdot 10^{22}$ to $2.5 \cdot 10^{19}$	$2.5 \cdot 10^{19}$ to $2.5 \cdot 10^{15}$	$< 2.5 \cdot 10^{15}$

88. According to Table 1 above, in millibar units, rough/low vacuum ranges from 1000 to 1 millibars; medium vacuum ranges from 1 to 0.0001 millibars; high vacuum ranges from 0.0001 to 0.0000001 millibars; and ultra-high vacuum range falls below 0.0000001 millibars. *Id.*

89. DIN 28400 does not provide specific guidance for vacuum level selection in any particular application (let alone in the context of electric vehicle battery recycling processes). A person of skill in the art reviewing DIN 28400 would have no guidance to as to how to determine the appropriate level of vacuum for a particular application, such as EV battery recycling.

VIII. GROUND 1: ANALYSIS OF LITHOREC AND THE COMBINATION OF LITHOREC WITH DIN 28400 AND PERRY

90. I understand that Petitioner contends that claims 1-3, 7-8, and 10 of the ’097 patent would have been obvious over LithoRec in view of DIN 28400 and

Perry (Ground 1). I disagree that these prior art references, viewed in combination, would have rendered the challenged claims obvious.

A. LithoRec does not teach the claim steps of "inactivating the comminuted material such that an inactivated comminuted material is obtained" and "wherein the inactivating step is performed by drying the comminuted material, and wherein the drying occurs at a maximum pressure of 300 hPa"

91. Petitioner and its expert, Volker Spies, assert that LithoRec teaches inactivating comminuted material by vacuum drying. *See* Pet. at 24-28; *see also* Ex. 1003 at ¶¶95-101. I disagree. As set forth below, it is my opinion that LithoRec does not teach the limitations of Independent Claim 1 of the '097 patent of: "inactivating the comminuted material such that an inactivated comminuted material is obtained" and "wherein the inactivating step is performed by drying the comminuted material, and wherein the drying occurs at a maximum pressure of 300 hPa."

92. Petitioner does not contend that LithoRec teaches vacuum drying at 300 hPa. *See* Pet. at 37 ("LithoRec does not explicitly teach a specific vacuum pressure to be used."). There is no discussion in LithoRec about drying comminuted material at 300 hPa.

93. Moreover, it is my opinion that LithoRec does not provide a disclosure of vacuum drying for inactivating comminuted batteries that would have allowed a person of skill in the art in 2015 to practice the invention of the '097

patent. The point of the LithoRec publication was to provide a framework for harvesting and shredding batteries so they could further undergo hydrometallurgical processing in order to fabricate new electrodes. Ex. 1016 at 226 ("The electrolytes need to be evaporated for the subsequent dry treatment processes, which are primarily aimed at extracting the active mass."). LithoRec does not identify the goal of inactivating the shredded battery material for safe transport. The discussion regarding drying is cursory, internally contradictory, and incomplete, and it would have been insufficient to enable a skilled person to perform the drying claimed in the '097 patent.

94. There is a statement in LithoRec suggesting the use of vacuum drying. The report states: "As some of the liquids to be vaporized are highly flammable solvents, the drying temperature should probably be severely restricted. This in turn speaks in favor of drying under vacuum, as the drying temperature can be kept low." Ex. 1016 at 226. LithoRec does not say what device would be suitable for vacuum drying, as acknowledged by Petitioner. *See* Pet. at 47 ("LithoRec is silent regarding the device that produces the vacuum for the dryer."). This statement of the goal of using vacuum drying is not supported by the conceptual discussion of the pilot plant in LithoRec, which is inconsistent with the use of vacuum drying.

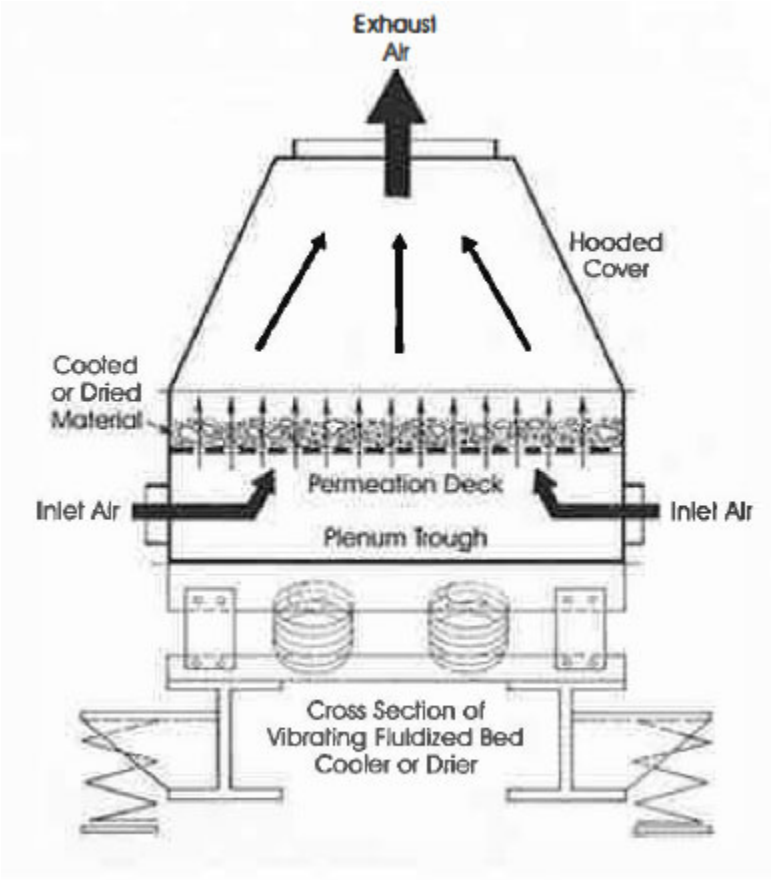
1. LithoRec teaches the use of a vibratory fluidized bed dryer, which is counter to drying at 300 hPa

95. LithoRec expressly recommends the use of a vibratory fluidized bed dryer. Ex. 1016 at 227. Attached as Exhibit 2012 is a brochure from Kinergy Corporation ("Kinergy Brochure") entitled "*Transferring Heat with a Vibrating Fluidized Bed*," which describes and illustrates fluidized bed dryers. *See* Ex. 2012. I have confirmed that this brochure was available through the Kinergy Corporation website at least as early as October 15, 2013, by viewing the capture of the document made by the Wayback Machine internet archive. The Kinergy Brochure describes that vibratory fluidized bed dryers depend on the flow of gas to agitate the material to be dried:

> A vibratory conveying action reduces "inter-particle" friction. Consequently, the material tends to reflect the characteristics of a fluid as it is gently "induced" to move. Add air that is simultaneously forced up through the openings in the conveying surface so that it permeates through the mat depth of material. The result is a vibrating "fluidized" bed of dynamically active particles that can efficiently exchange heat energy. The reason is the intimate contact the air makes with their individual surfaces. Therefore, the incoming air can cool or heat the conveyed bulk solid (or unit pieces) by convection on a "continuous" basis. Further, heating and then cooling can be accomplished in the same unit when it is needed.

Ex. 2012 at 1.

96. Below is a depiction of a fluidized bed dryer from the Kinergy Brochure, showing that gas enters below the deck containing the materials to be dried. The gas is blown up through the materials, facilitating the drying:



Id. at 1.

97. Using a vacuum would be at cross-purposes with the use of a vibratory fluidized bed dryer. The Kinergy Brochure confirms that fluidized bed dryers typically operate at atmospheric pressure. Ex. 2012 at 1 ("Thermodynamically, it is a constant heat process which makes it adiabatic, and it typically occurs at atmospheric pressure."). A large amount of air is required to agitate the material and to dry it. *Id.* at 2 ("During this step, a large amount of air is

required and exhausted to carry away the resulting vapor."). That is, the gas molecules themselves are an active agent in the vibratory fluidized bed dryer. If the gas molecules were to be evacuated in order to create a vacuum, then the agitative force and the convective heat transfer capacity of the gas would be weakened.

98. Table G-7 confirms that the drying system contains a blower, which I understand would provide the forceful flow of gas for the vibratory fluidized bed dryer. The blower is needed to force a stream of gas up through the material, to suspend the material and dry it. Ex. 2012 at 1 ("Add air that is simultaneously forced up openings in the conveying surface so it permeates through the mat depth of material. The result is a vibrating 'fluidized' bed of dynamically active particles that can efficiently exchange heat energy."). A blower creates a positive pressure that blows upwards through the drying bed. Ex. 2012 at 1. Here, the material in question consists of shredded chunks of batteries, which are dense and may be sizable. Even accounting for the vibratory functionality of the proposed fluidized bed dryer, a forceful stream of gas would be necessary to suspend and dry the shredded battery material.

99. It would not work to operate the fluidized bed dryer under vacuum. The entire purpose of the fluidized bed dryer is to force the shredded chunks up, to agitate them, and use the convective heat capacity of the gas to evaporate the

solvents. This functionality could not occur at 300 hPa. *See* Ex. 2012 at 1 ("[fluidized bed drying] typically occurs at atmospheric pressure.").

99.1. In its Institution Decision, the Board raised the issue of whether LithoRec more expansively disclosed the use of convention dryers. *See* Institution Decision at 11 (citing Ex. 1016 at 226). However, the reference in LithoRec to "convection dryers" does not change the analysis. Convection dryers are simply a broader category of dryers that operate with airflow being a driving force to make the drying process work. Vibratory fluidized bed dryers are simply one kind of convection dryers. And in singling out a vibratory fluidized bed dryer as the preferred instrumentality for drying, the LithoRec authors were identifying the key features they saw as desirable to carry out the goals of the proposed plant.

99.2 The fact that convection dryers are simply the broad category of airflow-driven dryers is confirmed by industry literature. Attached as Exhibit 2026 is a webpage from SINOTHERMO, which describes convection dryers, and explains that: "These dryers are used to remove moisture from materials by using hot air or gases, which circulate around the material." *Id.* Although the SINOTHERMO webpage is a present-day publication, it accurately reflects the way these devices operated in the 2015-time period – these devices have remained fundamentally the same for decades. The SINOTHERMO webpage describes various types of convection dryers, "including Belt Dryers, Tray Dryers, Rotary

Kilns, Flash Dryers, Spray Dryers, Vibrating Dryers, and Fluidized Bed Dryers." *Id.* Thus, fluidized bed dryers (and vibratory fluidized bed dryers) are simply a kind of convection dryer. These convention dryers all operate in reliance on a steady flow of air to drive the drying process.

99.3. The SINOTHERMO website confirms that convection dryers are distinct from vacuum dryers. Under "Products," SINOTHERMO lists their various kinds of drying apparatuses:

SINOTHERMO PROCESS ENGINEERING INFRASTRUCTURE | Home | Products | Application | Services | SINOTHERMO WORLD

Conduction and Vacuum Dryer

Rake Dryer
Paddle Dryer
Vacuum Tray Dryer
Vertical Plate Dryer
Drum Scraper Dryer
Rotary Vacuum Dryer
Horizontal Disc Dryer
Ribbon Screw Vacuum Dryer

Convection Dryer

Belt Dryer
Tray Dryer
Rotary Kiln
Flash Dryer
Spray Dryer
Vibrating Dryer
Fluidized Bed Dryer

Granulator and Extruder

Dry Granulator
Basket Granulator
Fluid Bed Granulator
Oscillating Granulator
Wet Mixing Granulator
Screw Compression Granulator

Mixer

Screw Mixer
Conical Mixer
Rotary Mixer
Ribbon Blender
Horizontal Mixer
High Speed Mixer

Ex. 2026. Expressly, SINOTHERMO distinguishes between its convection dryer products and its vacuum dryer products. Separate and apart from its convection dryers, SINOTHERMO describes its "Ribbon Screw Vacuum Dryer," explaining that: "This dryer is perfect for operating under low temperature vacuum conditions making it suitable, for handling explosive and heat sensitive materials."

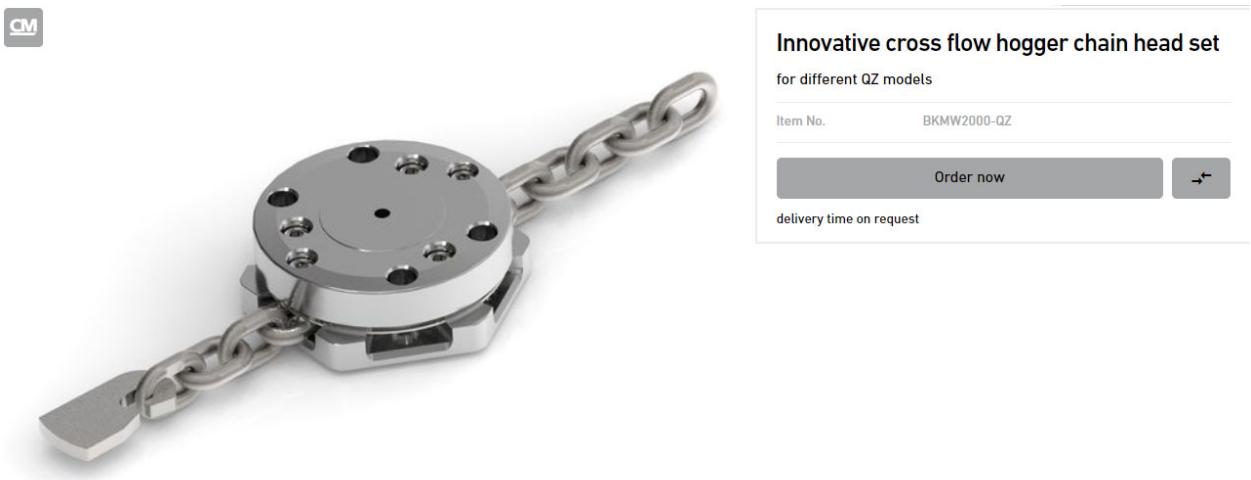
Thus, this supplier of drying instrumentalities expressly distinguishes between convection dryers and vacuum dryers. They are fundamentally different devices, operating on different principles. Whereas convection dryers operate with the need for airflow to drive the drying process, vacuum dryers operate under the principle of low pressure to drive evaporation. The SINOTHERMO webpage accurately describes how a POSITA in the 2015 time frame would have understood the difference between convection dryers and vacuum dryers.

2. Cross-flow hoggers operate at atmospheric pressure

100. In the LithoRec proposed design, the nitrogen circuit is connected to a "Cross-flow hogger." Ex. 1016 at 230. The corresponding component in the original German version is "Querstromzerspaner" which is abbreviated "QZ" and discussed as such in the LithoRec text. Ex. 1004 at 265 (German); Ex. 1016 at 227 (English). LithoRec specifically recommends use of the "QZ 1200 depressurized" unit from MEWA. Ex. 1016 at 235. Attached hereto as Exhibit 2013 is the German language manual from MEWA for the QZ 1200 cross-flow hogger, dated 2009. Attached hereto as Exhibit 2014 is a certified English language translation, on which I rely for my opinions. Ex. 2014.

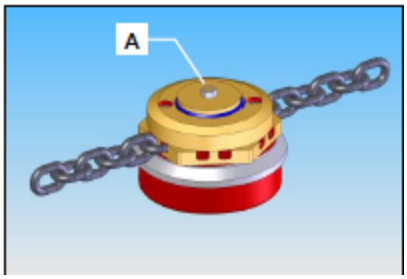
101. A cross-flow hogger is a device that smashes materials (like EV batteries) into pieces. The device includes a rotating hammer that circulates to

smash the items. A representative image of a cross-flow hogger chain head set is shown below:



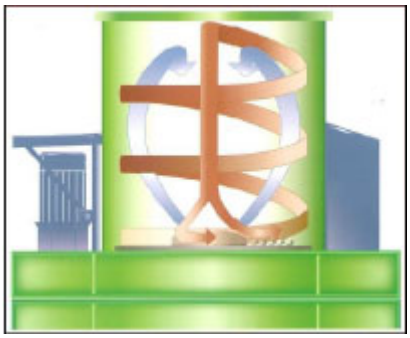
Ex. 2016 (https://www.cutmetall.com/us/innovative-cross-flow-hogger-chain-head-set-p47892/) (last visited on August 17, 2024)

102. Following is the image of the rotary mechanism from the 2009 MEWA brochure (which shows the chains, but not the hammers):



Ex. 2014 at 81.

103. The device is called a "cross-flow" hogger because of the tortuous path the incoming material takes as it gets shredded, as shown in the picture below:



Ex. 2014 at 34.

104. As the hammer whirls around and smashes the material, a tremendous amount of heat is generated. The cooling is done by not only by the circulating air, but also by using a water jacket around the machine. Ex. 2014 at 36. A stream of gas will separate away smaller particulates, while the bigger chunks fall down into subsequent processing steps. This separation functionality is shown in LithoRec Figure G-1, with a dotted line going from the cross-flow hogger to the Jet filter, representing the removal of dust generated by the hammering. Ex. 1016 at 230.

105. Table G-7 of LithoRec refers to the MEWA device as the "QZ 1200 depressurized." Ex. 1016 at 235. The "QZ 1200" refers to the size of the unit. A person of skill would understand that the mention of "depressurized" refers to the ability to depressurize the system as the pressure inside the system increases above acceptable levels. An option is to run the system under an inert atmosphere filled with nitrogen gas. Ex. 2014 at 52 (noting a "gas tight enclosure" when the device is "equipped with inert gas system"). When using an inert atmosphere within the

system, the pressure can rise due to the evaporation of solvents from the heat generated when the battery materials are being crushed. LithoRec specifies the need for a "depressurized" system, which I understand would allow these solvent vapors to be carried away when the pressure exceeds a preset threshold. Ex. 1016 at 235. This confirms beyond any doubt that that the system is not operating under vacuum. You would not have to depressurize the system if it was working below atmospheric pressure.

106. The word "vacuum" only appears in the QZ 1200 manual to refer to occasional cleaning of the unit with a "vacuum cleaner." Ex. 2014 at 47, 61, 63 & 64.

107. Cross-flow hoggers typically run at atmospheric pressure. Even at atmospheric pressure, caution must be taken to avoid overheating. These machines cannot be run in a vacuum, because the convective heat capacity of gas at atmospheric pressure (in addition to a water jacket) is needed to cool the system. Indeed, the QZ 1200 manual explains that one feature of the system is the ability to run it under an inert atmosphere filled with nitrogen, and that a "fault" will arise if the nitrogen pressure is too low. Ex. 2014 at 52 (noting the cause of a fault: "Leakage in the gas-tight enclosure. Insufficient nitrogen **inertization** (tank pressure dropped?).").

108. A robust gas flow is needed to carry away the dust. Ex. 1016 at 230 (dotted line going from cross-flow hogger to Jet filter). If there were a vacuum, the cross-flow hogger would overheat, and the dust would not get carried away. If the machine were to overheat, the hammers would ultimately get annealed (*i.e.*, softened) and lose their ability to shred the incoming feedstock.

108.1 In its Institution Decision, the Board noted LithoRec's reference to "rotor shredders." Institution Decision at 11, citing Ex. 1016 at 226. The Board questioned whether LithoRec's reference to "rotor shredders" might suggest the use of a vacuum system. *Id*. It does not. Attached as Exhibit 2027 is a brochure from a rotor shredder (V-ECO Series Rotary Shredders by Vecoplan). Though this brochure is current, the same information would have been known to a person of skill in the art in 2015. This brochure depicts the rotors that contain rows of knives that are used to shred materials. *Id.* at 2, 4. The brochure notes that there is an option for a "rotor cooling" design, which circulates chilled water through the rotors. *Id.* at 4. This confirms concerns about overheating. Indeed, there is not a mention of "vacuum" in this detailed brochure. In my experiences I have worked with about ten rotor shredders, and none of them were under vacuum. Thus, it is my opinion that the mention of "rotor shredders" in LithoRec does nothing to change the analysis. And it is on a common nitrogen line with the dryer, confirming that the dryer is likewise not run under vacuum. For

completeness, two other brochures of shredders are attached as Exhibits 2028 and 2029. These "shaft shredders" likewise do not operate under vacuum. Exh. 2028 & 2029.

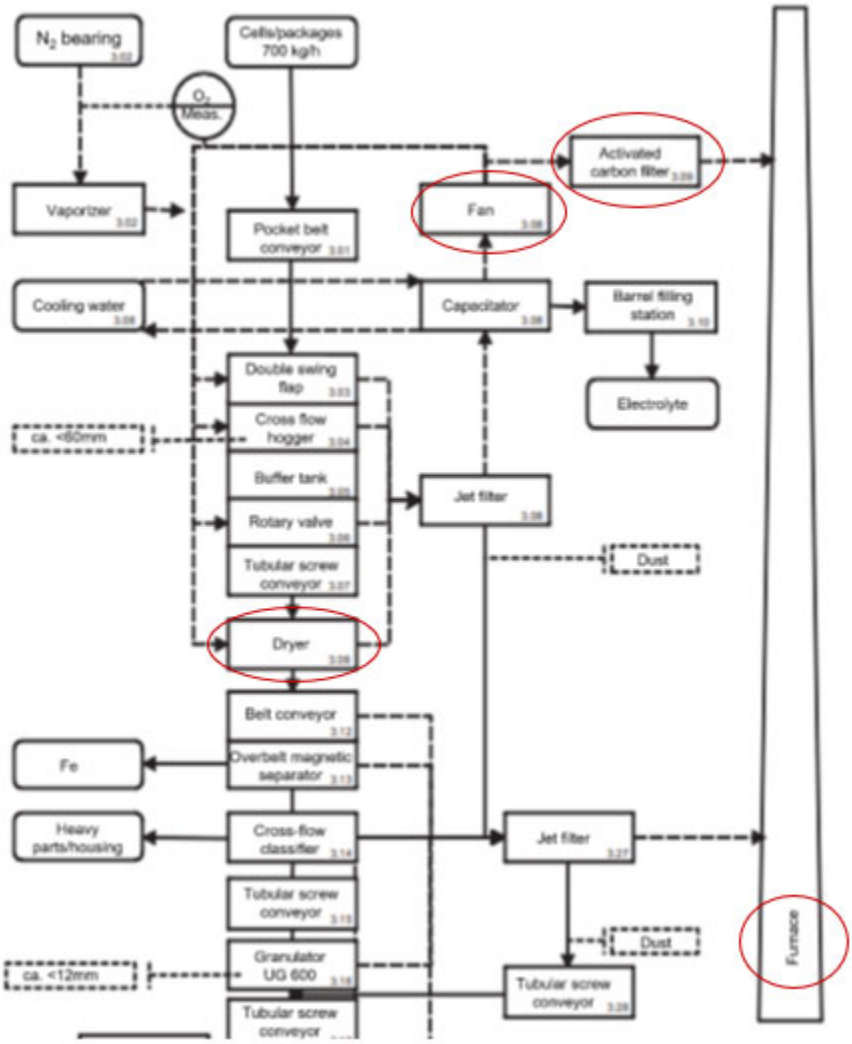
3. The schematic in LithoRec and supporting discussions confirms there is no vacuum pump

109. LithoRec includes a schematic of the proposed system, "Figure G-1: Mechanical treatment process flow chart." Ex. 1016 at 230. This flow chart depicts a "Fan." Ex. 1016 at 230. The original German version labels the corresponding box as "Ventilator." Ex. 1004 at 265. I have spoken with Mr. Til Bussmann of Duesenfeld, and he confirms that a "Ventilator" in German means the same as in English. In English or German, a ventilator is a system for circulating air, typically driven by a fan. Notably, the authors of LithoRec did not use the term "vacuum pump" (or its German translation, "Vakuumpumpe"). A person of skill in the art would understand that, while a fan can create a pressure differential, it is weaker than a vacuum pump. In a closed circuit, a fan simply directs/guides the flow of gas.

110. LithoRec specifies the air flow rate of the system, which is 2000 m^3/hr. Ex. 1016 at 235, Table G-7. This figure is consistent with the disclosure of a fan, because fans are specified in terms of the volume of air that they move per unit of time. A person of skill in the art would expect that, if a vacuum pump were

intended to be in a system, it would be specified in terms of the lowest pressure (*e.g.*, in units of mbar or hPa) that the vacuum pump can maintain within a specific enclosure. There is no such pressure disclosed, which confirms that the LithoRec system is not intended to have a vacuum pump. Hence the description and depiction are internally conflicting, contradicting, and confusing.

111. As depicted in Figure G-1 (cropped and annotated image shown below), the output flow from the fan is divided. Some of the nitrogen stream returns to the shredder and the dryer. Additionally, some of the output of the fan is discharged through an "activated carbon filter," to remove dust and capture any remaining electrolyte vapors from the system. Ex. 1016 at 230. The output of the activated carbon filter is directed to a "Furnace," which looks like a furnace exhaust flue or chimney. *Id.* A person of skill would understand that the furnace vents to the atmosphere. This is confirmed by LithoRec itself. Ex. 1016 at 227 ("In order to ensure the negative pressure in the gas circuit at all times, a partial quantity of gas must be discharged from the system into the environment. Due to the solvent residues it contains, the discharged gas must be cleaned using an activated carbon filter (3.09) before it can be released into the atmosphere.").



Ex. 1016 at 230 (Figure G-1) (cropped and annotated).

112. Thus, while LithoRec states that the "dryer gases are circulated in a closed circuit and cleaned using a filter and condenser," it is not a fully closed circuit. Ex. 1016 at 227. It is partially open to the atmosphere. Because it vents to the outside, the output of the fan depicted in Figure G-1 would be approximately at atmospheric pressure. As drawn, the entire dashed line representing the nitrogen

circuit would be at approximately atmospheric pressure, with combination of blower(s) and fan(s) simply directing the flow of gases and dust.

113. LithoRec says that the system is operated at a "negative pressure." This language is consistent with the use of a fan, as depicted in Figure G-1. A person of ordinary skill would understand this to refer to a modest pressure differential between the system and the ambient atmosphere, as driven by a fan, in order to circulate the nitrogen gas. A negative pressure is useful for workplace safety reasons, so that hazardous chemicals do not leak out into the workplace (if there is a leak, external air is pulled into the system, rather than hazardous chemicals getting pushed out into the factory). A pressure differential of a few Pascals (*i.e.*, between 2.5 - 8 Pa) would be sufficient to keep the dust and other chemicals in the system. Attached hereto as Exhibit 2017 is a standard established by a UK company, Commercial Air Filtration, saying that a 2.5 Pa pressure differential is the minimum required to maintain negative pressure within an enclosure and prevent contaminants from leaving an enclosure. *See* Ex. 2017 at 2 ("The pressure differential should be greater than 2.5 Pa."). This pressure of 2.5 Pa is the same as 0.025 hPa (*i.e.*, far less than a single hPa).

114. Generating a higher negative pressure would be counterproductive, first because a more expensive system would be needed, but more fundamentally because the system described in LithoRec would need to operate at about

atmospheric pressure. As explained above, both the vibratory fluidized bed dryer and the cross flow hogger need a robust airflow, typically at atmospheric pressure. These devices simply would not work in a vacuum.

4. LithoRec teaches the use of a continuous process, which is at odds with vacuum drying at a maximum pressure of 300 hPa and with inactivating the shredded material

115. LithoRec is explicit that the drying should be performed under a continuous process, rather than a batch process. The authors state that they contemplated whether a batch process could be used. *Id.* at 226 ("There is also a question of whether drying should take place in batch or continuously."). The authors rejected the batch approach in favor of continuous drying. *Id.* at 226 (noting that the necessary process steps of a discontinuously operating dryer would require a longer work cycling, and concluding "[f]or this reason, batch drying is not used.").

115.1 A POSITA would recognize the benefit of operating the proposed system as a continuous process, rather than as a batch process. Shredded battery material is toxic, and potentially hazardous. It would have been advantageous to use a continuous system to avoid the accumulation of shredded battery material, to avoid fires, explosions, and the production of toxic by-products like hydrogen fluoride gas. By adopting a continuous process, shredded material could be immediately subject to the low-temperature pre-dryer and the pyrolytic furnace, to

most promptly remove the hazard. In a batch process, by contrast, shredded battery material would accumulate until enough material is shredded to make up a batch, which would pose chemical hazards.

116. Vibratory fluidized bed drying is compatible with a continuous drying system. The Kinergy Brochure describes that fluidized bed drying is typically done in a continuous process, whereas vacuum drying is often done as a batch process. Ex. 2012 ("A vibrating fluidized bed has the advantage of providing 'continuous' drying. It is second in thermal efficiency to only a vacuum type dryer which often is a batch type operation.").

117. In my professional experience, vacuum drying is always done with a batch system, not a continuous system. In the manufacturing facilities and processes I worked with, the main objective of vacuum dryers is not to contaminate the material being dried, partially dried and ready to be discharged with fresh raw material that needs to be dried. Once the dryer is filled with a load of the material to be dried, it is sealed (to maintain the vacuum levels as it is connected to a vacuum pump), the temperature levels will be elevated to the required drying temperatures, maintained at those levels and the drying process will commence and continue for a specified time period until the material in the dryer reaches the specified level of dryness – at which point the material can be discharged and the container is ready to be filled with a fresh load of material to be dried. I have listed

four of my personal experiences of batch vacuum drying of shredded Lithium ion battery materials in Exhibit 2035 (Confidential **Appendix C)**.

118. LithoRec does not address the complications that would result from attempting to conduct vacuum drying in the context of a continuous process. In batch drying, the process controls can be governed to ensure that a vacuum is properly maintained throughout the process, and that the materials are fully dried (i.e., inactivated) by the end of the process. By contrast, in a continuous process, there are new materials continually entering the system, which requires that flaps be opened to allow entry to the new materials. Ex. 1016 at 227. When these flaps are opened, the vacuum weakens. Although there are air lock systems to try to prevent the loss of vacuum, in reality these systems are highly limited and leaky, and not well suited for maintaining vacuum. *See* Ex. 2030 ("An improperly designed and applied rotary airlock valve can lead to poor efficiency, extra maintenance and operator manpower, low yields of product, equipment wear and replacement, and lost production due to process shutdowns.") (describing problem of leakage through rotary airlocks, and studying leakage as a function of various parameters).

119. Furthermore, with new material continually entering the system, amid the agitation provided by the vibratory fluidized bed dryer, there would be a mix of freshly-introduced material and material that has already been in the dryer for some time. Depending on the degree of fluidization in the bed, the newly-entered

materials may tumble together with the materials that had been in the dryer already. It would be difficult to design this system such that material exiting the dryer is fully inactivated for subsequent safe for transport.

120. A particular complication is that the shredded batteries typically have a mix of solvents, with some having a lower boiling point than others. For example, dimethyl carbonate boils at 90°C at atmospheric pressure, and ethyl methyl carbonate boils at about 107°C at atmospheric pressure. Exs. 2032 & 2033. And as freshly-entering battery material enters the vibratory fluidized bed dryer (or other convection oven), there is a risk that the newly-entering material will preferentially evaporate, and that the partially-dried material (and especially the solvents with higher boiling points) will not be fully inactivated. LithoRec does not disclose any mechanism for ensuring that the material exiting the dryer would be fully dry (*i.e.*, inactivated).

121. LithoRec does not teach the operating temperature for the proposed drying system. *See* Pet. at 37. Nor does LithoRec specify pressure ranges to use.

122. LithoRec does not state a goal of rendering the materials safe for transport. Rather, it appears that the goal of LithoRec was to sufficiently dry the materials that some quantity of electrolyte solvents could be captured, and then the resulting black mass could be recycled through hydrometallurgical processing to isolate out the precious metals. Ex. 1016 at 226. The continuous process outlined

in LithoRec might be sufficient for preparing the black mass for hydrometallurgical processing; however, LithoRec's prescription for continuous processing works against the ability to determine that the materials would be sufficiently inactivated to be safe for transport. LithoRec does not back up its assumption that the drying operation, as proposed, "eliminates the potential hazard of flammable substances." Ex. 1016 at 226.

123. Thus, it is my opinion that LithoRec does not teach the limitations of Claim 1 of the '097 patent of: "inactivating the comminuted material such that an inactivated comminuted material is obtained" and "wherein the inactivating step is performed by drying the comminuted material, and wherein the drying occurs at a maximum pressure of 300 hPa."

B. I disagree that LithoRec with Perry or DIN 28400 would be combined to teach the vacuum drying limitations

124. I understand that that Petitioner is attempting to combine LithoRec with Perry and DIN 28400 in order to argue that these prior art references, in combination, would have rendered the challenged claims of Ground 1 obvious. I disagree.

1. A person of skill would not have combined LithoRec with Perry

125. A person of ordinary skill in the art would not have combined LithoRec with Perry and DIN 28400. And even under this proposed combination, the challenged claims in Ground 1 would not have been obvious.

126. A person of skill would not have combined LithoRec with Perry. Perry is expressly directed to discussion of batch drying processes. Ex. 1006 at 12-44 (header entitled "*Batch Through-Circulation Dryers*"). LithoRec expressly counsels against using batch processing. Ex. 1016 at 226 (explaining that a discontinuously operating dryer require[s] a longer work cycle in total than the pre-shredder, and thus "batch drying is not used").

127. Batch drying, as taught by Perry, is fundamentally incompatible with the continuous process drying recommended by LithoRec. Batch drying systems operate by handling materials in separate, distinct batches, where each batch is loaded, dried, and unloaded separately and sequentially. This process involves starting and stopping, with each cycle necessitating setup and takedown time. Batch drying does have the advantage of being able to more completely control the outcome of a batch, for example, to ensure that shredded battery material is completely dry before it exits the dryer. And in a batch dryer, the vacuum level can be controlled more reliably. By contrast, in a continuous process, new material is

continually entering the dryer from the shredder, meaning that the flaps are frequently opening and closing, which compromises the vacuum. Furthermore, the material in the dryer will be a mixture of newly-shredded battery material and materials that have already been dried – all of which may be tumbled together, depending on the degree of fluidization. In such a continuous process, it is harder to ensure that the material exiting the system is completely dried (*i.e.*, inactivated). Thus, batch processing and continuous processing are fundamentally different operations, and a person of skill would not reach for the batch processing teachings of Perry to learn how to implement a continuous system as recommended by LithoRec.

128. For these reasons, a person of skill in the art would not have been motivated to combine LithoRec with Perry to practice the invention claimed in the ’097 patent.

2. A person of skill would not have combined LithoRec with DIN 28400

129. Nor would a person of skill have combined LithoRec with DIN 28400. DIN 28400 is simply a glossary of terms and does not teach any particular application of vacuum drying. DIN 28400 teaches broad characterizations of ranges of vacuum. Ex. 1018 at 1 DIN 28400 Part 1, Section 1, Table 1. According to Table 1 of DIN 28400, rough/low vacuum ranges from 1000 to 1 millibars;

medium vacuum ranges from 1 to 0.0001 millibars; high vacuum ranges from 0.0001 to 0.0000001 millibars; and ultra-high vacuum range falls below 0.0000001 millibars. *Id.* DIN 28400 does not provide any direction as to what range of vacuum would be appropriate for particular applications. There is no mention of drying of shredded EV batteries. A person of skill in the art, looking to develop a vacuum drying system, would find no teachings in DIN 28400 as to how to select an appropriate range of vacuum pressure.

130. DIN 28400 does have a statement, which Petitioner cites, that "[v]acuum refers to the state of a gas when the pressure of the gas, and thus the number density of molecules, in a container is lower than outside, or when the pressure of the gas is lower than 300 mbar, i.e., lower than the lowest atmospheric pressure on the Earth's surface."[2] Ex. 1018 at Section 1.1. The same paragraph lists a formula and underlying parameters for computing vacuum levels, as set forth in Table 1. *Id.* Thus, a person skilled in the art could read this paragraph (Section 1.1) in connection with Table 1, which is derived from the same formula.

131. A pressure of 300 mbar (or equivalently, 300 hPa) is not definitionally a vacuum. This is confirmed by Table 1 of DIN 28400, which states that a rough (low) vacuum is in the range of 1000 mbar (*i.e.*, one atmosphere) to 1 mbar. Ex.

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[2] 300 mbar is equivalent to 300 hPa.

1018 at Section 1, Table 1. This definition of a rough (low) vacuum is the same as 1000 hPa to 1 hPa. Thus, DIN 28400, itself, says that 300 hPa is not the definition of a vacuum, and that weaker pressures (*i.e.*, between 1000 hPa[3] and 300 hPa) still qualify as a vacuum.

132. Mr. Spies writes that "Din 28400 teaches the conditions that define a vacuum according to the international standard ISO 3529-1:1981, issued by the International Organization for Standardization (ISO)." Ex. 1003 at ¶97. He further writes that "One of the conditions that meets the international standard ISO 3529-1:1981 for a vacuum is that the pressure is between 0 and 300 millibars (i.e., between 0 and 300 hpa)." *Id.* There is no dispute that a pressure between 0 and 300 millibars is a condition that meets the definition of a vacuum. However, the ISO does not define a vacuum to be a pressure below 300 millibars. Ex. 2018. Mr. Spies did not attach a copy of the ISO standard itself.

133. Attached hereto as Exhibit 2018 is a true and correct copy of the 1981 ISO standard referenced in DIN 28400. Ex. 2018. The ISO standard confirms that 300 hPa is not definitionally a vacuum. Ex. 2018 at 1, Section 1.1.1. The 1981 version of the ISO standard, upon which DIN is premised, does not mention 300 hPa (or 300 mbar) at all. Ex. 2018. In relevant part, the 1981 standard states:

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[3] One atmosphere is 1013.24 hPa.

1.1.1

vacuum

A commonly used term to describe the state of a rarefied gas or the environment corresponding to such a state, associated with a pressure or a mass density below the prevailing atmospheric level.

1.1.2

ranges of vacuum

It has been the practice to distinguish between various ranges or degrees of vacuum according to certain pressure intervals. While there has been some variation in the selection of the limits of these intervals, the following list gives typical ranges for which the limits are to be considered as approximations :

100 kPa to 100 Pa	low (rough) vacuum
100 Pa to 0,1 Pa	medium vacuum
0,1 Pa to 10 µPa	high vacuum (HV)
below 10 µPa	ultra-high vacuum (UHV)

Ex. 2018 at 1, §§1.1.1-1.1.2.

134. The 1981 ISO standard confirms that a vacuum is used to describe a gaseous environment "associated with a pressure or a mass density below the prevailing atmospheric level." Ex. 2018 at Section 1.1.2. The 1981 ISO standard then gives ranges of vacuum levels which it states are typical for low, medium, high, and ultra-high vacuum environments. *Id.* For low (rough) vacuum levels, the 1981 ISO standard attributes a pressure range of "100 kPa to 100 Pa." *Id.* This is the same as 1000 hPa to 1 hPa. Nothing in the 1981 ISO standard states that 300 hPa is somehow definitional of a vacuum.

135. The use of the "300 hPa" figure in DIN 28400 is related to prevailing atmospheric pressures on the surface of the earth, as DIN 28400 acknowledges. Ex. 1018 at Section 1.1. The 1981 ISO standard was updated in 2019. A true and correct copy of the 2019 ISO standard is attached hereto as Exhibit 2019. The 2019

standard states: "The prevailing atmospheric pressure on ground depends on weather conditions and altitude and ranges from 31 kPa (altitude of the Mount Everest, weather condition 'low') up to 110 kPa (altitude Dead Sea, weather condition 'high')." Ex. 2019 at 1, Section 3.1.2, n.2. The fact that atmospheric pressure on the surface of the earth may be as low as 31 kPa (310 hPa) is likely the source of the 300 hPa remark in DIN 28400. This simply means that if someone were to set up an experiment on the top of Mount Everest, in order to pull a vacuum, they would need to decrease the pressure to below 310 hPa. This phenomenon is inapposite in environments closer to sea level. Ex. 2018 at 1, Section 1.0.1 - Standard ambient conditions ("atmospheric pressure of dry air: 101325 Pa = 1013.25 hPa"). Closer to sea level, as long as the pressure of a system is below about 1000 hPa, it is at a vacuum. A person of ordinary skill in the art in the 2015 time period would understand that a vacuum is a pressure below the prevailing atmospheric level, as taught by the 1981 ISO standard. The statement in the 2019 ISO Standard that the prevailing pressure atop Mount Everest was as low as 31kPa would have been known to a POSITA by 2015. *See* Ex. 2020 at 1063 ("Figure 3 shows that, at the coordinates of the Everest summit, the altitude of the 300-mbar pressure was 9,715 m, which corresponds to almost the highest altitude on the chart.").

136. There would be no motivation for a person of skill in the art to combine the teachings of LithoRec with the reference to "300 hPa" in DIN 28400, because that 300 hPa parameter is applicable only to the prevailing atmospheric pressure in environments such as Mount Everest, inapplicable here.

137. The list of vacuum ranges outlined in Table 1 of DIN 28400 does not provide specific guidance for vacuum level selection in the context of electric vehicle battery recycling processes. Ex. 1018 at Section 1.1, Table 1. The absence of application-specific recommendations necessitates further investigation to determine appropriate vacuum conditions for this particular industrial application. Appropriate vacuum conditions for drying comminuted EV battery material depend on operational temperature and target substance composition. A POSITA seeking to determine appropriate vacuum conditions would need to know parameters such as at what temperature the drying is to occur and how this temperature is affected by different levels of vacuum. As mentioned above, LithoRec does not provide a POSITA with this information. DIN 28400 does not cure LithoRec's deficiencies. Therefore, a POSITA seeking to determine specifications for drying comminuted battery material would not be motivated to combine LithoRec with DIN 28400.

138. There are no guidelines from LithoRec that would instruct a person of skill as to which range of pressures, listed in DIN 28400, to use for vacuum drying of shredded EV batteries. *See generally*, Ex. 1016. The most that LithoRec says is

that in view of the presence of highly flammable solvents, "the drying temperature should probably be severely restricted," and that this "speaks in favor of drying under vacuum, as the drying temperature can be kept low." Ex. 1016 at 226. This statement does not specify how low the pressure must be. It does not teach a method for determining the level of vacuum that must be applied to vaporize the highly flammable solvents. In my opinion, while a POSITA in 2015 would have known that pressure below 1000 hPa is generally considered "low pressure," as confirmed by DIN 28400; a POSITA would not have understood LithoRec's mention of "low pressure" to mean "maximum pressure of 300hPa," and would not have deduced this from the statement in Section 1.1 of DIN 28400. Indeed, the 1981 ISO standard confirms that a low vacuum is simply one from 1000 hPa to 1 hPa, with no reference to 300 hPa. Ex. 2018 at 1, Section 1.2.1.

139. LithoRec does expressly teach to use a vibratory fluidized bed dryer. Ex. 1016 at 227. As explained above, such dryers require a forceful flow of gas molecules to agitate the materials being dried, to tumble the materials and facilitate convective heat transfer. This express teaching to use a vibratory fluidized bed dryer is at odds with any suggestion to use a vacuum dryer. If anything, a person of skill would read that teaching to counsel a weak vacuum. DIN 28400 confirms that a weak vacuum may include the range from 1 hPa to 1000 hPa, outside the range of the '097 patent. Ex. 2018 at 1, Table 1. Thus, a person of skill in the art would not

read LithoRec in view of DIN 28400 and understand that drying of shredded EV batteries should occur at a pressure below 300 hPa.

C. The combination of LithoRec with Perry or DIN 28400 would not enable performance of Claim 1

140. A person skilled in the art would not be able to practice Claim 1 of the '097 patent based on the combined disclosures of LithoRec with Perry and DIN 28400.

141. The combination of LithoRec with Perry and DIN 28400 would not teach inactivating of shredded batteries by drying at a maximum pressure of 300 hPa.

142. For all the reasons set forth above, *supra* ¶¶ 65 – 141, LithoRec simply does not disclose a system "wherein the drying occurs at a maximum pressure of 300 hPa." The express teachings of LithoRec are actually contrary to this limitation, because LithoRec recommends using components that are used at atmospheric pressure.

143. As noted above, LithoRec recommends the use of a vibratory fluidized bed dryer and a cross-flow hogger. Both of these devices work at atmospheric pressure. They are linked together in the LithoRec schematic. Ex. 1016 at 230. Because the cross-flow hogger must operate at atmospheric pressure, so must the fluidized bed dryer.

144. No level of experimentation, based on LithoRec's teachings, would arrive at a system for inactivating shredded batteries that dries at a maximum pressure of 300 hPa. Attempting to do that would result in a cross flow-hogger that is overheated and that fails to exhaust the dust. Likewise, attempting to follow LithoRec's disclosure would result in a fluidized bed dryer that fails to blow sufficient gas to fluidize the material being dried. Furthermore, as I described above, LithoRec's reference to "convection dryers" and "rotor shredders" does not change my analysis. *See* ¶¶ 99.1-99.3, 108.1, *supra*.

D. My opinions apply to all claims in Ground 1

145. The opinions above are directed to Claim 1. They apply equally to the remaining dependent claims addressed in Ground 1.

145.1 Furthermore, Claim 2 is not taught by LithoRec. There is no discussion in LithoRec that the electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible. As explained above, even if LithoRec discloses that some drying of some solvents occurs, there is no disclosure that drying is so thorough that electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible. *See* ¶ 120, *supra*. Rather, different solvents have different boiling points, and lower-boiling solvents will preferentially evaporate first. Depending on the configuration, the continuous process of LithoRec may not evaporate all the electrolyte solvent

material. I have reviewed Mr. Spies' declaration on this point, and he provides no evidence that the evaporation would be so complete as to meet this limitation. *See* Ex. 1003 at ¶¶ 102-105.

145.2 Furthermore, Claim 7 is not taught by LithoRec. There is no discussion in LithoRec that the electrolyte content in the comminuted material is so low no flammable or explosive gas mixture is formable above the comminuted material in the transport container, or that the comminuted material is so dry that no flammable or explosive gas mixture is able to emerge in the transport container. As explained above, even if LithoRec discloses that some drying of some solvents occurs, there is no disclosure that drying is so thorough that electrolyte content in the comminuted material is so low that these criteria would be met. *See* ¶¶120, 145.1, *supra*. Rather, different solvents have different boiling points, and lower-boiling solvents will preferentially evaporate first. Depending on the configuration, the continuous process of LithoRec may not evaporate all the electrolyte solvent material. I have reviewed Mr. Spies' declaration on this point, and he provides no evidence that the evaporation would be so complete as to meet this limitation. *See* Ex. 1003 at ¶¶ 108-117. While he refers to page 229 (lines 21-22) of LithoRec, that passage is simply stating an assumption, and is not a disclosure that the LithoRec system would achieve this level of drying. I also

note that he bases his opinion on the teachings of the ’097 patent, which I understand is improper.

IX. GROUND 2: CLAIM 9 HAS NOT BEEN SHOWN TO BE INVALID FOR THE SAME REASONS AS INDEPENDENT CLAIM 1

146. I understand that Ground 2 of the URT petition asserts that Claim 9 of the ’097 patent is invalid as being obvious over LithoRec in view of DIN 28400, Perry, and WO 2013/023640 to Hanisch (“Hanisch”). *See* Pet. at 35. Claim 9 depends on Claim 1. Accordingly, all my opinions from Ground 1 apply as well to Claim 9.

146.1 Furthermore, a POSITA would not have combined LithoRec with Hanisch to arrive at Claim 9 of the ’097 patent. Petitioner is relying on the disclosure in Hanisch of the low-temperature pre-dryer. See Ex. 1003 at ¶ 129 (citing Ex. 1020 at 5). However, it is my opinion that the pre-dryer in Hanisch would not inactivate the comminuted battery material. The pre-dryer of Hanisch is configured to remove some quantity of electrolyte solvent that has not already been removed through stirred reactor 26 prior to the material entering the high temperature oven. The purpose of the pre-dyer is to recover electrolyte. Ex. 1020 at 5 (“This has the advantage that the electrolyte solvent can be reclaimed.”). The pre-dryer is run on a continuous basis, not a batch process. *Id.* at 4. Hanisch ’419 is not concerned with inactivating the battery material at the pre-dryer, for several

reasons. Foremost, the battery material goes straight from the pre-dryer to the decomposition oven, where it will be subjected to temperatures of 400°C to 600°C. Ex. 1020 at 8. The residual solvent that remains in the comminuted battery material through the pre-dryer will be destroyed in this furnace. So there would be no need to take the caution and incur the cost to dry the material to the endpoint result of inactivation. Furthermore, Hanisch provides no attention to the details that would be needed if he were teaching how to inactivate battery material through the pre-dryer. There is no disclosure of duration of time needed in the pre-dryer. There is no disclosure of the pressures needed in the pre-dryer. There is no disclosure of how to measure the endpoint to determine if the material is sufficiently dry. There is no disclosure of the different kind of electrolyte solvents that need to be evaporated, depending on the kinds of batteries being processed, and the different drying conditions needed to fully evaporate away those different solvents. And the pre-dryer is run under a continuous process, for which it would be difficult to maintain control over the pressure, particularly due to the leaky nature of continuous processing steps, as opposed to batch processing. There is no rationale for taking these precautions to ensure inactivation, because in the very next step (*i.e.*, the decomposition oven), the remaining electrolyte solvent would be pyrolyzed away. Because the pre-dryer of Hanisch does not inactivate the battery material, a POSITA would not be motivated to combine Hanisch with LithoRec to

arrive at Claim 9, because there is no showing that this would inactivate the battery material.

X. GROUND 3: ANALYSIS OF LITHOREC AS ANTICIPATING CLAIMS 12-13, 15-16, AND 18-19

147. I understand that Petitioner contends that claims 12-13, 15-16, and 18-19 of the '097 patent are anticipated by LithoRec (Ground 3). *See* Pet. at 39. I disagree that LithoRec anticipates these claims. In particular, LithoRec does not disclose the following limitations: "an inactivation device comprising a drying device configured to inactivate the comminuted material;" and "a vacuum installation connected to the drying device and configured to generate a vacuum in the drying device."

A. LithoRec does not disclose "a vacuum installation connected to the drying device and configured to generate a vacuum in the drying device"

148. LithoRec recognizes that the drying temperature should probably be severely restricted, and this "in turn speaks in favor of drying under vacuum, as the drying temperature can be kept low." Ex. 1016 at 226. This remark is simply a suggestion. It is not a disclosure of a vacuum installation configured to generate a vacuum in the drying device.

149. Petitioner admits that "LithoRec is silent regarding the device that produces the vacuum for the dryer." *See* Pet. at 47. I agree—there is no vacuum installation disclosed in LithoRec that generates a vacuum in the drying device. *See*

supra at ¶94. To the contrary, LithoRec specifies the air flow rate of the system (2000 m^3/hr) but does not specify a pressure; this confirms that there is no vacuum pump in the system. *See supra* at ¶¶109 – 114.

150. The drying equipment described in LithoRec is a vibratory fluidized bed dryer. Ex. 1016 at 227. As I have opined above, *supra* at ¶69 – 77; 95 - 99, a vibratory fluidized bed dryer is not a vacuum dryer. Ex. 2012 at 1 ("Thermodynamically, it is a constant heat process which makes it adiabatic, and it typically occurs at atmospheric pressure."). A vibratory fluidized bed dryer requires a forceful flow of a stream of gas to agitate the material being dried, which is at odds with the use of vacuum drying. Ex. 2012 at 1 ("Add air that is simultaneously forced up openings in the conveying surface so it permeates through the mat depth of material. The result is a vibratory 'fluidized' bed of dynamically active particles that can efficiently exchange heat energy."). A vibratory fluidized bed dryer would not work under vacuum. I incorporate my opinions above. *See supra* at ¶¶ 69 - 77; 95 - 99.

151. To generate the forceful flow of gas up through the fluidized bed, there is a "blower." Ex. 1016 at 235 (Table G-7). A blower creates a positive pressure, which creates the updraft that brings the materials being dried into flotation/suspension. *See supra* at ¶¶98-99. The positive pressure generated by the blower agitates the materials and allows the convective heat capacity of the nitrogen

to volatize the solvents/electrolytes. This positive pressure drives the dust and vapors of solvents/electrolytes out of the system, through the jet filter. Ex. 1016 at 230.

152. Expressly, the drying system proposed in LithoRec includes a blower. Ex. 1016 at 230 (Table G-7). Using a blower is the opposite of generating a vacuum in the drying device. *See* Ex. 2012 at 1 ("Add air that is simultaneously forced up openings in the conveying surface so it permeates through the mat depth of material."); *see also supra* at ¶¶71; 74; 112-114; 98-99.

153. LithoRec also discloses the use of a cross-flow hogger. Ex. 1016 at 230. As I opined above, *supra* at ¶¶ 100 -108, a cross-flow hogger needs to operate at about atmospheric pressure. *See supra* at ¶¶ 100 -108; 114. A cross- flow hogger cannot operate under vacuum, because the machine would overheat and it would be unable to exhaust the dust particles generated by the hammering action. In addition, the hard metallic parts within the cross-flow hogger will become softened as they are exposed to high temperatures and the machine will lose its ability to shred the feed material. *See supra* at ¶108.

154. The cross-flow hogger and the drying device are connected on the same nitrogen circuit. *See supra* at ¶100. They would thus be at the same pressure. Because the cross-flow hogger must be at atmospheric pressure to function, the fluidized bed dryer would also be at atmospheric pressure. LithoRec specifies the

"QZ 1200 depressurized" system from MEWA. Ex. 1016 at 235. The reference to "depressurized" confirms that the system is not working under vacuum, as I explained above. *See supra* at ¶ 105.

154.1 Moreover, the disclosure in LithoRec to "convection ovens" and "rotor shredders does not change the analysis, for the reasons set forth above. *See* ¶¶ 99.1-99.3, 108.1, *supra*.

155. The system in LithoRec is not a completely closed system. *See supra* at ¶¶111 - 112. LithoRec says that a portion of the nitrogen gas exiting the dryer needs to be discharged to the environment. Ex. 1016 at 227. LithoRec discloses the use of a "fan" to discharge this gas to the activated carbon filter, and then out through a furnace to the environment. Ex. 1016 at 230 (Table G-1). Because the fan discharges to the environment, the output of the fan would be at approximately atmospheric pressure. *See supra* at ¶¶109 – 114.

156. At most, the fan disclosed in LithoRec might accommodate a slight negative pressure. *See supra* at ¶¶113-114. It is typical for workplace safety reasons to maintain a slight negative pressure to ensure that dust and other harmful chemicals do not escape into the workplace. A pressure difference of a few Pascals (*i.e.*, between 2.5 – 8 Pa) would be sufficient to provide this safety buffer. *See* Ex. 2017 (specifying a pressure differential of 2.5 Pa (*i.e.*, 0.025 hPa) to prevent contaminants from leaving an enclosure). *See supra* at ¶113.

157. A slightly lower pressure at the exhaust fan says nothing about the pressure within the dryer. There may be a pressure gradient across the system. And expressly, there is a blower attached to the dryer. Ex. 1016 at 235. This blower will generate a high pressure within the dryer, to fluidize the material being dried. *See supra* at ¶98.

158. LithoRec does not teach how to reconcile its recommendation to use a vibratory fluidized bed dryer and a cross-flow hogger with its suggestion to conduct drying under vacuum. Ex. 1016 at 222-236. Applying a vacuum would work at cross-purposes to the function of a vibratory fluidized bed dryer, which requires a forceful flow of gas to agitate and dry via conductive heat transfer the material being dried. *See supra* at ¶¶99; 114. Likewise applying a vacuum would compromise the working of the cross-flow hogger, which would overheat and lose its ability to exhaust the particulates, not to mention the ability to shred the material. *See supra* at ¶¶108; 114.

B. The system disclosed in LithoRec is not "configured to inactivate the comminuted material"

159. Claim 12 does not simply disclose a vacuum installation, but rather a vacuum installation to "inactivate" the comminuted material so that materials are safe to transport. LithoRec is not a disclosure of a vacuum installation for <u>inactivating</u> shredded EV batteries (*i.e.*, it is not a disclosure of an "inactivation

device comprising a drying device configured to inactivate the comminuted material").

160. As I explained above, LithoRec discloses a continuous system, whereby wet, shredded material is continuously fed into the dyer. *See supra* at ¶¶115 - 123; *see also supra* at ¶¶126 – 127. The material in the dryer is subjected to a vibratory fluidized bed dyer, whereby it is tumbled with material that has been in the dryer for some period of time already. Thus, freshly shredded material is mixed with material that is partially dry. Meanwhile, the system continually outputs material from the dryer. The materials exiting the dryer would be a mix of shredded battery materials—some more wet, some more dry. *See supra* at ¶¶119-120. LithoRec does not provide for any mechanism that would ensure that the material exiting the system would be completely dry (*i.e.*, inactivated).

161. Lithium-ion batteries typically contain a mix of solvents. Some evaporate at a lower temperature, others at a higher temperature. Ex. 1016 at 227 (noting that the solvent "adheres more or less strongly to the arrester foils"). In a continuous system, there will be new material continually entering the drying chamber, and solvents from that fresh material would preferentially evaporate, suppressing the evaporation of material that had already been partially dried. *See supra* at ¶¶119-120. Unlike in a batch system, where controls can be maintained to

ensure that all solvents are evaporated, this continuous system would work against the thorough evaporation of all the solvents. *See supra* at ¶¶118; 120.

162. The continuous system also suffers from the problem that it would be hard to maintain a vacuum, due to flaps opening to allow material to continually enter and exit the system, especially when the fluidized bed dryer is operating. *See supra* at ¶118. It would be difficult to maintain a substantial vacuum in this system. Therefore, higher temperatures would be needed to dry the material, which in turn would pose hazards of the formation of toxic gases.

163. Thus, it is not necessarily the case that the material exiting the dryer in the system proposed by LithoRec would be inactivated. *See supra* at ¶120-123. To the contrary, in the continuous system proposed by LithoRec, there would be obstacles to thoroughly drying the shredded material. There is a high probability that the system, as described, would output shredded material that is not fully dry (*i.e.*, not inactivated).

163.1. I understand that in its Institution Decision, the Board stated, "the '097 patent states that the 'inactivation device' not only includes, but is 'in the form of a drying device,' suggesting that drying and inactivation are intended to have similar, if not identical, meanings." Inst. Dec. at 12. I understand the Board further stated, "inactivation mean[s] the same as drying," and "both terms refer[] to the removal of at least one solvent, such as dimethyl carbonate or ethyl methyl

carbonate, from the conducting salt…" *Id.* at 13. I disagree with the Board's determination, both that drying and inactivation are equivalent, and that inactivation means "the removal of at least one solvent, such as dimethyl carbonate or ethyl methyl carbonate, from the conducting salt."

163.2 First, the '097 patent describes, and a person of skill in the art would understand, drying and inactivation to be two different concepts. Inactivation is an important end goal of the invention of the '097 patent, rendering the comminuted material safe for transport, and allowing the battery recycling process to proceed. Drying is a means of achieving inactivation. *See* Ex. 1001, at 1:55-57 ("The invention solves the problem by means of a method according to the preamble, in which the inactivation occurs at least also by way of drying the comminuted material.").

163.3. Second, the '097 makes clear, and a person of skill in the art would understand, that the goal of the inactivation is to render the comminuted material safe for transport, so that the material could be taken to central facility for processing—solving a fundamental problem unanswered by the prior art. *See* Ex. 1001 at 2:2-4 ("The comminuted material is therefore largely inert and can be transported safely, especially if it is packed under vacuum."); *id.* at 3:13-14 ("In addition, it is advantageous that a comminuted material is obtained that can be transported safely."); *see also supra*, ¶¶ 48, 57-58, 60, 159, 163.2. Therefore,

rather than equating inactivation with drying, which a person of skill in the art would not do, the Board should give the term "inactivate" its ordinary meaning as it would be understood by a person of skill in the art: material that has been rendered safe for transport.

163.4. For the reasons, a person of skill in the art would understand the "drying device configured to inactivate the comminuted material" to be "a device configured to produce inactivated comminuted material as a result of drying." The '097 patent explains that the drying device is what transforms "comminuted material" into "inactivated comminuted material." Ex. 1001 at Fig. 2 & 9:7-23 (describing an embodiment of the invention where "comminuted material" becomes "inactivated comminuted material" after exiting the "drying device"); *see also id.* at 6:32-34 ("The drying device is configured to dry the comminuted material until an electrolyte content is so low that an electrochemical reaction is impossible."). Therefore, a person of skill in the art would understand that the "drying device configured to inactivate the comminuted material" would have its ordinary meaning, i.e., "a device configured to produce inactivated comminuted material as a result of drying."

163.5. As stated above, the Board in its Institution Decision that drying means "the removal of at least one solvent, such as dimethyl carbonate or ethyl methyl carbonate, from the conducting salt…" Inst. Dec. at 13. A person of skill

in the art would largely agree with the Board, but would not restrict the definition of "drying the comminuted material," as used in Claim 12, to dimethyl carbonate or ethyl methyl carbonate. The '097 patent teaches that "the term drying should be understood to particularly mean the removal of one solvent in the conducting salt." Ex. 1001 at 2:23-25. But the specification also contemplates drying comminuted battery material—not only a conducting salt. *See, e.g.*, *id*. at 1:56-58, 3: 49-56, 4:28-36. Therefore, a person of skill in the art would understand "drying the comminuted material" to have an ordinary meaning of "removing at least one solvent from the comminuted material."

163.6 It is my opinion that under a proper construction that distinguishes drying from the result of inactivation, that LithoRec does not teach that it is "configured to inactivate the comminuted material." Rather, the various disclosures in LithoRec work at cross-purposes to one another (i.e., the inability to work under vacuum, due to the vibratory fluidized bed dryer and the cross-flow hogger, the use of a continuous system, and the absence of any controls to ensure thorough drying), and there is thus no teaching that LithoRec is configured to inactivate the comminuted material.

C. LithoRec does not enable Claim 12

164. I understand that for a reference to be anticipating, it must enable a person of skill in the art to practice the invention as claimed. It is my opinion that

LithoRec would not have enabled a person of skill in the art to practice Claim 12 of the ’097 patent and its challenged dependent claims.

165. Specifically, LithoRec does not teach how to reconcile its recommendation to use a vibratory fluidized bed dryer with its suggestion to conduct drying under vacuum. Ex. 1016 at 222-236. Applying a vacuum would work at cross-purposes to the function of a vibratory fluidized bed dryer, which requires a forceful flow of gas to agitate and dry via conductive heat transfer the material being dried. Ex. 2012 at 1 (“Add air that is simultaneously forced up open-ings in the conveying surface so it permeates through the mat depth of material. The result is a vibrating ‘fluidized’ bed of dynamically active particles that can efficiently exchange heat energy.”). LithoRec suggests no pressures that would be applied by the vacuum pump and offers no explanation of how this would affect the efficacy of the vibratory fluidized bed dryer. Ex. 1016 at 222-236; *see supra* at ¶121.

166. The vibratory fluidized bed dryer includes a blower. Ex. 1016 at 235. A blower creates a positive pressure that blows upwards through the drying bed. Ex. 2012 at 1. LithoRec does not teach how to “generate a vacuum in the drying device.” To the contrary, LithoRec teaches putting a blower in the vacuum device, which generates positive pressure. *See supra* at ¶98.

167. It would not work to maintain the system under vacuum, because the system includes a cross-flow hogger. *See supra* at ¶¶100 - 108. Cross-flow hoggers need to be operated at atmospheric pressure. Otherwise, they would overheat and lose their ability to shred and fail to exhaust the dust generated through the hammering action. *See supra* at ¶108. Indeed, the manual for the MEWA QZ 1200 specifies a "fault" if the nitrogen pressure drops. Ex. 2014 at 52.

167.1. LithoRec states that the fluidized bed dryer and the cross-flow hogger should run on a common nitrogen gas circuit. Ex. 1016 at 227. Thus, these devices would be at the same pressure level. Because the cross-flow hogger must run at atmospheric pressure, so too must the fluidized bed dryer. Running the vibratory fluidized bed dryer and the cross-flow hogger under vacuum would be non-operational, because those devices need sufficient air flow to function.

167.2. The disclosure in LithoRec to use a "convection dryer" or a "rotor shredder" does not change the analysis, as set forth above. *See supra* ¶¶ 99.1-99.3, 108.1. Briefly, convection dryers are simply the broader category of dryers that operate on the basis of the use of airflow to dry materials, and a vibratory fluidized bed dryer is simply the kind of convection oven that the LithoRec authors considered the most suitable to the task. Convection dryers are distinct from vacuum dryers, as explained above, and function under different principles. Likewise, as shown by Exhibit 2027, the depicted rotor shredder confirms that it

does not operate under vacuum; to the contrary, it offers an optional "cooling rotor" to counteract heat build-up, which would be exacerbated by vacuum conditions.

167.3. Developing the system of the '097 patent would not be predictable, in view of the nature of the invention. LithoRec notes a "high level of uncertainty" in being able to obtain batteries at the 2015 time period. Ex. 1016 at 8. The batteries "cannot be processed as a homogeneous mass due to the different chemical compositions of the battery variants." *Id*. at 8. Transporting used batteries would be dangerous. *Id*. at 33 ("The danger posed by defective batteries must be eliminated by suitable measures before transportation (deactivation)."). Safety hazards would complicate attempts to experiment. *See id*. at 96 ("Due to the high reactivity of the electrolyte salt to water (humidity) and the associated difficulty and costly handling when opening the cells, safe operating concepts must be developed as a first step."). Mishandling the materials could result in lithium hexafluorophosphate ($LiPF_6$) being hydrolyzed, with the formation of deadly hydrogen fluoride gas. LithoRec states that a "fire and explosion-proof environment" is needed. *Id.* at 96. There would be regulatory hurdles. *Id.*at 220. And it would have been difficult and costly to obtain the recommended drying equipment – even the authors could not secure cooperation of manufacturers of drying systems. *Id.* at 226.

167.4 In view of the internally contradictory teachings of LithoRec, if vacuum drying was actually the goal, a POSITA would have to reconfigure the recommended framework, to avoid using devices such as a vibratory fluidized bed dryer (or other convection dryer) and a cross-flow hogger (or similar shredder, such as a rotor shredder or shaft shredder). The entire bill of materials would have to be reevaluated. This would require undue experimentation, particularly in view of the relatively low level of skill in the art.

168. The system in LithoRec is simply a proposal. *See supra* at ¶¶68; 92 - 94. The teachings are internally contradictory. A person skilled in the art could not make the invention claimed in the ’097 patent based on what LithoRec says. If any amount of experimentation could result in the claimed invention of Claim 12 of the ’097 patent, it would be undue experimentation.

D. My opinions apply equally to the dependent claims

169. My opinions above are directed to claim 12. They apply equally to the dependent claims that are the target of Ground 3.

169.1 Furthermore, Claim 13 is not taught by Lithorec. There is no discussion in LithoRec that the electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible. As explained above, even if LithoRec discloses that some drying of some solvents occurs, there is no disclosure that drying is so thorough that electrolyte content in the comminuted

material is so low that an electrochemical reaction is impossible. *See* Section VIII.D, *supra*. Rather, different solvents have different boiling points, and lower-boiling solvents will preferentially evaporate first. Depending on the configuration, the continuous process of LithoRec may not evaporate all the electrolyte solvent material. I have reviewed Mr. Spies' declaration on this point, and he provides no evidence that the evaporation would be so complete as to meet this limitation. *See* Ex. 1003 at ¶¶ 102-105.

XI. GROUND 4: ANALYSIS OF LITHOREC AND THE COMBINATION OF LITHOREC WITH HANISCH

170. I understand that Ground 4 of the URT petition asserts that Claim 17 of the '097 patent is invalid as being obvious over LithoRec in view of WO 2013/023640 to Hanisch ("Hanisch"). *See* Pet. at 35. Claim 17 depends from Claim 12. Accordingly, all my opinions from Ground 3 apply as well to Claim 17.

XII. SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

171. I understand the Patent Owner has provided such evidence of nonobviousness, including with respect to long-felt need, unexpected results, commercial success, and licensing, with respect to Duesenfeld's commercialization of the '097 patent. In my view, such evidence supports my views, expressed herein, that the challenged claims are not unpatentable.

1. Objective Indicia of Nonobviousness as to the ’097 Invention

1. Long-felt but unmet need and unexpected results

172. Companies tried and failed prior to the ’097 invention to develop a process for inactivating depleted rechargeable batteries for safe storage and transport. Prior approaches included mixing various additional chemicals with the comminuted material to mitigate known hazards relating to the comminuted material, including: flame retardants (Ex. 2008 at 2-3); aqueous solution or a deactivating powder (Ex. 2004 at 5:[0034]-[0035]); mineral acids (Ex. 2001, at 5:18-52); brine solutions (Ex. 2002, 5:4-11); and pressurized solvents (Ex. 2011 at 3:3-5). However, it was apparent that adding foreign substances to the comminuted battery material had deleterious effects on the recycling process. *See* Ex. 1001 at 2:6-12 (teaching that avoiding the addition of foreign substances has great benefits because it “decreases the complexity of the battery processing, reduces the weight of the inactivated comminuted material and increases the purity in the subsequent separation and recycling steps”). In addition, it was known that that treatment with aqueous solutions could cause partial electrolysis and produce toxic gases, which underscored the need for safe battery processing in such conditions. Ex. 2001 at 1:26-29 (“when $LiPF_6$ reacts with water, $LiPF_6$ is hydrolyzed and generates toxic hydrogen fluoride. For this reason, a safe processing method is required.”). LithoRec noted the costs to neutralize HF expected to be generated in its process.

Ex. 1016 at 190 (describing costs of sodium hydroxide (NaOH) for washing hydrofluoric acid, and associated disposal costs).

173. The ’097 patent allows batteries to be comminuted directly, and then inactivated by drying at a pressure below 300 hPa. The ’097 patent eliminates contaminants from recycling by not requiring foreign substances. *See, e.g.,* Ex. 1001, 1:63-2:4, 2:5-12. The ’097 patent provides a safer, more efficient method to recover spent battery material by safely inactivating electrolytes and solvents without producing hydrogen fluoride, ensuring high purity and safe transport.

174. The ’097 invention demonstrated unexpected results. As previously mentioned, prior battery recycling methods involved the use of foreign substances or high temperatures that introduced significant hazards, such as freezing, incineration, melting, adding reactants, and shredding in water. The ’097 patent adopted a fundamentally different and unforeseen approach to mitigating these hazards—by avoiding their creation altogether. The advantages and benefits of vacuum drying at pressures below 300 hPa without using foreign substances were notably superior. This method allows solvents to be recovered at a purity exceeding 99%, has low energy requirements, requires short drying times, eliminates the need for waste gas scrubbing, avoids the disposal of toxic filter materials, requires no chemicals, and retains lithium in the black mass as LiPF6 rather than as a breakdown product.

2. Nexus between secondary considerations and the claims of the ’097 Patent

175. I understand that “the evidence of secondary considerations must have a ‘nexus’ to the claims, *i.e.*, there must be ‘a legally and factually sufficient connection’ between the evidence and the patented invention.” *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019).

176. I understand that Duesenfeld operates a battery comminution facility at its Wendeberg Plant. Ex. 2040 ¶¶ 6-8 (Declaration of Lydia Grote). I have reviewed materials regarding the Wendeberg Plant and have determined that it practices the ’097 claimed invention. Ex. 2037; Ex. 2040, ¶¶1-9; Ex. 2041; Ex. 2053. Exhibit 2036 (Confidential **Appendix D)** is a chart illustrating, on a per-limitation basis, how Duesenfeld’s Wendeberg Plant practices Independent Claims 1 and 12 and various dependent claims. These claims directly address the functionality that drove customer demand and commercial success, and that frustrated others in the field.

177. From my review of the ’097 patent specification, the Wendeberg Plant represents one of the preferred embodiments disclosed in the ’097 patent. Ex. 1001, 3:4-12 (“According to a preferred embodiment, the drying occurs under vacuum. The size of the vacuum is preferably selected such that the vapour pressure of dimethyl carbonate at 80° C., especially at 70° C., is not reached. It is

beneficial if the drying occurs at a maximum pressure of 300 hPa, in particular a maximum of 100 hPa. At such low pressures, considerable parts of most electrolytes vaporise, especially dimethyl carbonate and ethyl methyl carbonate, and do so at temperatures of less than 80° C.”).

178. From my review of the trial record, I understand that Duesenfeld markets its battery recycling technology. The marketing materials that I reviewed reference the functionalities practiced by Duesenfeld’s Wendeberg Plant. Ex. 2053 (Duesenfeld Brochure), 3 (“we have developed and licensed processes that do not require melting down or high-temperature treatment of batteries”), 3 (“Patent: Drying below 80 degrees Celsius is only possible with the Duesenfeld patented process”); 5 (“During mechanical shredding and inactivation of the batteries, the drying process takes place below 80°C and at a low vacuum; Only under these conditions is no exhaust gas scrubbing necessary. Only in this temperature range can also the solvents of the electrolyte, the graphite and the lithium be recovered in a purity so that they can be reused. Through this technology, Duesenfeld combines environmental friendliness with maximum economic efficiency.”); Ex. 2012 (Duesenfeld website https://www.duesenfeld.com/recycling_en.html) (“. . . A low process temperature prevents the formation of toxic gases, so no exhaust gas scrubbing is necessary. The separated solvent has a very high purity level because the production of hydrogen fluoride from reaction products is avoided.”).

XIII. ADDITIONAL REMARKS

179. I reserve any right that I may have to supplement this declaration if further information becomes available or if I am asked to consider additional information. Furthermore, I reserve any right that I may have to consider and comment on any additional expert statements and testimony of Petitioner's experts in this matter.

180. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application, or any patents issued thereon.

Dated: February 12, 2025

Vani Dantam

Appendix A

VANI K. DANTAM

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EXECUTIVE SUMMARY

Accomplished global C-suite executive with 40+ years of strategic leadership experience in Energy Storage, Renewables, Utilities, Smart Grid, Electric Vehicle (EV) Infrastructure, and Defense industries. Managed multinational operations with substantial growth in highly complex and regulated sectors. Extensive expertise in managing large teams, design, construction and launch of global plants, and executing global mergers, acquisitions, and joint ventures. Proven ability to scale operations, increase profitability, and implement innovative technologies such as advanced energy storage solutions. Deeply involved in setting global industry standards for battery technologies as a member of SAE and UL committees. Fluent in Spanish, Portuguese, Hindi, and Telugu, with a strong international proficiency in key markets including North America, South America, Europe, and Asia. U.S. Navy veteran, recognized for public speaking and guest lectures at prestigious institutions.

CAREER HIGHLIGHTS

- **Global Leadership & Strategy:** Over 15 years of experience as VP and at C-Suite level and Board Advisor to leading global companies in the energy, materials, and defense sectors. Built a career on operational excellence, growth strategy, and business transformation across diverse geographies and industries.
- **IPO Experience:** Played a key role in leading the Initial Public Offerings (IPOs) for industry leaders like Landis+Gyr, Axion Power, and Remy International, raising significant capital.
- **Advanced Battery Technology Expertise:** Decades of experience in lead acid batteries, multiple lithium-ion chemistries and other advanced battery technologies. Successfully managed the full lifecycle of energy storage projects including project financing, feasibility studies, plant construction, and operations.
- **Global Operations/Partner Management:** Directed joint ventures and acquisitions in China, Brazil, Mexico, and India, managed OEM partnerships, large-scale manufacturing, and global energy storage/generator/motor plant (10) construction/launch in Mexico, Brazil, South Korea, France, Hungary, Poland and India. Deep expertise in energy management, smart grid technologies in utility sector.
- **Revenue Growth & Business Development:** Demonstrated success in building and managing business pipelines worth over $200 million. Achieved a 670% increase in global sales at Remy Electric, growing international annual revenue from $18M to $120M in just six years.
- **Leadership & Industry Recognition:** Frequent speaker at major global conferences on advanced battery technologies, EV infrastructure, and energy storage solutions. Active member of global technical committees (SAE, UL) responsible for developing and implementing industry standards. Advisor and guest lecturer at multiple universities, including Purdue University and Harvard University.

PROFESSIONAL EXPERIENCE

- **Vanderbilt University, Nashville, TN** **Present**
  Advisor – School of Engineering
  - Provide advice on undergraduate & graduate curricula in Energy (Generation, Storage, & Management) Engineering and recruiting doctoral and post-doctoral candidates.
- **Robins & Kaplan LLP (Global Law Firm)**
  Duesenfeld (Li-ion Battery Recycling Firm) **Present**
  Industry Expert/Advisor
  - Provide advice on lithium-ion battery recycling technology related intellectual property (IP) and patent infringement. Appraise technical documentation and prepare expert declarations.
- **SAE & UL Committees** **Present**
  Committee Member
  - Develop global standards for EV battery packs, recharging protocols, and second-life applications for energy storage technologies. Curricula development for engineering institutions and technical colleges, focused on EV infrastructure and battery technologies.
- **NanoX (Rare-earth Materials Firm, Netherlands),**
  B.K. Batteries (Non-Li-ion Battery firm, South Korea) **Present**
  Chief Strategic Consultant & Board Member
  - Provide technical advice on rare earth and magnetic materials. Advise on market entry/plant construction and financing strategies, global partnerships to drive innovation and commercialization of new battery technologies.
- **Capattery (Advanced Lithium-Graphene Materials/Battery Manufacturer)** **Present**
  Chief Strategic Advisor & Board Member
  - Provide advice on financing, partnerships, development of new applications and market expansion strategies.
- **Quantum Copper (University of Nevada, Las Vegas Startup)** **2023-2024**
  Chief Advisor - Testing, Standardization & Certification -
  Lead initiatives to develop testing and certification protocols for advanced separator materials in energy storage applications. Collaborate with university researchers and industry stakeholders to standardize new technologies.
- **UTILTYX - Cybersecurity software provider to utilities, (Milpitas, CA)** **2021-Present**
  Chief Advisor - Financing & Business Development, Strategic Planning & Global Partnerships
- **Nevada Technology Corporation (Battery Recycling & Repurposing Company)** **2023-24**
  CEO & Chairman of the Board
  Managed technology providers, investor relations and strategic partnerships for the company's expansion.
- **Lohum CleanTech - Noida, India** **2022-24**
  Provider of Advanced Recycling Technologies of Lithium-ion batteries
  Chief Advisor - Strategy
- **NexTech Batteries (Carson City, NV)** **2022-23**
  Chief Operating Officer

- Responsible for managing all operational functions, including HR, procurement, logistics, engineering, production, business development and pilot projects with CAISO
- manage manufacturing facility design & development for lithium-sulfur battery technology.
- Collaborated with external partners such as IBM to develop hybrid electrode technology and raised funding for research projects.

- **Canadian Storage & Solar (Edmonton & Toronto, Canada) 2020- 21**
  Developer and converter of Natural Gas PPPs to solar and storage
  Chief Project Consultant
  - Acquire Midwest PPP's (MISO territory), convert them to solar and storage-based units for smart grid integration with long term financing and PPAs
- **Lucas TVS (Chennai, India) & 24m Technologies (Cambridge, MA) 2019-21**
  Chief Project Consultant
  - Managed plant feasibility and project/product viability studies to develop semi-solid-state Li-ion battery technology in India on behalf of Lucas-TVS under license from 24m.
  - Led the financing, design, and construction of pilot and commercial-scale manufacturing plants for energy storage systems.
- **Landis+Gyr (Toshiba), Alpharetta, GA 2015-19**
  Vice President, Partner Relations & Strategic Planning 2017-19
  - Member - IPO Team (Landis+Gyr divestiture). Rationalized and managed over 130+ partnerships with utilities and vendors across all product lines and services worldwide
  - Oversaw development of scalable grid connected and islanded microgrid design and development, predictive and prescriptive analytics, integrating these into NOCs and coaching Sales Managers to develop multiyear service and maintenance contracts with utilities.
  Vice President, Business Development & Sales 2015-17
  - Managed grid energy storage, smart grid analytics & control system project design, development, pricing, financing and installation for utilities and private/institutional investors for energy arbitrage, with and without renewable integration with LTO (from Toshiba), LFP and NMC chemistries as appropriate in different ISO regions.
  - Recruited, managed, and mentored Regional Sales managers, engineers, and analysts.
  - Led partner development for lithium-ion batteries and power electronics.
- **Axion Power International (Start-up Manufacturer of Lead-Carbon Batteries) 2012-15**
  Senior Vice President, Business Development & Sales
  - Led business development, sales, and marketing efforts for grid energy storage, controls and analytics systems, company's IPO, capital raises from PE and venture capital firms.
  - Developed revenue and cash flow models for large-scale energy storage arbitrage projects in different ISO/RTO territories, including integration with renewable energy sources.
- **Ener1 (Lithium Ion Battery Manufacturer), Indianapolis, IN 2010-12**
  Vice President, Business Development & Sales
  (EV/Hybrid Transportation, Renewables, & Smart Grid Networks)
  - Directed business development and sales for lithium-ion battery systems in electric vehicles (EV), hybrid electric vehicles (HEV), and utility-scale energy storage projects.
  – Managed relationships with major automakers and utility companies.

- **Remy International - Global Manufacturer of EV Motor/Generators, Starter Motors & Alternators (Anderson, IN)** **1994-2010**
  Global Director - EV/Hybrid & Traction Motor Sales and Business Development **2008-10**
  Global Director - Heavy Duty Sales & Marketing (Daimler, Volvo & PACCAR) **2003-08**
  Global Director - Automotive Motor/Generator Sales & Marketing **2000-03**
  Director - International Sales, Engineering & Operations **1994-2000**
- **Delco Remy (Division of General Motors)** **1991-94**
  Operations Director
- **General Motors Truck & Bus** **1989-91**
  Chief Resident Electrical Engineer
- **Delco Remy (Division of General Motors)** **1984-89**
  Senior Product Manager **1987-89**
  Test & Development Engineer **1984-87**
- **U.S. Navy & Reserves** **1982-91**
  Lieutenant (Junior Grade)
- **Vanderbilt University, Nashville, TN** **1979-82**
  Civilian Researcher
- **Tata Iron & Steel, Jamshedpur, India** **1978**
  Summer Intern
- **Kolar Gold Fields, Kolar, India** **1977**
  Summer Intern

EDUCATION

- **MBA - 1988** (Finance & International Business), **Indiana University, USA**
- **MS - 1982** (Mechanical Engineering), **Vanderbilt University, USA**
- **B.Tech - 1979** (Metallurgical Engineering), **Indian Institute of Technology (IIT-BHU), India**
- **Churchill Scholar** - **Trinity College, University of Cambridge, UK**

CERTIFICATIONS & CONTINUING EDUCATION

- **APQP Quality Engineering Certification** - GM Quality Institute, Kettering University
- **Mercosur/NAFTA and Eurozone Certifications** - Indiana University & Purdue University
- **Continuing education** in **Contracts, Corporate Taxation, and Export/Import Classifications**, Wharton School of Business

VOLUNTEER EXPERIENCE

- **Board Member** - Chirala Medical & Educational Trust **2018-Present**
- **Advisor & Primary Benefactor** - Our Children Our Planet (501c3) **2016-Present**
- **Organic/Non-GMO Farmer** - promoting sustainable farming practices through an agricultural cooperative **2014-Present**
- **Board Member** - Thrive Solar Private Ltd. **2016**
- **Guest Lecturer** - Indiana University, Harvard University, Purdue University & other institutions
- **Board Member** - YMCA of Madison County, IN **2003-2008**

Appendix B

Appendix B

Materials Considered

The Petition and supporting exhibits
The ’097 Patent (Ex. 1001)
The prosecution history of the ’097 patent (Ex. 1002)
The Spies Declaration (Ex. 1003)
U.S. Patent No. 9,843,077 (“Hayashi”) (Ex. 2001)
U.S. Patent No. 9,450,277 (“Dunagan”) (Ex. 2002)
Electrocycling Patent (German) (Ex. 2003)
Electrocycling Patent (English) (Ex. 2004)
Certification of Translation of the Electrocycling Patent (Ex. 2005)
Gao Liu *et al.*, *Binder Interactions in the Electrodes of the Lithium-ion Batteries*, TFUG Conference, February 17, 2009 (Ex. 2006)
WO 2010/149611 A1 to LiMotive Company Ltd. (“LiMotive”) (German) (Ex. 2007)
WO 2010/149611 A1 to LiMotive Company Ltd. (“LiMotive”) (English) (Ex. 2008)
Certification of Translation of the Limotive Patent (Ex. 2009)
U.S. Patent No. 7,198,865 to Sloop (“Ecobat”) (Ex. 2011)
Kinergy Corporation, *Transferring Heat with a Vibratory Bed Dryer* (2013) (Ex. 2012)
MEWA Manual (German) (Ex. 2013)
MEWA Manual (English translation) (Ex. 2014)
Certification of Translation of the MEWA Manual (2015)

Cross-flow hogger image (from https://www.cutmetall.com/us/innovative-cross-flow-hogger-chain-head-set-p47892/) (last visited on August 17, 2024) (Ex. 2016)
Commercial Air Filtration System Manual (Ex. 2017)
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Declaration of Lydia Grote in support of Patent Owner's Response to the Petition (Ex. 2040)
Duesenfeld GmbH Wendeburg plant processing conditions (Ex. 2041)
German regulations available at https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Abfallwirtschaft/kreislaufwirtscaftsgesetz_dn_bf.pdf (English translation) (Ex. 2042)
Certification from Braunschweig State Trade Supervisory Office to Duesenfeld (German) (Ex. 2043)
Certification from Braunschweig State Trade Supervisory Office to Duesenfeld (English) (Ex. 2044)
Translation Certification of Certification from Braunschweig State Trade Supervisory Office to Duesenfeld (Ex. 2045)
Duesenfeld GmbH Preliminary Financial Statements 2021 and 2022 (German) (Ex. 2046)
Duesenfeld GmbH Preliminary Financial Statements 2021 and 2022 (English) (Ex. 2047)

Translation Certificates - Duesenfeld GmbH Preliminary Financial Statements 2021 and 2022 (Ex. 2048)
License Agreement between Duesenfeld GmbH and Seval S.r.l., dated February 05, 2024 (Ex. 2049)
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Any other materials referenced in my Declaration.

Appendix C

Located at Exhibit 2035

Appendix D

Located at Exhibit 2036