

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ASCEND ELEMENTS, INC.,
Petitioner,

v.

DUESENFELD GMBH,
Patent Owner.

Case No. IPR2024-00948

U.S. Patent No. 11,050,097

DECLARATION OF WALTER VAN SCHALKWIJK, PH.D.

I, Walter van Schalkwijk declare as follows:

I. INTRODUCTION

1. I have been retained by Ascend Elements to provide analysis and opinions regarding the patentability of certain claims in U.S. Patent No. 11,050,097 ("the '097 Patent").

2. I am being compensated for my time at the rate of \$895 per hour. I have no interest in the outcome of this proceeding and the payment of my fees is in no way contingent on my providing any particular opinions.

3. If requested, I am prepared to explain (in a deposition or at a trial before

the Patent Trial and Appeal Board (the "Board")) the technology disclosed in the '097 Patent—including the state of the art in the relevant timeframe. Similarly, I am prepared to explain the technology disclosed in the Hanisch (U.S. Patent No. 9,780,419), Meador (U.S. Patent No. 5,632,863), Hayashi (U.S. Patent No. 9,843,077), and Shin (U.S. Patent No. 10,396,408) references, and in any other prior art references cited herein. This may include, among other things, background information on lithium battery design and recycling processes.

II. EDUCATIONAL AND PROFESSIONAL BACKGROUND

4. My qualifications to testify as an expert in the design and recycling of lithium batteries are set forth in my curriculum vitae attached as Appendix A—which includes a listing of cases in which I have provided expert testimony.

5. I am an expert in the field of lithium-ion batteries, with over 40 years of experience in the design of lithium-ion batteries and their chemistry, the characteristics of the materials used in construction of lithium-ion batteries, waste materials of such batteries, and the business considerations of processing such waste streams.

6. Since 2001, I have been an Affiliate Professor of Chemical Engineering at the University of Washington, and since 2020 I have been an Affiliate Professor of Materials Science and Engineering at the same institution. My focus is on the design and improvement of various technologies implemented in lithium-ion

batteries, and I was directly involved in the creation of some of the first lithium-ion batteries in 1986.

7. I hold a Ph.D. in electrochemistry from the University of Ottawa and I earned my M.Sc. in physical chemistry from Carleton University. I received my B.S. in chemistry from what is now the University of Massachusetts Lowell.

8. I have been active in professional societies since 1991, having held leadership positions and roles within the Electrochemical Society beginning in 1998, including service on that organization's Executive Committee of Battery Division (2002-04 and 2018), and the Executive Committee of the Energy Technology Division (2002-10, 2018-present).

9. I have received recognition for my work in the field of energy technology, and in May 2019 the Electrochemical Society established an award in my name to honor my work in the field of sustainable energy technology.

10. My curriculum vitae contains further details regarding my experience, education, publications, and other qualifications which allow me to render expert opinions in connection with this proceeding.

III. MATERIALS REVIEWED

In preparing this declaration, I reviewed and considered the following materials, along with any other materials referenced in the body of my declaration:

Exhibit	Description
1001	U.S. Patent No. 11,050,097 ("097 Patent")

Exhibit	Description
1002	Patent Prosecution History for U.S. Patent No. 11,050,097
1004	U.S. Patent No. 9,780,419 ("Hanisch")
1005	U.S. Patent No. 6,447,669 ("Lain")
1006	U.S. Patent No. 9,843,077 ("Hayashi")
1007	PCT Application Publication No. WO 2010/102377 ("Stevens")
1008	U.S. Patent No. 4,357,215 ("Goodenough")
1009	Dorella G. & Mansur M.B., A study of the separation of cobalt from spent Li-ion battery residues, 170 J. Power Sources 210 (2007) ("Dorella")
1010	U.S. Patent No. 10,396,408 ("Shin")
1011	U.S. Patent No. 5,632,863 ("Meador")
1014	U.S. Patent No. 9,509,025 ("Iida")
1015	U.S. Patent No. 3,671,318 ("Moe")
1016	U.S. Patent No. 4,118,219 ("Elmore")
1017	U.S. Patent No. 6,524,737 ("Tanii")
1018	U.S. Patent No. 9,450,277 ("Dunagan")

11. I may use these documents and information, or other information obtained during the course of this proceeding, as well as representative charts, graphs, schematics and diagrams, animations, and models based on those documents and information, to support and to explain my testimony.

12. My opinions are based in part on a review and analysis of the abovementioned documents and materials. I have also drawn on my education, experience, and knowledge of basic engineering and design principles in forming my opinions.

IV. RELEVANT ART AND LEVEL OF ORDINARY SKILL

13. I have been informed that the level of ordinary skill in the relevant art at the time of the invention is relevant to inquiries such as the meaning of claim

terms, the meaning of disclosures found in the prior art, and the reasons one of ordinary skill in the art may have for combining references.

14. I have been informed that factors that may be considered in determining the level of ordinary skill include: (1) the type of problems encountered in the art; (2) prior art solutions to those problems; (3) rapidity with which innovations are made; (4) sophistication of the technology; and (5) education level of active workers in the relevant field. I have been further informed that a POSITA is also a person of ordinary creativity.

15. In my opinion, A POSITA in the field of the '097 Patent would have had at least a master's degree in chemical engineering, mechanical engineering, materials science/engineering, or a related field, and three to five years of experience in design and implementation of battery recycling processes.

16. At the time of the alleged invention, I was at least a POSITA in the art relevant to the '097 Patent. Further, based on my experience, I understand and know of the capabilities of a POSITA in 2015—and I am familiar with how a POSITA would have understood and used the terminology found in the '097 Patent and the Challenged Claims at the time of filing, and with the state of the art at that time.

17. Even though my own experience and qualifications exceed that of a POSITA, the statements herein regarding the knowledge of a POSITA and what would have been obvious to a POSITA are from the perspective of POSITA at the

relevant priority date.

V. LEGAL STANDARDS APPLIED

18. I am not an attorney, but I have been informed of several legal principles, which I have employed in forming my opinions in this declaration. I have been informed that each patent claim is considered separately for purposes of patentability and that a dependent claim that depends from another claim includes all of the limitations of the claim from which it depends.

A. Burden of Proof

19. I have been informed that the petitioner in an *inter partes* review bears the burden of establishing unpatentability by "a preponderance of the evidence." I have been further informed and understand that, to prove an assertion by "a preponderance of the evidence," the party with the burden of proof must demonstrate that it is more likely than not that the assertion is true.

B. Claim Construction

20. I have been informed that the claims of the '097 Patent in this proceeding are to be construed using the same claim construction standard applied in district court. I have been informed the claim construction analysis begins with the ordinary meaning of a claim term, and there is a presumption that the term carries its plain and ordinary meaning to a person of ordinary skill in the art ("POSITA") as of the effective filing date of the patent. I have also been informed that the most important sources for determining the meaning of a claim term are the claims, the

specification, and the prosecution history of the patent at issue, which collectively is "intrinsic evidence."

I have also been informed that a patentee can act as their own lexicographer and provide specific definitions of claim terms that may differ from the plain and ordinary meaning. The '097 Patent defines the term "drying" to mean "the removal of at least one solvent in the conducting salt." (EX1001, 2:23-25.) I have applied this definition of "drying" in my analysis. For all other terms in the '097 Patent, I have performed my analysis using their plain and ordinary meaning to a POSITA.

C. Anticipation

21. I have been informed that a patent claim is unpatentable if it is "anticipated" by prior art. I have been informed that a reference anticipates a claim if the reference discloses each limitation of the claim at issue, either expressly or inherently. I have been informed that a prior art reference may anticipate a claim without disclosing a feature of the claimed invention if that missing characteristic is necessarily present, or inherent, in the single anticipating reference as would have been understood by a POSITA.

D. Obviousness

22. I have been informed that a patent claim is unpatentable if it would have been obvious to a POSITA at the time of the claimed invention. I have been further informed that a claimed invention is not patentable if differences between it and the

prior art are such that the subject matter as a whole would have been obvious to a POSITA at the time of invention. I have been informed that factors relevant to the determination of obviousness include the scope and content of the prior art, the level of ordinary skill in the art at the time of the invention, differences between the claimed invention and the prior art, and "secondary considerations" or objective indicia of nonobviousness.

23. I have been informed that a single reference alone can render a patent claim obvious if any differences between the reference and the claim would have been known or obvious to a POSITA at the time of the invention. That is, if the POSITA could have adapted the reference to meet the claims of the patent by applying known concepts to achieve expected results, then the patent claims are rendered obvious by that reference.

24. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I have been further informed and understand that when a patent claim simply arranges old elements with each performing the same function it had been known to perform and yields no more a POSITA would expect from such an arrangement, the combination is obvious.

25. I have been informed that a patent claim composed of several limitations is not obvious merely because each limitation was independently known

in the prior art. Hindsight reasoning is not an appropriate basis for combining references to form an obviousness combination. I have been further informed that it can be important to identify a reason that would have prompted a POSITA to combine multiple prior art references, or multiple teachings of the same prior art reference.

26. I have been informed that various "secondary considerations" (sometimes referred to as objective indicia of nonobviousness) may support a determination of nonobviousness and that such secondary considerations must be considered as part of an obviousness analysis. I have been informed that even strong evidence of secondary considerations may not be sufficient to rebut a strong showing of obviousness. I have been informed that the patentee bears the burden of showing the existence and effect of secondary considerations of nonobviousness, after which the burden of coming forward with rebuttal evidence shifts to the party arguing obviousness. I have been informed that the following secondary considerations may indicate nonobviousness:

- a. Evidence that others, including the accused infringer, copied the patented invention.
- b. Evidence of a persistent problem or need in the art that was resolved by the patented invention.
- c. Evidence that others have tried and failed to solve the problem

or failed to provide the need resolved by the claimed invention.

- d. The willingness of industry to license the patent at issue.
- e. Evidence that those of ordinary skill in the art were skeptical as to the merits of the invention.
- f. Evidence of praise directed to the invention by others in the field.
- g. Evidence that those of ordinary skill in the art were surprised by the capabilities of the claimed invention.

27. I have also been informed that the near-simultaneous invention by others can be evidence that a claimed invention is obvious.

28. I have further been informed that the patentee bears the burden of showing a "nexus" between the claimed invention and the evidence proffered on secondary considerations.

VI. TECHNOLOGY BACKGROUND

29. The '097 Patent deals with recycling used batteries, including but not limited to lithium-ion batteries. The technologies and challenges involved in the design and recycling of such batteries have been well-understood in the art for many years prior to the effective filing date of the '097 Patent.

30. Lithium-ion batteries are units that transform electrical energy into chemical energy, storing it for future use. The fundamental component of a battery is the electrochemical cell, which, through series-parallel configurations, achieves

the necessary energy capacity and voltage to operate a device. Each cell consists of a cathode, an anode, a separator, and an electrolyte. Both the cathode and anode are mounted on substrates linked internally to the cell's casing, allowing for positive and negative connections to other cells within the battery, and eventually to the external circuits that utilize the battery.

31. For example, such lithium-ion battery compositions are disclosed in Lain, which has an effective filing date of December 3, 1997. (*See* EX1005, 1:5-29, 2:25-39.) Similar designs have been known in the art since the 1980s (EX1008, 3:25-4:15) and lithium-ion battery designs using carbon particle anodes and ethylene carbonate solvent were disclosed as early as 1990.s

32. As is well known to a person of ordinary skill in the arts ("POSITA"), a lithium-ion cell and battery are comprised of a cathode, an anode, a solid electrolyte interphase, a separator, the electrolyte, as well as other structural components, all of which are critical for its function and safety.:

1. Lithium-ion Battery Design and Components

a) The Cathode

33. In a lithium-ion battery, the cathode, or positive electrode, typically consists of a lithium-containing transition metal oxide or phosphate, the most common examples being LiCoO_2 (LCO) or LiFePO_4 (LFP). The cathode provides the reservoir of lithium that will be moved back and forth between the cathode and

anode as the battery is charged and discharged.

34. The cathode material is a finely divided powder, characterized by specific particle sizes and shapes. It is combined with a binder, such as polyvinylidene fluoride (PVDF), and a small amount of “electric carbon” to form a slurry that is then applied to an aluminum substrate. After coating, the mixture is dried, compressed to a specific thickness through calendaring, and trimmed to a precise geometric area. Adjustments, such as coating the cathode particles and doping the cathode with small amounts of other elements —enhance its durability, enabling the battery to achieve a longer operational lifespan.

b) The Anode

35. In most instances, the anode of a lithium-ion battery is made from either natural or synthetic graphite. Graphite is a layered, crystalline form of carbon which provides good conductivity and allows for the insertion of lithium ions between its layers during the charging of a lithium-ion battery.

36. Like the cathode process, the anode material is combined with a binder to create a slurry, which is then coated onto a copper substrate. As with the cathode, following the application, this mixture is dried, compressed to a designated thickness using a calendaring process, and cut to a specific geometric size.

37. There are several other prominent anode materials that have been found in commercially available lithium-ion batteries before the filing date of the '097

patent. Such materials include lithium titanium oxide, silicon, and hard carbon.

38. Lithium titanium oxide (LTO) is known for its exceptional safety and stability over a wide range of temperatures. LTO anodes are often used in applications requiring high-rate capabilities and a large number of charge/discharge cycles.

39. Silicon can store about ten times more lithium per gram than graphite, which significantly increases the energy density of the battery. However, its volume expands dramatically during charging, which can lead to mechanical degradation and reduced battery life. It is often used in a composite with graphite to mitigate these effects.

40. Hard carbon is another form of carbon with a disordered structure, hard carbon is used in some niche applications, especially in anodes for sodium-ion batteries.

c) The Separator

41. The separator is a thin microporous film that physically divides the cathode and anode while allowing lithium ions to pass through. It is crucial in preventing the electrodes from touching and causing a short circuit.

42. As of the filing date of the '097 patent, the separators used in lithium-ion batteries were primarily made from porous polymer films, due to their good chemical stability, mechanical strength, and ability to facilitate ion transfer while

preventing electrical contact between the anode and cathode. The most common types of materials used for these separators included polyethylene, polypropylene, composite membranes, and coated separators.

43. Polyethylene (PE) is a popular choice for separators because it has a low melting point, which acts as a safety feature; the pores of the separator close when the temperature rises too high, preventing further reactions that might result in a thermal runaway.

44. Polypropylene (PP) is used either on its own or in combination with polyethylene. It has a higher melting point than PE, providing additional thermal stability.

45. Composite membranes are made from layers of different materials, typically combining the properties of PE and PP. For instance, a separator might have a core of PP for thermal stability, sandwiched between layers of PE for shutdown safety.

46. Coated separators involve a base membrane (often PE or PP) that is coated with additional materials like ceramic or alumina to enhance thermal stability and wettability, which improves the ionic conductivity. The coating also helps to prevent shrinking of the separator to minimize the chance for an internal short circuit (anode touching cathode) in the cell.

47. The material used in the separator is chosen for the ability to permit

ionic flow (necessary for battery operation) while maintaining physical separation between the electrodes to prevent short-circuiting. Over time, advances in separator technology have focused on improving safety features, enhancing battery performance, and increasing the overall efficiency of lithium-ion batteries.

d) The Electrolyte

48. As of the filing date of the '097 patent, the predominant electrolyte used in lithium-ion batteries was typically based on a mixture of organic carbonates with a lithium salt, primarily lithium hexafluorophosphate (LiPF_6), dissolved therein.

49. The liquid electrolyte in a lithium-ion battery plays several crucial roles that are essential for the battery's operation and overall performance. These include ion transport, electrical insulation, formation of the solid electrolyte interphase, thermal management, as well as ionic contact and conformity with the internal structures such as the anode, cathode, and separator.

50. Ion transport is the primary function of the liquid electrolyte. This means that the electrolyte serves as a medium through which lithium ions can move between the cathode and anode during charging and discharging cycles. The electrolyte contains dissolved lithium salts (such as lithium hexafluorophosphate, LiPF_6) which dissociate into lithium ions and accompanying anions. These ions are what carry the electric charge across the cell, enabling the electrochemical reactions that power the battery.

51. While the electrolyte facilitates the flow of ions, it also acts as an electrical insulator, ensuring that electrons cannot pass directly from the anode to the cathode within the battery. This separation is crucial because it forces electrons to travel through an external circuit to reach the cathode, thus doing useful work (such as powering a device).

52. The electrolyte is also involved in the formation of the solid electrolyte interphase (SEI) on the surface of the anode as described earlier. The SEI allows lithium ions to pass through while preventing direct contact between the electrolyte and the anode material. This layer is vital for enhancing the lifespan and safety of the battery by reducing unwanted side reactions.

53. The liquid electrolyte also helps with thermal management, distributing heat generated during the battery's operation. This is important for maintaining the battery's temperature within safe operating limits. Excessive heat can lead to thermal runaway, which might cause the battery to degrade prematurely or even fail catastrophically.

54. As a liquid, the electrolyte can easily infiltrate the porous structure of the electrodes and the separator, ensuring good ionic contact and conformity to irregular surfaces. This maximizes the surface area over which the electrochemical reactions can occur, thus improving the efficiency and capacity of the battery.

55. The performance of the liquid electrolyte, including its ionic

conductivity, electrochemical stability, and compatibility with other battery components, critically influences the overall efficiency, safety, and durability of lithium-ion batteries.

56. Common components of these electrolytes include organic carbonates such as ethylene carbonate (EC), dimethyl carbonate (DMC), diethyl carbonate (DEC), and ethyl methyl carbonate (EMC).

a. Ethylene Carbonate (EC): A crucial component due to its high dielectric constant and ability to dissolve lithium salts effectively.

b. Dimethyl Carbonate (DMC): Used for its low viscosity and good conductive properties but is known to be a volatile compound and flammable.

c. Diethyl Carbonate (DEC): Also chosen for its low viscosity and providing excellent conductivity for the electrolyte.

d. Ethyl Methyl Carbonate (EMC): Frequently used to provide a balance between the properties of DMC and DEC but is known to be a volatile compound and flammable.

57. These organic carbonates were blended to optimize the electrolyte's properties, such as ionic conductivity, viscosity, and temperature stability. Ethylene carbonate was essential in forming a stable SEI on the anode surface. Most lithium-ion batteries employ these components in their electrolyte; however, some cells may be found that use different solvents or salts.

58. Special additives are usually included in electrolyte formulations in

small quantities, but their identity and the amount used are usually proprietary. These additives are usually consumed during the final stages of cell manufacture, so their identity is not revealed in Safety Data Sheets. Thus, these additives cannot be recovered during a recycling process.

e) Additional Components

59. Besides the chemical components like the cathode, anode, electrolyte, substrates, and separator, a lithium-ion battery cell includes several other components that are critical to its function and safety. These include:

a. **Current Collectors:** These are conductive materials that serve as substrates for electrode materials. Typically, aluminum is used for the cathode and copper for the anode. They facilitate the movement of electrons in and out of the electrodes during the battery's operation.

b. **Battery Casing:** The casing encloses all internal components of the battery and provides structural integrity. It is usually made of metal or plastic and is designed to withstand physical stress and, in some cases, to act as a safety barrier against external elements.

c. **Electrical Insulators:** Insulating materials are used to prevent unintended electrical contact between various internal parts of the battery, particularly between the current collectors and the battery casing.

d. **Tabs and Leads:** These are metal strips or wires that connect the

current collectors to the external terminals of the battery. They play a critical role in conducting the electric current from the internal electrodes to the device or charger.

e. Vent Mechanism: Some lithium-ion batteries include a built-in pressure relief vent. This vent is a safety feature designed to release internal pressure if it becomes too high, thus preventing the battery from rupturing or exploding.

f. Thermal Management Components: Depending on the battery design, various thermal management components like thermal pads or gels might be included to help regulate the temperature within the battery during operation.

g. Safety Circuitry: In battery packs, especially those used in consumer electronics, additional circuitry may be included to manage charging and discharging rates, monitor temperature, and ensure overall safety through features like overcharge protection and thermal shutdown.

60. These non-chemical components are essential for the safe and efficient operation of lithium-ion batteries, playing key roles in structural support, electrical management, and safety.

2. Operation of Lithium-Ion Batteries

61. A lithium-ion battery operates through a series of electrochemical

reactions that enable the flow of ions back and forth between the anode (negative electrode) and cathode (positive electrode) during charging and discharging cycles.

62. When the battery is connected to a power source for charging, the lithium ions move from the cathode through the electrolyte towards the anode. Simultaneously, electrons flow from the cathode to the anode through an external circuit (the charger and wires connecting it to the battery). Once the lithium ions arrive at the anode, they intercalate (embed) themselves within the anode material, usually graphite. This storage of lithium ions at the anode is what "charges" the battery.

63. When the battery is used to power a device, the stored lithium ions at the anode are released back into the electrolyte and travel towards the cathode, where they re-enter the cathode material, often a lithium metal oxide. As the lithium ions move, electrons are simultaneously released from the anode and travel through the external circuit (now the device being powered) to the cathode. This electron flow through the external circuit provides the electrical energy to power the device.

3. Recycling Lithium-ion Batteries

64. The economic and environmental considerations of recycling batteries such as lithium-ion batteries have been long understood in the art. The recycling process not only helps in reducing production costs and conserving natural resources but also reduces the environmental impact of mining and processing raw materials;

as materials such as lithium cobalt oxide and electrolyte salts can be costly to produce. (EX1009, 210-11.) Cobalt, lithium, nickel, copper, iron, and aluminum can be recovered, as well as chemicals such as electrolyte solutions. Preserving such materials has been a central design focus for such batteries and their anticipated waste streams for decades before the filing date of the '097 Patent.

65. The '097 Patent discloses processing techniques like comminution and vacuum/low-pressure drying. (EX1001, 1:11-12; 3:4-16.) Comminution can include shredding or cutting up materials into smaller pieces. (EX1001, 2:57-58, 8:2-5) (battery cells "are fed into a comminution unit 18, which comprises, for example, a rotary shear with a rotor and a stator or several rotors, or a cutting mill with a rotor and/or several rotors.".) This sort of process has been known for decades. (EX1016, 2:23-29; EX1011, 3:26-30.)

66. As the '097 Patent acknowledges, comminution leads to smaller particles having greater available surface area, which facilitates evaporation from the surface of the comminuted material. (EX1001, 2:57-58.) This is a phenomenon that has been understood for at least a century, if not longer, and occurs because there are more surface molecules per unit of volume that are potentially able to transition into a gas phase.

67. The risks associated with recycling lithium-ion batteries have also been long known in the art. For example, it has been known that LiPF_6 , a commonly used

electrolyte in lithium-ion batteries can undergo hydrolysis in the presence of water to form hydrogen fluoride, which is toxic. (EX1006, 1:26-29, 2:7-11.) Organic carbonate solvents such as EMC or DMC are also volatile and flammable. (EX1006, 1:26-29, 2:7-11, 4:12-23; EX1007, [0041].)

68. It has long been understood in the art that battery recycling processes, including those for lithium-ion batteries, should avoid conditions that could lead to explosion, fire, and/or release of toxic compounds. Lower temperatures during LiPF_6 evaporation, for example, have long been known to be desirable given the reduction of hydrogen fluoride formation from the electrolyte. (EX1005, 1:20-24, 2:2-27.) This comes from the understanding of the basic Arrhenius relationship in thermodynamics. This relationship, which is guided by pre-exponential and activation energy factors, means that rates of reaction slow by approximately half when the temperature is reduced by 10 degrees Celsius, or approximately double if the temperature is increased by 10 degrees Celsius. Thus, lower temperatures reduce the rate of the LiPF_6 hydrolysis reaction that forms toxic HF, thereby slowing HF formation.

69. Similarly, it has long been understood that reduced ambient air pressure lowers the boiling point of fluids (the temperature at which a fluid transitions to a gas), such that drying under reduced air pressure or in a vacuum can allow the use of lower drying temperatures than needed at higher ambient pressures. (EX1017,

26:31-34.) A common example of this is the demonstration that water can boil at room temperature, rather than the normal boiling point of 100°C, if a vacuum is applied. The lower temperature conditions that allow for the reduction in HF formation by slowing the rate the LiPF_6 hydrolysis reaction also tend to slow the rate of organic solvent evaporation. Reducing the pressure conditions thus provides the benefit of facilitating such organic solvent evaporation at the lower temperatures used to reduce the rate of HF formation from LiPF_6 hydrolysis.

70. The prior art reveals numerous examples in the context of battery recycling (including recycling lithium-ion batteries) of the use of reduced atmospheric pressure and reduced drying temperatures. (EX1005, 2:57-67; 3:10-15; EX1006, 2:24-28, 3:12-19, 4:1-5, 4:38-5:25; EX1004, 3:65-4:8.) Early work on water-activated batteries demonstrated that batteries with aqueous electrolyte solvents could be rendered inactive by evaporating the water from the electrolyte using heat and vacuum (EX1015, 6:63-7:38.) And other prior art in the field of lithium-ion batteries, demonstrated that by heating the batteries to temperatures around 150°C under vacuum, the organic solvents in the electrolyte would evaporate, resulting in a voltage drop to near zero due to the inactivation of the electrochemical reactions in the cell; evaporating organic solvents in the electrolyte would thus "completely destroy the function of the battery." (EX1014, 6:65-7:8, Fig. 2.)

71. In addition, it has been well-known in the art that comminuted material that results from shredding and drying stages of lithium-ion battery recycling contains a mix of materials including lithium, manganese, cobalt, and nickel, among other compounds, many of which can exist in toxic or hazardous forms when present in this material. Because such material can often exist in a fine particulate that can enter air circulation if sufficiently disturbed, it has also been well-known in the art that care must be taken to prevent dust and fine particulate from entering air circulation, given the potential for health risks from inhalation or soft tissue exposure.

VII. PRIOR ART

A. Hanisch Summary

72. Hanisch is a U.S. Patent entitled "Method for Reclaiming Active Material from a Galvanic Cell, And Active Material Separation Installation, Particularly an Active Metal Separation Installation." (EX1004.) Hanisch claims priority to a German patent application publication, DE 102011110083, filed August 12, 2011, several years before the effective filing date of the '097 Patent. I note that the '097 Patent acknowledges that Hanisch was prior art, noting that Hanisch discloses "a method for recovering active material from a galvanic cell." (EX1001, 1:43-50.)

73. Hanisch relates to battery recycling process and systems, such as those

for "retrieving active material, in particular lithium or lithium compounds, from a galvanic cell, which comprises an active material, a support for the active material, a binder for bonding the active material and the support and if necessary an electrolyte." (EX1004, 1:8-12.) Hanisch discloses a method of treating used batteries "with the steps: (a) crushing the cells, in particular under inert gas, so that solid cell fragments are also formed, (b) heating the solid cell fragments up to the decomposition temperature, which is high enough to make the binder decompose and/or evaporate, such that heat treated cell fragments are formed, and (c) classifying the heat treated cell fragments." (EX1004, 1:12-18.)

74. Hanisch also describes the use of heating shredded batteries at temperatures below 80°C to evaporate materials like electrolyte solvents: "The method preferably comprises the step that, before heating the cell fragments up to the decomposition temperature, the cell fragments are dried at a drying temperature, so that dry cell fragments and drying vapours are formed, whereby the drying vapours are at least partly condensed. This has the advantage that the electrolyte solvent can be retrieved. It is therefore advantageous for the drying temperature to be below 100°C., in particular below 80°C." (EX1004, 3:65-2:5.) Hanisch describes an example apparatus for this evaporative drying as "a pre-dryer which is set up in the material flow, behind the cell crushing device and before the oven. The pre-dryer is configured to heat the cell fragments up to the drying temperature." (EX1004,

4:55-59.)

75. Hanisch also describes the use of high-temperature heating of shredded batteries to cause the decomposition of the binder: disclosure also includes "heating the solid cell fragments up to the decomposition temperature, which is high enough to make the binder decompose and/or evaporate," (EX1004, 1:14-17.) Hanisch provides an example of an apparatus that can be used to carry out this high-temperature heating in the description accompanying Fig. 1: "An oven 44 is set up in the direction of material flow behind the classifier 42, in which there is a decomposition temperature T_z between 400 and 600°C. The binder, for example, polyvinylidene flouride [sic] (PVDF), thus decomposes." (EX1004, 6:8-11.)

B. Meador Summary

76. Meador is a U.S. Patent entitled "Battery Pyrolysis Process." Meador issued May 27, 1997, approximately eighteen years before the effective filing date of the '097 Patent.

77. Meador relates to the treatment and recycling of a range of battery types, including lithium batteries: "reclamation of used batteries and recovery of the metals, and organic and inorganic materials," including "lithium batteries." (EX1011, 3:12-23.) Meador describes comminuting batteries in "a crusher or grinder," followed by transferring that material to a pyrolysis chamber, where this comminuted material is heated to high temperatures that decompose the material.

(EX1011, abstract & 3:17-30.) According to Meador, the pyrolysis chamber can be maintained under slight vacuum such as 0.5 inches of mercury, (EX1011, 3:24-25) which is approximately 16.9 hPa. Meador explains that this resulting dried material "containing valuable components of the batteries and other wastes" are transferred to a "hopper or bin." (EX1011, 3:17-37.)

C. Hayashi Summary

78. Hayashi is a U.S. Patent entitled "Method for Processing Fluorine-Containing Electrolyte Solution." Hayashi was published on Oct. 2, 2014, as WO/2014/155784, before the effective filing date of the '097 Patent.

79. Hayashi relates to various approaches to processing electrolyte solutions such as those used in lithium-ion batteries. These solutions include compounds such as lithium hexafluorophosphate and organic solvents such as dimethyl carbonate and ethyl methyl carbonate. (EX1006, 4:1-23.) Hayashi describes heating lithium-ion batteries containing the electrolyte solution under reduced pressure, such that the organic solvents of the electrolyte are evaporated. (EX1006, 4:33-36.) In several examples, Hayashi explains that using reduced pressure during evaporation makes it possible to create conditions that reduce the boiling points of volatile organic solvents used in lithium batteries such that they can be evaporated under controlled conditions. (EX1006, 4:43-67.) Hayashi also notes that the organic solvents used in the electrolyte solution of lithium-ion batteries have

boiling points of 90°C for dimethyl carbonate and 109°C for ethyl methyl carbonate. (EX1006, 4:38-45.) In several examples, heating is carried out at pressures "less than or equal to 1 kPa" over temperatures ranging from 80°C to 150°C. (EX1006, 3:20-25.)

D. Shin Summary

80. Shin is a U.S. Patent entitled "Waste Battery Treatment Apparatus Using Continuous Heat Treatment, and Method for Recovering Valuable Metals from Lithium-Based Battery Using Same." Shin claims a priority date of February 11, 2015.

81. Shin relates to treatment of waste batteries including lithium-ion batteries, for example, by heating batteries under a vacuum, such that electrolyte is evaporated during the process. (EX1010, 2:65-3:20.) According to Shin this vacuum drying provides the benefit of mitigating combustion or explosion risks, and also reduces the chance that poisonous gases are released. (EX1010, 3:42-4:17.) Shin recognizes that recycling lithium-ion batteries allows for the recovery of useful and valuable materials. (EX1010, 1:15-17, 2:65-3:1.)

VIII. SUMMARY OF OPINIONS

82. I have been asked to compare the references cited herein to claims 1-3, 7, 8, 9, 10, 12-13, and 19 of the '097 patent (the "Challenged Claims").

a. Ground 1: In my opinion, every element of the Challenged

Claims can be found explicitly or inherently in Hanisch, when read from the perspective of a POSITA. In addition, it is my opinion that the minor differences between the subject matter in Hanisch and the Challenged Claims, in view of the knowledge of a POSITA, would have been obvious to a POSITA.

b. Ground 2: In my opinion, the minor differences between the subject matter in Hanisch (in view of Meador, Shin, and/or Hayashi and the knowledge of a POSITA) and the Challenged Claims, would have been obvious to a POSITA.

IX. GROUND 1 –HANISCH ALONE OR IN COMBINATION WITH DUNAGAN, IN VIEW OF THE KNOWLEDGE OF A POSITA

A. Claim 1

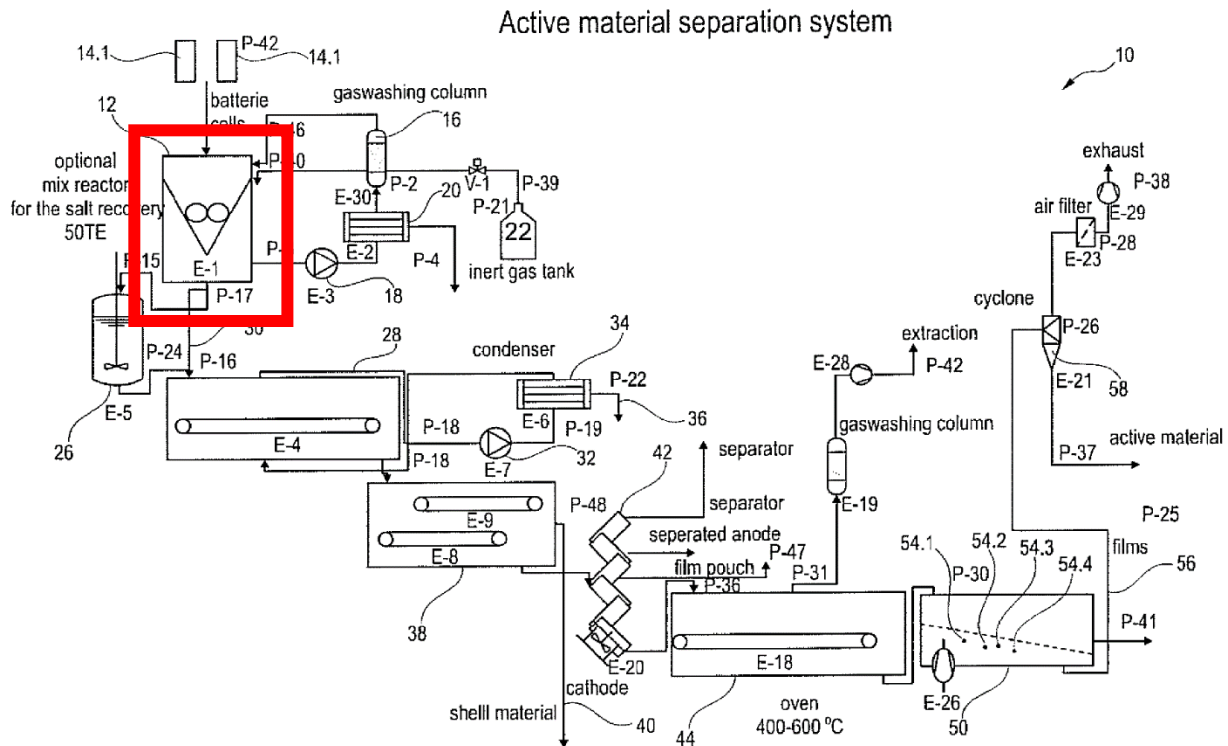
1. Claim 1 [pre]: "A method for the treatment of used batteries, comprising the steps:"

83. In my opinion, a Hanisch discloses methods for treatment of used batteries because it teaches that "the invention concerns a method for retrieving active material, in particular lithium or lithium compounds, from a galvanic cell. . ." (*see* EX1004, 1:8-10) and "the object of the invention is to improve the retrieval of lithium or lithium compounds, from old batteries or accumulators." (*See* EX1004, 1:42-45.)

2. Claim 1[a]: "(a) comminuting the batteries such that comminuted material is obtained;"

84. Hanisch discloses this limitation. The '097 Patent itself admits that Hanisch teaches a method in which "galvanic cells are initially mechanically comminuted." (*See* EX1001, 1:43-45.)

85. In my opinion, a POSITA would understand that comminution refers to processes such as cutting, chopping, grinding, shredding, and other such physical mechanisms of reducing starting materials, such as batteries, into smaller pieces. This view is further supported where Hanisch explains that it uses the term "crushing" in a manner synonymous with comminution, as would be understood by a POSITA. (EX1004, 2:65-67.) Hanisch discloses at item 12 of Fig. 1 a device in a processing system that comminutes batteries: "FIG. 1 shows a flow chart of the active material separation system 10 according to the invention, which possesses a cell crushing device 12, to which galvanic cells 14.1, 14.2, . . . are supplied." (EX1004, 5:37-40.) Item 12, indicated in the figure below by the added red box annotation is the comminuting device:



86. Hanisch provides additional examples of comminuting batteries to produce comminuted material, such as "crushing the cells, in particular under inert gas, so that solid cell fragments are also formed." (EX1004, 1:13-14; *see also* EX1004, 1:24-28, 3:19-26.) Hanisch also discloses examples of the comminuting machinery that could be used. (EX1004, 5:14-22.)

3. **Claim 1[b]: "(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"**

87. In my opinion a POSITA would understand that the '097 Patent discloses two examples of inactivating the comminuted material: (1) an electrolyte

evaporation approach that involves heating the comminuted material to evaporate organic carbonate solvents in the electrolyte to minimize the possibility of electrochemical reactions in the comminuted material, (*see, e.g.*, EX1001, 1:6-2:2, 4:5-18) and (2) heating the comminuted material to the point that the binder carrying the electrochemically active material in the battery decomposes (*see, e.g.*, EX1001, 5:37-52).

88. In my opinion Hanisch discloses both examples of this limitation. As to the electrolyte evaporation example Hanisch discloses this limitation because it teaches that the comminuted material is dried to evaporate the electrolyte and solvent from the comminuted material and that this is carried out after the comminution step. Hanisch also discloses the decomposition heating example of this limitation because a POSITA would have understood that Hanisch and the '097 Patent both teach the step of heating comminuted materials containing a binder that carries active material from the battery to decomposition temperature.

a) Hanisch's Disclosure of the Electrolyte Evaporation Approach for Inactivating Comminuted Material

89. As to the electrolyte evaporation approach, a POSITA would have understood that Hanisch discloses the same electrolyte evaporation approach taught in the '097 Patent for several reasons.

90. For example, the '097 Patent teaches that "drying should be understood particularly to mean the removal of at least one solvent in the conducting salt. In

particular, the drying is executed such that dimethyl carbonate and/or ethyl carbonate is removed." (EX1001, 2:24-27.) A POSITA would have understood that term "conducting salt" used in this context, had the same meaning as the term "electrolyte" mentioned in the '097 Patent.

91. The '097 Patent further discloses that the "amount of electrolyte that can be obtained from the comminuted material through drying is such that an electrochemical reaction is no longer possible, or only to a negligibly small extent." (EX1001, 1:63-66.) A POSITA would therefore have understood from these disclosures that this limitation could include inactivating the comminuted material by the evaporation of sufficient portions of the electrolyte, such as organic carbonate solvents like dimethyl carbonate and/or ethyl carbonate.

92. A POSITA would conclude that Hanisch discloses this limitation under the electrolyte evaporation approach because it teaches the use of a "pre-dryer" that heats the comminuted material to a "drying temperature, so that dry cell fragments and drying vapours are formed, whereby the drying vapours are at least partly condensed. This has the advantage that the electrolyte solvent can be retrieved." EX1004, 3:67-4:4.

93. Hanisch provides additional disclosures of this limitation, for example, that the system "preferably possesses a pre-dryer which is set up in the material flow, behind the cell crushing device and before the oven. The pre-dryer is configured to

heat the cell fragments up to the drying temperature." EX1004, 4:55-59. Hanisch also discloses this limitation in the description of Fig. 1: "A pre-dryer 28 is set up in the direction of material flow behind the cell crushing device 12, which is connected to the cell crushing device 12 via a pipe 30. During crushing of the galvanic cells 14, resulting cell fragments arrive at the pre-dryer 28 via the pipe 30. Here there is a dry temperature T_t of preferably $T_t=80^{\circ}\text{C}$. The pre-dryer 28 comprises a circulation pump 32 and a condenser 34 for condensing electrolyte, which can be removed via the pipe 36. The pre-dryer 28 is designed to be gas-proof and is flushed with inert gas by the circulation pump 32." EX1004, 5:54-63; Fig. 1. Hanisch also claims this limitation in dependent claim 5, "The method according to claim 1, further comprising the steps of: drying the solid cell fragments at a drying temperature to form dry cell fragments and drying vapours and at least partly condensing the drying vapours to retrieve electrolyte solvents before heating the solid cell fragments up to the decomposition temperature." (EX1004, claim 5.)

b) Hanisch's Disclosure of the Decomposition Heating Approach to Inactivating Comminuted Material

94. As to the decomposition heating approach, a POSITA would have understood that Hanisch discloses the same approach as that in the '097 Patent for several reasons.

95. In my opinion, a POSITA would have understood that Hanisch and the '097 Patent disclose the same active material, support foil and binder being subjected

to heating to decompose the binder carrying the active material.

96. Hanisch and the '097 Patent disclose the same "active material." The '097 Patent teaches that "[t]he active material should be understood to mean the material that reacts electrochemically during operation of the batteries." EX1001, 5:53-55. A POSITA would have understood this description to refer to materials such as a cathode comprising lithium-based compounds and/or an anode comprising carbon-based compounds because these are the parts of the lithium battery that react electrochemically to provide an electric current during battery operation.

97. Similarly, Hanisch teaches that "active material is understood in particular to mean a bond which can reversibly take up and release lithium-ions. On the cathode side, for example, lithium nickel manganese cobalt oxide, lithium nickel aluminum oxide, and lithium iron phosphate; on the anode side, for example, graphite." (EX1004, 3:9-13.) A POSITA would have understood this disclosure of "active material" in Hanisch to be substantially the same disclosure of "active material" as that in the '097 Patent because they would have understood that this portion of Hanisch discloses components in the battery that react electrochemically during the operation of the battery.

98. Hanisch and the '097 Patent also both disclose that the active material in lithium-ion batteries is present in the form of particles on an aluminum-based foil. For example, the '097 Patent teaches that a "carrier for the active material should be

understood particularly to mean a carrier foil to which the active material is applied in the form of particles." EX1001, 5:55-57. Hanisch discloses that the "support for the active material is understood in particular to mean a support foil, upon which the material is placed in the form of particles. The support foil can, for example, be aluminum foil." EX1004, 3:14-17.

99. And both the '097 Patent and Hanisch disclose the use of a polyvinylidene fluoride binder that binds the active material to the foil. For example, the '097 Patent teaches that the "binder is the material which binds the active material with the carrier; for example, the binder contains polyvinylidene fluoride." EX1001, 5:59-61. Similarly, Hanisch discloses the "binder for bonding the active material and the support", (EX1004, 1:11-3) and that "[t]he binder can, for example, be polyvinylidene fluoride (PVDF)." (EX1004, 3:17-18.) A POSITA would have understood from these disclosures that the '097 Patent and Hanisch teach the same binder.

100. These disclosures would, in my opinion, lead a POSITA to understand that both Hanisch and the '097 Patent disclose subjecting the same materials to the decomposition heating process to free the active material from the binder.

101. Specifically, the '097 Patent discloses "drying at a drying temperature and for a drying time that have been selected such that the binder which binds the active material of the lithium battery to a carrier at least largely decomposes."

(EX1001, 5:38-41.) Hanisch also discloses such a drying process, for example, "heating the solid cell fragments up to the decomposition temperature, which is high enough to make the binder decompose and/or evaporate". (EX1004, 1:14-17.) Hanisch provides additional disclosures of this process in the description accompanying Fig. 1.: "An oven 44 is set up in the direction of material flow behind the classifier 42, in which there is a decomposition temperature T_z between 400 and 600°C. The binder, for example polyvinylidene fluoride (PVDF), thus decomposes." (EX1004, 6:8-11.)

102. In my opinion, a POSITA would further understand that decomposing the binder that carried the active material would render the resulting material inactive and not capable of undergoing the sorts of electrochemical reactions that would be observed in a functioning battery.

103. It is also my opinion that a POSITA would also understand that for solvents like EMC and DMC that have boiling points around 90-110°C, heating to temperatures used for decomposing a binder (e.g., at or above 400°C) would also mean that solvents like EMC and DMC would be evaporated and removed from the comminuted material. A POSITA would appreciate that the removal of such solvents would tend to prevent electrochemical reactions from occurring in the comminuted material, such that it was inactivated.

4. Claim 1[c]: "(c) filling a transport container with the inactivated comminuted material;"

104. A POSITA would, in my opinion, have understood that this limitation was obvious from Hanisch because it explains that the "invention concerns a method for retrieving active material, in particular lithium or lithium compounds, from a galvanic cell." Further, where a POSITA would understand that the recovered materials at issue in Hanisch would typically contain rare and often costly substances, such as lithium, copper, nickel, and/or cobalt, which can then be reused in downstream activities such as battery and/or battery component manufacturing.

105. In my opinion, a POSITA would consider it obvious that, to make the recovered materials available to such downstream manufacturers or processors, the recovered materials would have to be collected in some form of container for transport; such reuse would require that the recovered materials be transported to other locations such as battery and/or battery component manufacturing plants, or other facilities that would process and use the recovered materials.

106. In my opinion, a POSITA, in view of the common knowledge in the field before the effective filing date of the '097 Patent would have considered it obvious that the recovered inactivated comminuted material would need to be transported in a safe and effective manner, which would require the use of a container given the safety and health risks known to be associated with the chemicals and metal compounds in the mixture. A POSITA would have understood that there were

commercially available containers such as bags, bins, or other such containers commonly used and suitable to transport bulk materials such as the inactivated comminuted material. But even if Hanisch does not disclose this limitation by itself, in my opinion, a POSITA would have considered this limitation obvious from Hanisch in view of Dunagan (which deals with recycling used batteries to recover metals and other materials, EX1018, 4:6-14, and does so using comminution and inactivation methods, EX1018, 4:27-6:37). Dunagan expressly discloses the use of such containers to store and transport comminuted material: "[t] further processed material will then be disposed in super sacks or suitable carrier, weighed, labeled and transported for end users to reclaim the valuable metals and other materials from the recycled materials." (EX1018, 6:15-37.) I conclude that a POSITA would have found it obvious, straightforward, and advantageous to apply the teachings of Dunagan to Hanisch, as both references are in the same field of endeavor as the '097 Patent—battery recycling—and the teachings in Dunagan are reasonably pertinent to the problems addressed by the '097 Patent and Hanisch. Given that both Hanisch and Dunagan deal with recycling used batteries, it is my opinion that a POSITA would have been motivated to apply the transport containers in Dunagan to the processes in Hanisch, to allow for the safe and convenient transport of inactivated comminuted material to downstream users. I also believe that a POSITA would have had a reasonable expectation of success in applying Dunagan to Hanisch, because

the approach merely involves a straightforward step of filling "super sacks or suitable carrier" with inactivated comminuted material..

5. Claim 1[d]: "wherein the inactivating step is performed by drying the comminuted material, and"

107. Hanisch discloses the inactivation of comminuted material by drying it. See paragraphs 74-75, 87-101.

108. Claim 1 does not recite a temperature for drying the comminuted material to inactivate it, which I understand means that claim 1 is not limited to a drying temperature for inactivating the comminuted material.¹ And the '097 Patent discloses examples of drying at lower temperatures such as less than 80°C (EX1001, 3:4-16, 5:7-10), but also discloses examples using high temperatures to treat the comminuted material (EX1001, 5:37-45), which a POSITA would understand would also dry the comminuted material given that the temperatures are characterized as those at which the binder "largely decomposes" (EX1001, 5:36-41), which can be at or above 350°C for binders such as PVDF. A POSITA would also understand that for solvents like EMC and DMC that have boiling points around 90-110°C, heating to temperatures used for decomposing a binder (e.g., at or above 350°C) would also mean that solvents like EMC and DMC would be evaporated and removed from the

¹ I also understand that where claim 9, which depends from claim 1, adds the requirement that the drying "occurs at a temperature of less than 80°C," claim 1 is presumed not to include any such limitation.

comminuted material.

109. In my opinion, a POSITA would therefore have understood that Hanisch discloses inactivating comminuted material by drying in view of the disclosures of either or both of heating comminuted material to temperatures "below 100°C, in particular below 80°C" to evaporate electrolyte (EX1004, 5:54-63; Fig. 1.) and heating the comminuted material to temperatures at which the binder decomposes, "preferably at least 350°C and at the most 800°C." (EX1004, 4:26-28).

6. Claim 1[e]: "wherein the drying occurs at a maximum pressure of 300 hPa."

110. Hanisch discloses this claim limitation because it teaches that "[i]n particular, the heating up takes place under inert gas or in a vacuum." (EX1004, 3:6-8.) A POSITA would have understood that the pressure of a "vacuum" is below 300 hPa.

111. Hanisch does not limit this teaching to the electrolyte evaporation approach or the decomposition heating approach, and a POSITA would understand that it could be applied to both approaches. The electrolyte evaporation approach where Hanisch discloses that "[i]n particular, the heating up takes place under inert gas or in a vacuum" (EX1004, 3:6-8), and teaches that a pre-dryer is "configured to heat the cell fragments up to the drying temperature" (EX1004, 4:55-59). Further, Hanisch teaches that an embodiment of a "pre-dryer" used for the electrolyte evaporation approach "is designed to be gas-proof," (EX1004, 5:62-63), and that

such gas-proof containers can be used with inert gas or vacuum (EX1004, 3:4-9). Although Hanisch also describes this embodiment of a "gas-proof" pre-dryer as "flushed with inert gas," (EX1004, 5:62-63), a POSITA would understand this disclosure to allow for the use of vacuum, in view of Hanisch's teaching that the pre-dryer is "configured to heat the cell fragments up to the drying temperature," (EX1004, 4:55-59), that "heating up" can occur "under inert gas or vacuum," (EX1004, 3:6-8), that an embodiment of the pre-dryer is gas-proof (EX1004, 5:62-63), and the common knowledge that evaporation is typically increased at given temperature when ambient pressure is reduced, such as in a vacuum.

112. Hanisch also discloses this limitation as to the decomposition heating approach, where Hanisch teaches that "heating of cell fragments up to the decomposition temperature is preferably carried out under inert gas or in a vacuum," (EX1004, 4:6-8), and also recites the use of a vacuum for this process in dependent claim 6: "The method according to claim 1, wherein the heating of the solid cell fragments up to the decomposition temperature takes place under inert gas or in a vacuum." (EX1004, claim 6.)

113. And even if Hanisch does not explicitly disclose this claim limitation, it is my opinion that a POSITA, in view of the common knowledge in the field before the effective filing date, would have understood that using pressures at or below 300hPA when drying the comminuted material would be desirable, and that doing so

would have likely been successful.

114. For example, it has been well-known for decades if not longer that the evaporation of gases, including volatile compounds and gasses formed during drying, occurs more rapidly at lower temperatures. In addition, the boiling point of organic carbonate solvents such as dimethyl carbonate or ethyl methyl carbonate over ranges of ambient pressures and temperatures was well-known in the art for many years before the effective filing date of the '097 Patent. A POSITA would also have understood that the formation of toxic hydrogen fluoride during hydrolysis of LiPF_6 is an endothermic reaction and the reaction rate and rate of heat generation due to the hydrolysis is therefore reduced at lower temperatures. A POSITA would, in my opinion, conclude that use of reduced pressure when drying comminuted material would be desirable, as it would allow the use of lower temperatures to evaporate organic solvents in the electrolyte.

115. The use of reduced temperatures for drying that would be available under lower ambient pressure would also have been attractive as they would permit reduced energy utilization by the recycling system.

116. In my opinion, a POSITA would also have had a reasonable expectation of success in applying pressures at or below 300hPA during either the electrolyte evaporation approach or the decomposition heating approach, where Hanisch teaches that the devices used when drying comminuted material to evaporate

electrolyte is gas-proof, and thus capable of maintaining reduced ambient pressures, such as those below 300hPA.

B. Claim 2: "The method according to claim 1, wherein the comminuted material is dried until an electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible."

117. Hanisch discloses this limitation for at least the same reasons as that disclosed above regarding the use of drying to inactivate comminuted material. See paragraphs 87-101, 107-109. But there are other reasons that a POSITA would understand that Hanisch also discloses this limitation.

118. The '097 Patent provides at least one example where the comminuted material is dried to a point at which the electrolyte is low enough that the voltage drops below a threshold at which "to a good approximation, an electrochemical reaction is no longer possible." (EX1001, 4:5-18.) The '097 Patent also provides examples indicating that the duration and temperature selected for drying the comminuted materials can be empirically determined by a POSITA, for example, "drying step shall be performed, for example, for a pre-determined period of time," (EX1001, 6:32-37), and that the duration of drying is long enough that, for example, "the electrolyte content of organic components that are volatile at 80°C. has a maximum value of 3% by weight, in particular a maximum of 2% by weight, especially preferably a maximum of 1.5% by weight." (EX1001, 4:28-32).

119. Hanisch discloses examples of drying comminuted material to

evaporate electrolyte solvents "below 100°C., in particular below 80°C," (EX1004, 3:65-4:5), which is the same temperature range used to evaporate electrolyte solvents as described in the examples of the '097 Patent (EX1001, 4:28-32).

120. In my opinion, a POSITA, in view of the common knowledge in the field regarding the boiling point and other physical/chemical characteristics of the organic carbonate solvents used in the electrolyte of lithium-ion batteries, would have understood the relationship between the organic carbonate concentration in the electrolyte and the likelihood of electrochemical reactions, at least because this relationship was already well-known (before the effective filing date of the '097 Patent) from the knowledge gleaned during the design of such battery compositions.

121. In view of this knowledge and the disclosures in Hanisch, a POSITA would, in my opinion, have understood the duration of drying and pressure ranges required to evaporate electrolyte components from the comminuted material to a point low enough that, as disclosed by the '097 Patent, "to a good approximation, an electrochemical reaction is no longer possible."

C. Claim 3: "The method according to claim 1, wherein the drying occurs under vacuum."

122. Hanisch discloses this limitation because it discloses that vacuum can be used when drying to inactivate the comminuted material, as discussed above for claim element 1[e]. See paragraphs 110-116.

- D. Claim 7: "The method according to claim 1, wherein the drying of the comminuted material is only completed if one or more of the following conditions is met: no flammable or explosive gas mixture is formable above the comminuted material in the transport container, and the comminuted material is so dry that no flammable or explosive gas mixture is able to emerge in the transport container."**

123. Hanisch alone or in combination with Dunagan discloses and/or renders obvious this limitation for the same reasons as that discussed above regarding the use of drying to inactivate comminuted material (see paragraphs 87-101, 107-109) and filling a transport container with the inactivated comminuted material (see paragraphs 104-106). But even if Hanisch or Dunagan does not expressly disclose this limitation, it would, in my opinion, have been obvious to a POSITA from Hanisch in view of the common knowledge in the field at the time.

124. It was well-known in the field before the filing date of the '097 patent that batteries such as lithium-ion batteries contained components such as LiPF_6 and volatile organic carbonates such as EMC and DMC, which carried risks of combustion or explosion, and that such materials could be present in comminuted material if not sufficiently treated. Where a POSITA would have known of these risks, it would have been obvious that allowing the formation of flammable or explosive gasses in any container used to transport comminuted material would be a health and safety risk, and that allowing such risks to continue would create challenges in effectively and safely reusing the materials recovered from recycling

batteries.

125. Given the knowledge in the field before the filing date of the '097 Patent regarding the boiling points of various volatile compounds in batteries such as lithium-ion batteries, a POSITA would have been able to determine the parameters of temperature, pressure, and duration of drying that would be required to render the comminuted material in a condition where no flammable or explosive gasses would be formable over the comminuted material or able to emerge in the transport container.

E. Claim 8: "The method according to claim 1 wherein the batteries are lithium batteries."

126. Hanisch discloses "[t]he invention concerns a method for retrieving active material, in particular lithium or lithium compounds, from a galvanic cell. . ."
(EX1004, 1:8-10.) Hanisch therefore discloses this limitation.

F. Claim 9: "The method according to claim 1 wherein drying occurs at a temperature of less than 80° C."

127. Hanisch discloses this limitation in the examples that comminuted material is dried to evaporate electrolyte components at temperatures below 80°C:
"The method preferably comprises the step that, before heating the cell fragments up to the decomposition temperature, the cell fragments are dried at a drying temperature, so that dry cell fragments and drying vapours are formed, whereby the drying vapours are at least partly condensed. This has the advantage that the

electrolyte solvent can be retrieved. It is therefore advantageous for the drying temperature to be below 100°C., in particular below 80°C." (EX1004, 3:65-4:5.)

128. Hanisch also discloses this limitation in the description of the drying stage depicted in Figure 1: "A pre-dryer 28 is set up in the direction of material flow behind the cell crushing device 12, which is connected to the cell crushing device 12 via a pipe 30. During crushing of the galvanic cells 14, resulting cell fragments arrive at the pre-dryer 28 via the pipe 30. Here there is a dry temperature T_t of preferably $T_t=80^{\circ}\text{C}$. The pre-dryer 28 comprises a circulation pump 32 and a condenser 34 for condensing electrolyte, which can be removed via the pipe 36. The pre-dryer 28 is designed to be gas-proof and is flushed with inert gas by the circulation pump 32." (EX1004, 5:54-63.)

G. Claim 10: "The method according to claim 1 further comprising a step of sealing the transport container so as to be dust-tight after the step of filling with the inactivated comminuted material."

129. Hanisch discloses this limitation for substantially the same reasons as those discussed above regarding claim limitation 1[c] and claim 7. See paragraphs 104-106, 123-125. In my opinion, it would also be obvious to a POSITA in view of the well-understood properties of the inactivated comminuted material (which contain fine particulate matter, including metals and other compounds) that the failing to avoid dust or fine particulates from escaping the transport container represented a potential safety risk from inhalation or soft tissue exposure during

storage and/or transport.

H. Claim 12

- 1. Claim 12[pre]: "A battery processing installation for treatment of used batteries, comprising:"**

130. Hanisch discloses this claim preamble for the same reasons discussed previously as to the preamble of claim 1. See paragraph 83.

- 2. Claim 12[a]: "(a) a comminution unit configured to comminute the batteries such that comminuted material is obtained;"**

131. Hanisch discloses this claim limitation for the same reasons discussed previously as to claim limitation 1[a]. See paragraphs 84-86.

- 3. Claim 12[b]: "(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;"**

132. Hanisch discloses this claim limitation for the same reasons discussed previously as to claim limitations 1[b] and 1[d]. See paragraphs 87-101, 107-109.

- 4. Claim 12[c]: "(c) a filling device configured to fill a transport container with the inactivated comminuted material; and"**

133. Hanisch, alone or in combination with Dunagan, discloses and/or renders obvious this claim limitation for the same reasons discussed previously as to claim limitation 1[c]. See paragraphs 104-106.

5. Claim 12[d]: "(d) a vacuum installation connected to the drying device and configured to generate a vacuum in the drying device."

134. Hanisch discloses this claim limitation for at least the same reasons discussed previously as to claim limitation 1[e]. See paragraphs 110-116. In addition, it is my opinion that Hanisch discloses this limitation for the additional reasons below.

135. Hanisch discloses a drying device in the example of a "pre-dryer" that "is configured to heat the cell fragments up to the drying temperature." (EX1004, 4:55-59.) Hanisch also discloses that comminuted material is preferably heated up in a "gas-proof container," (EX1004, 3:4-5), and that "heating up takes place under inert gas or vacuum." (EX1004, 3:6-8, 4:6-8.) In my opinion, these examples would lead a POSITA to conclude that Hanisch discloses generating a vacuum in the drying device.

136. Further, Hanisch discloses a drying device that is connected to a vacuum installation: "pre-dryer 28 comprises a circulation pump 32 and a condenser 34 for condensing electrolyte, which can be removed via the pipe 36." (EX1004, 5:59-61.) In my opinion, a POSITA would understand the circulation pump and condenser of Hanisch to be a "vacuum installation" in view of the examples in the '097 Patent describing that a "vacuum pump should be understood particularly generally to mean a device that creates a vacuum," (EX1001, 8:23-25), a "vacuum

pump is a compressor which sucks in and compresses gas 31 that is present in the drying device 26," (EX1001, 8:29-31), that the "vacuum installation comprises a condenser . . . arranged in the direction of material flow in front of a vacuum pump, by means of which the dryer is evacuated," (EX1001, 6:44-51), and that the "vacuum installation comprises an injector or venturi pump, i.e. a jet pump with a pump liquid that is used to generate negative pressure." (EX1001, 7:4-6.) In my opinion, a POSITA would understand that where Hanisch discloses that the "pre-dryer 28 **comprises** a circulation pump 32 and a condenser" (emphasis added), the circulation pump and condenser (i.e. a vacuum installation) would be "connected" to the pre-dryer (a drying device), given the "comprising" language used to modify "pre-dryer."

137. A POSITA would thus understand that Hanisch discloses this limitation because they would appreciate that both Hanisch and the '097 Patent describe a drying device from which electrolyte gasses and vapors are evaporated and drawn by a vacuum pump through a condenser, i.e. a "vacuum installation," that is connected to the drying device and generates a "vacuum in the drying device."

I. Claim 13: "The battery processing installation according to claim 12 wherein the comminuted material is dried until an electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible."

138. Hanisch discloses this limitation for the same reasons as discussed above regarding claim 2. See paragraphs 117-121

J. Claim 19: "The battery processing installation of claim 12 wherein the batteries are lithium batteries."

139. Hanisch discloses this limitation for the same reasons as discussed above regarding claim 8. See paragraph 126.

X. GROUND 2 - HANISCH IN VIEW OF DUNAGAN, MEADOR, SHIN, OR HAYASHI AND THE KNOWLEDGE OF A POSITA

A. Claim 1

1. Claim 1 [pre]: "A method for the treatment of used batteries, comprising the steps:"

140. Hanisch discloses the preamble of claim 1 for the same reasons discussed above in Ground 1. See paragraph 83.

2. Claim 1[a]: "(a) comminuting the batteries such that comminuted material is obtained;"

141. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 84-86

3. Claim 1[b]: "(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"

142. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 87-101.

4. Claim 1[c]: "(c) filling a transport container with the inactivated comminuted material;"

143. Hanisch alone discloses or renders obvious this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 104-106. But even if

Hanisch does not disclose this limitation by itself, in my opinion, a POSITA would have considered this limitation obvious from Hanisch in view of Dunagan (which deals with recycling used batteries to recover metals and other materials, EX1018, 4:6-14, and does so using comminution and inactivation methods, EX1018, 4:27-6:37). Dunagan expressly discloses the use of such containers to store and transport comminuted material: "[t] further processed material will then be disposed in super sacks or suitable carrier, weighed, labeled and transported for end users to reclaim the valuable metals and other materials from the recycled materials." (EX1018, 6:15-37.) I conclude that a POSITA would have found it obvious, straightforward, and advantageous to apply the teachings of Dunagan to Hanisch, as both references are in the same field of endeavor as the '097 Patent—battery recycling—and the teachings in Dunagan are reasonably pertinent to the problems addressed by the '097 Patent and Hanisch. Given that both Hanisch and Dunagan deal with recycling used batteries, it is my opinion that a POSITA would have been motivated to apply the transport containers in Dunagan to the processes in Hanisch, to allow for the safe and convenient transport of inactivated comminuted material to downstream users. I also believe that a POSITA would have had a reasonable expectation of success in applying Dunagan to Hanisch, because the approach merely involves a straightforward step of filling "super sacks or suitable carrier" with inactivated comminuted material.

5. Claim 1[d]: "wherein the inactivating step is performed by drying the comminuted material, and"

144. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 107-109.

6. Claim 1[e]: "wherein the drying occurs at a maximum pressure of 300 hPa."

145. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 110-116. But even if Hanisch does not disclose this limitation by itself, Meador, Shin, and Hayashi disclose the use of heating comminuted material or exposed electrolyte under reduced pressures at or below 300 hPa, including a vacuum, to inactivate it. It is my opinion that a POSITA would conclude that this limitation was obvious from Hanisch in view of these other disclosures.

146. Meador describes comminuting batteries in "a crusher or grinder", followed by transferring that material to a pyrolysis chamber, where this comminuted material is heated to high temperatures that decompose the material. (EX1011, abstract & 3:17-30.) According to Meador, the pyrolysis chamber can be maintained under slight vacuum such as 0.5 inches of mercury, (EX1011, 3:24-25) which is approximately 16.9 hPa. The vacuum is applied to a "pyrolysis chamber sufficient to remove vapors during said decomposition" and "condensing said vapors in a heat exchanger to obtain liquid and gaseous material," (EX1011, claim 1), which

in my opinion a POSITA would have understood to mean that the heating evaporates materials in the comminuted material, which would include evaporating volatile organic solvents such as those in the electrolyte of lithium-ion batteries. A POSITA would have known that EMC and DMC, for example, have boiling points around 90°C-109°C. They would, therefore, undergo evaporation at temperatures above those boiling points, such as the temperature around 350°C that Meador teaches in one example. (EX1011, abstract.) Meador explains that the resulting dried material "containing valuable components of the batteries and other wastes" is transferred to a "hopper or bin." (EX1011, 3:17-37.)

147. Meador discloses the use of heating comminuted material in a pyrolysis chamber to decomposition temperatures and that the comminuted material can be recovered in a container ("dry residue containing valuable components of the batteries and other wastes" are transferred to a "hopper or bin.") (EX1011, 3:17-37.) Meador further teaches that the pyrolysis chamber can be maintained under slight vacuum (EX1011, 3:24-25), such as "approximately one-half inch of mercury," (EX1011, 5:59-60) or "about one-half to one inch of mercury," (EX1011, claims 3, 4), which a POSITA would understand to be the mathematical equivalent of pressures ranging from approximately 16 to 33 hPa, pressures that are below a "maximum of 300 hPa."

148. Similarly, Shin provides examples in which waste batteries, including

lithium-ion batteries, are heated under a vacuum to evaporate electrolyte and the resulting gas is released in the process. (EX1010, 2:65-3:20.) According to Shin, this approach of using heat in combination with reduced pressures provides the benefit of mitigating risks of combustion, explosion, and the formation of toxic fumes that can occur during the recycling of batteries such as lithium-ion batteries. (EX1010, 3:42-4:17.)

149. Hayashi discloses processing lithium-ion batteries by heating the battery containing the electrolyte solution under reduced pressure, such that the organic solvents of the electrolyte are evaporated. (EX1006, 4:33-36.) Hayashi does not discuss comminuting the battery before a heating stage. But Hayashi explains embodiments in which a pipe connected is to the battery's pressure relief valve, and the exposed electrolyte is evaporated through the pipe by heating the battery under reduced pressure. (EX1006, 3:12-55; 4:24-36.) I note that the '097 Patent specification includes the same disclosure, where "the batteries are exposed to a vacuum when in an uncomminuted state such that at least parts of the electrolyte vaporise, wherein the resulting gas . . . escapes through a safety valve in the rechargeable battery." (EX1001, 2:41-46.) Examples in Hayashi of the reduced pressures used for heating include a pressure "less than or equal to 1 kPa" (i.e., less than or equal to 10 hPa) at temperatures ranging from 80°C to 150°C. (EX1006, 3:20-25.) The examples in Hayashi also acknowledge the understood relationships

between pressure and boiling point temperature and explain how the boiling point of a given substance, such as the solvents in the electrolyte, can be reduced under lower pressure to achieve controlled evaporation conditions (EX1006, 4:43-67, and Table 1.) Hayashi also acknowledges the known boiling points of the organic solvents used in the electrolyte solution of lithium-ion batteries, 90°C for dimethyl carbonate and 109°C for ethyl methyl carbonate. (EX1006, 4:38-45.)

150. In my opinion, a POSITA would have been motivated to implement Hanisch using the teachings of either Meador, Shin, or Hayashi that comminuted material or electrolyte could be inactivated under a vacuum. A POSITA would have found it obvious, straightforward, and advantageous to apply the teachings of Meador, Shin, or Hayashi to Hanisch, as these references are all in the same field of endeavor as the '097 Patent—battery recycling—and the teachings Meador, Shin, and Hayashi are reasonably pertinent to the problems addressed by the '097 Patent and Hanisch. For example, Hanisch relates to a "method for retrieving active material, in particular lithium or lithium compounds, for a galvanic cell, " *i.e.*, an electric battery. (EX1004, 1:8-10.) Likewise, Meador relates to "[u]sed batteries and other materials for reclamation and recovery" (EX1011, Abstract), Shin relates to "a waste battery treatment apparatus" (EX1010, Abstract), and Hayashi relates to a "method for processing a nonaqueous electrolyte solution which is used in a lithium ion battery or the like." (EX1006, 1:7-9.)

151. A POSITA would have recognized it would be advantageous to apply the teachings of Shin, Meador, and/or Hayashi to Hanisch at least because of the advantages of using lower pressures to facilitate evaporating electrolytes at lower temperatures (EX1006, 4:43-67, and Table 1), which in turn provides the ability to reduce or mitigate formation and potential release of harmful compounds like hydrogen fluoride during the heating process, and the control over potentially flammable compounds and gasses generated during such heating stages. (EX1011, claim 1; EX1010, 2:65-3:20; 3:42-4:17; EX1006, 4:12-36.)

152. In my opinion, a POSITA attempting to implement the teaching of any of Meador, Shin, or Hayashi with Hanisch would have had a reasonable expectation of success. This is because, like Hanisch, each of these references concerns battery recycling using heat to inactivate exposed electrolyte (EX1006, 4:12-67) or material that has been comminuted (EX1011, 3:17-37; EX1010, 2:65-3:6), each recognizes the advantages of using reduced air pressures during heating of the battery material (EX1011, 4:1-8, claim 1; EX1010, 2:65-3:20; 3:42-4:17; EX1006, 4:43-67, and Table 1), and each discloses the use of gas-proof or otherwise vacuum-compatible vessels for such heating, (EX1011, 3:25-40; EX1010, 3:3-11; EX1006, 3:31-40, 4:24-36) which a POSITA would understand to be compatible with the use of reduced air pressures under 300 hPa.

- B. Claim 2: "The method according to claim 1, wherein the comminuted material is dried until an electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible."**

153. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 117-121.

- C. Claim 3: "The method according to claim 1, wherein the drying occurs under vacuum."**

154. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 122.

- D. Claim 7: "The method according to claim 1, wherein the drying of the comminuted material is only completed if one or more of the following conditions is met: no flammable or explosive gas mixture is formable above the comminuted material in the transport container, and the comminuted material is so dry that no flammable or explosive gas mixture is able to emerge in the transport container."**

155. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 123-124.

- E. Claim 8: "The method according to claim 1 wherein the batteries are lithium batteries."**

156. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 126.

- F. Claim 9: "The method according to claim 1 wherein drying occurs at a temperature of less than 80° C."**

157. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 127-128.

G. Claim 10: "The method according to claim 1 further comprising a step of sealing the transport container so as to be dust-tight after the step of filling with the inactivated comminuted material."

158. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 129.

H. Claim 12

1. Claim 12[pre]: "A battery processing installation for treatment of used batteries, comprising:"

159. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 130.

2. Claim 12[a]: "(a) a comminution unit configured to comminute the batteries such that comminuted material is obtained;"

160. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 131.

3. Claim 12[b]: "(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;"

161. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraph 132.

4. Claim 12[c]: "(c) a filling device configured to fill a transport container with the inactivated comminuted material; and"

162. Hanisch, alone or in combination with Dunagan, discloses and/or renders obvious this claim limitation for the same reasons discussed above in Ground

1. See paragraph 133.

5. Claim 12[d]: "(d) a vacuum installation connected to the drying device and configured to generate a vacuum in the drying device."

163. Hanisch discloses this claim limitation for the same reasons discussed above in Ground 1. See paragraphs 134-137. But even if Hanisch alone does not disclose this limitation, Meador, Shin, and Hayashi all disclose the use of heating comminuted material or exposed electrolyte under vacuum. It is my opinion that a POSITA would conclude that this limitation was obvious from Hanisch in view of these other disclosures.

164. Meador describes comminuting batteries in "a crusher or grinder," followed by transferring that material to a pyrolysis chamber, where this comminuted material is heated to high temperatures that decompose the material. (EX1011, abstract & 3:17-30.) According to Meador, the pyrolysis chamber can be maintained under slight vacuum such as 0.5 inches of mercury, (EX1011, 3:24-25) which is approximately 16.9 hPa. The vacuum is applied to a "pyrolysis chamber sufficient to remove vapors during said decomposition" and "condensing said vapors in a heat exchanger to obtain liquid and gaseous material," (EX1011, claim 1), which in my opinion a POSITA would have understood to mean that the heating evaporates materials in the comminuted material, which would include evaporating volatile organic solvents such as those in the electrolyte of lithium-ion batteries. A POSITA

would have known that EMC and DMC, for example, have boiling points around 90°C-109°C. They would, therefore, undergo evaporation at temperatures above those boiling points, such as the temperature around 350°C that Meador teaches in one example. (EX1011, abstract.) Meador explains that the resulting dried material "containing valuable components of the batteries and other wastes" is transferred to a "hopper or bin." (EX1011, 3:17-37.)

165. Meador discloses the use of heating comminuted material in a pyrolysis chamber to decomposition temperatures and that the comminuted material can be recovered in a container ("dry residue containing valuable components of the batteries and other wastes" are transferred to a "hopper or bin.") (EX1011, 3:17-37.) Meador further teaches that the pyrolysis chamber can be maintained under slight vacuum (EX1011, 3:24-25), such as "approximately one-half inch of mercury," (EX1011, 5:59-60), or "about one-half to one inch of mercury," (EX1011, claims 3, 4), which a POSITA would understand to be the mathematical equivalent of pressures ranging from approximately 16 to 33 hPa, pressures that are below a "maximum of 300 hPa." This vacuum capability applied to the pyrolysis chamber would be understood by a POSITA to correspond to a "vacuum installation. . . configured to generate a vacuum in the drying device."

166. Similarly, Shin provides examples in which waste batteries including lithium-ion batteries, are heated under a vacuum to evaporate electrolyte and the

resulting gas is released in the process. (EX1010, 2:65-3:20.) According to Shin, this approach of using heat in combination with reduced pressures provides the benefit of mitigating risks of combustion, explosion, and the formation of toxic fumes that can occur during the recycling of batteries such as lithium-ion batteries. (EX1010, 3:42-4:17.)

167. Hayashi discloses processing lithium-ion batteries by heating the battery containing the electrolyte solution under reduced pressure, such that the organic solvents of the electrolyte are evaporated. (EX1006, 4:33-36.) Hayashi does not discuss comminuting the battery before a heating stage. But Hayashi explains embodiments in which a pipe connected is to the battery's pressure relief valve, and the exposed electrolyte is evaporated through the pipe by heating the battery under reduced pressure. (EX1006, 3:12-55; 4:24-36.) I note that the '097 Patent specification includes the same disclosure, where "the batteries are exposed to a vacuum when in an uncomminuted state such that at least parts of the electrolyte vaporise, wherein the resulting gas either escapes through a safety valve in the rechargeable battery." (EX1001, 41-46.) Examples in Hayashi of the reduced pressures used for heating include a pressure "less than or equal to 1 kPa" (i.e., less than or equal to 10 hPa) at temperatures ranging from 80°C to 150°C. (EX1006, 3:20-25.) The examples in Hayashi also acknowledge the understood relationships between pressure and boiling point temperature and explain how the boiling point

of a given substance, such as the solvents in the electrolyte, can be reduced under lower pressure to achieve controlled evaporation conditions. (EX1006, 4:43-67, and Table 1.) Hayashi also acknowledges the known boiling points of the organic solvents used in the electrolyte solution of lithium-ion batteries, 90°C for dimethyl carbonate and 109°C for ethyl methyl carbonate. (EX1006, 4:38-45.)

168. In my opinion, a POSITA would have been motivated to implement Hanisch using the teachings of either Meador, Shin, or Hayashi that comminuted material or electrolyte could be inactivated under a vacuum. I believe this would follow at least because of the advantages of using lower pressures to facilitate electrolyte evaporation at a given temperature (EX1006, 4:43-67, and Table 1), the ability to reduce or mitigate formation and potential release of harmful compounds like hydrogen fluoride during the heating process, and the control over potentially flammable compounds and gasses generated during such heating stages. (EX1011, claim 1; EX1010, 2:65-3:20; 3:42-4:17; EX1006, 4:12-36.)

169. In my opinion, a POSITA attempting to implement the teaching of any of Meador, Shin, or Hayashi with Hanisch would have had a reasonable expectation of success. This is because, like Hanisch, each of these references concerns battery recycling using heat to inactivate exposed electrolyte (EX1006, 4:12-67) or material that has been comminuted (EX1011, 3:17-37; EX1010, 2:65-3:6), each recognizes the advantages of using reduced air pressures during heating of the battery material

(EX1011, 4:1-8, claim 1; EX1010, 2:65-3:20; 3:42-4:17; EX1006, 4:43-67, and Table 1), and each discloses the use of gas-proof or otherwise vacuum-compatible vessels for such heating, (EX1011, 3:25-40; EX1010, 3:3-11; EX1006, 3:31-40, 4:24-36), which a POSITA would understand to be compatible with reduced air pressures, including a vacuum.

I. Claim 13: "The battery processing installation according to claim 12 wherein the comminuted material is dried until an electrolyte content in the comminuted material is so low that an electrochemical reaction is impossible."

170. Hanisch discloses this limitation for the same reasons as discussed above in Ground 1 regarding claim 2. See paragraphs 117-121.

J. Claim 19: "The battery processing installation of claim 12 wherein the batteries are lithium batteries."

171. Hanisch discloses this limitation for the same reasons as discussed above in Ground 1 regarding claim 8. See paragraph 126.

XI. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

172. Neither the applicant nor the Examiner identified any secondary considerations that favored a finding of non-obviousness during prosecution of the application that issued as the '097 Patent. *See generally* EX1002. Further, I am unaware of any secondary considerations that tend to show non-obviousness of the Challenged Claims. To the extent that such secondary considerations become available to me in the course of this proceeding, I reserve the right to address them in a supplemental declaration.

173. I declare under penalty of perjury that the foregoing is true and correct.

Executed this 21st day of May, 2024 in Duvall, WA.

A handwritten signature in black ink, appearing to read "Walter van Schalkwijk", written in a cursive style.

Walter van Schalkwijk

APPENDIX A

Walter van Schalkwijk, PhD

wvs@batterysciences.com

waltvans@uw.edu

425-445-2181

More than 45 years of experience in the battery industry in research, product development, manufacturing, facility design, battery electronics, applications engineering, battery system design, business development for batteries, battery raw materials and refined materials, and materials sustainability.

Very experienced in cell design and manufacturing design for all formats of lithium-ion battery technology from coin cells to small, medium, and large pouch cells, cylindrical cells, and small to large prismatic cells, pack modules for small and large applications using pouch, prismatic, or cylindrical cells.

Plant design for battery materials, cells, and battery packs / modules.

Built what are recognized as the first cylindrical manufactured lithium-ion cells in 1986 (*"Long Hard Road,"* Charles J. Murray, Purdue University Press, pp 121 – 123).

Industries: Consumer electronics, light industrial, military, portable, stationary, and implantable medical equipment, automotive, electricity grid, ESS, and battery and battery materials manufacture.

Twenty patents were granted and pending including eight on FDA approved formulations for kidney dialysate.

At Microsoft: developed and filed for several patents on battery use algorithms that protect lithium-ion polymer cells from premature swelling (2018 - 2020)

At Meta Corporation: filed provisional patent on a design for a thread-like battery (2022)

Co-lead in the successful effort to create a division, now called the Nano Division at the Electrochemical Society. This was a multi-year effort (2003 - 2007) leading to many symposia on carbon nanostructures including fullerenes, single- and multi-walled carbon nanotubes, and graphene.

ACADEMIC QUALIFICATIONS

Ph.D., Electrochemistry, University of Ottawa, Ottawa, Ontario, Canada.

Conway Group. Interfacial kinetics of lithium intercalation / deintercalation at single crystal TiS_2 and TiSe_2 cathodes.

M.Sc. Physical Chemistry Carleton University, Ottawa, Ontario, Canada. Study of ion behavior in non-aqueous solvents.

B.S. Chemistry, Lowell Technological Institute (now the University of Massachusetts at Lowell)

PROFESSIONAL ACTIVITY

Electrochemical Society

Member, 1991 to present, now Emeritus Member Board of Directors, 1999 – 2003

Chairman of New Technology Committee, 1999 – 2003 Chairman of Nanotechnology Committee, 2003 – 2006

Vice-Chairman of New Technology Committee, 2006 to 2010

Member of the Individual Membership Committee, 2009 to 2014

Technical Affairs Committee, 1998 – 2006

Executive Committee of Battery Division, 2002 – 2004, 2018

Executive Committee of the Energy Technology Division, 2002 – 2010, 2018 – present.

Education Committee, 2019 - 2023

American Chemical Society

Member 2015 – present

SIGNIFICANT PUBLICATIONS

"Advances in Lithium-Ion Batteries," Co-editor (and multiple chapter author) with Dr. Bruno Scrosati of the University of Rome, published in May 2002 by Plenum/Kluwer (now Springer).

"Advanced Lithium Batteries", Co-editor with Dr. Bruno Scrosati of the University of Rome, and Dr. K.M. Abraham of Northeastern University, 2013, Wiley

"Sustainability in the Battery Industry: Materials and Processes Toward a Circular Economy," Wiley, In preparation, publication: Fall – 2024

RESEARCH INTERESTS

The use of Computed Tomography and magnetic methods for the study of battery failure mechanisms

Thermal management systems design for battery packs and systems up to 2 MWh

Interaction of static and dynamic magnetic fields with transition-metal based lithium-ion cathodes

New test and characterization methods for batteries and capacitors

New manufacturing methods for Lithium-based batteries.

Electrochemical and thermal methods of detection for termination of procedure for kidney dialysis

Liquid inorganic electrolytes for high voltage lithium-ion batteries

New polymer electrolytes for solid-state lithium-ion batteries

AWARDS

Electrochemical Society Battery Division Student Research Award, 1981

At the 235h Meeting of the Electrochemical Society in Dallas in May 2019, the Energy Technology Division voted to create the "**ECS Energy Technology Division Walter van Schalkwijk Award in Sustainable Energy Technology**" First recipient of the award was at the Fall meeting of the ECS in 2022

VISITING SCHOLAR

University of Rome "La Sapienza", Rome, Italy 2002, 2003-2004, 2007, 2009

PROFESSIONAL EXPERIENCE

1994 – Present, Consultant

Clients in all aspects of battery industry, medical appliance, industrial test equipment, automotive, raw materials, electricity grid industries and legal and financial industries. Developed relationships with University of Washington, Clean Energy Institute (University of Washington) and the University of Rome. Several battery-

related patents – cell design, materials formulations, charging methods and battery operation control, thermal management. Also - eight patents related to kidney dialysis.

Performed business development activities for emerging battery, battery materials and battery systems companies and business units.

Extensive travel in Asia visiting many battery companies to assess their manufacturing operations, factory design, manufacturing methodology and DFMEA for product OEM customers of battery companies. Many visits were technology assessments and manufacturing assessments for valuation and a focus on intellectual property, and capital equipment allocations for the investment community.

Experienced in assessments of business and marketing plans.

Some consulting is done through my corporate entity, Battery Sciences, Inc. Recent engagements include Microsoft, Meta, Innolith AG, WH-Power, Inc., Ionic Materials, Inc., and Proton Power, Inc.

Experience with Li-ion (all types), NiMH, NiCd, NiZn, ZnBr, Lead acid (several types), Li-primary, medical batteries (several types), alkaline MnO₂

Failure analysis (FMEA), Design failure analysis (DFMEA), and Kaizen (improvement) analysis of cell and battery construction for Li/MnO₂ primary batteries used for implantable applications.

Development of new cell designs using high-voltage capable inorganic liquid electrolytes. Funded by a European technology development company.

2022 – Present, Senior Advisor, Ionic Materials Inc., Woburn, MA

2020 - Present, Affiliate Professor of Materials Science and Engineering, University of Washington, Seattle Washington.

2018 – Present, Affiliate Professor, Clean Energy Institute University of Washington, Seattle, Washington

2001 – Present, Affiliate Professor of Chemical Engineering University of Washington, Seattle, Washington

Chairman of the Advisory Committee for the Bio-Energy IGERT Program funded by the National Science Foundation, 2008 – 2011.

1994 – 1997, Chief Scientist, SelfCharge Inc., Redmond, Washington

Managed battery technology selection and design of battery packs and smart chargers for light industrial and medical device applications.

Developed and patented a safe fast-charge algorithm.

1991 – 1994, Director of Product Development & Director of Research Moli Energy Ltd., Maple Ridge, British Columbia, Canada

Managed research and technology transfer from fundamental research to prototype development to manufacture of new battery products based on lithium-ion technology. Reconfiguration of battery cell design and re-design of factory layout.

Moli Energy, then owned by NEC of Japan was the second company to commercialize the lithium-ion battery.

1986 – 1991, Owner/Proprietor of an Engineering Research and Consulting Company Inland Research Corporation, North Andover, Massachusetts

Consulting in batteries and materials.

Developed jelly-roll rechargeable Li/SO₂ and Li/Al-SOCl₂ primary batteries (under contract to Battery Engineering, Inc).

Developed supercapacitors based on disentangling of soap molecules.

Constructed early prototypes (pre-commercialization) of lithium-ion cells of a manufacturable design at Battery Engineering under contract to a Japanese company. Developed early designs of Li-ion cell manufacturing lines. (*"Long Hard Road,"* Charles J. Murray, Purdue University Press, 2022, pp 121 – 123)

Worked with the Commonwealth of Massachusetts on Toxic Use Reduction regulations as they pertain to battery recycling.

1986-1988, Contract: Staff Scientist, Energy Research Corporation (later called Fuel Cell Energy Corporation), Danbury, Connecticut.

Principal Scientist in a DOE/EPRI sponsored development program on zinc/bromine batteries for electricity grid applications.

1985-1986, Lecturer, Chemistry, Brandeis University, Waltham, Massachusetts

Taught advanced general Chemistry, Inorganic Chemistry, and graduate courses in Electrochemistry.

1977-1979, 1983 – 1985, Staff Scientist, GTE Corporation (now Verizon), Waltham, Massachusetts

Developed Li/SO₂ rechargeable batteries and very large Li/SOCl₂ and LiSO₂Cl₂ primary batteries and systems for military and telecommunications applications.

Walter A van Schalkwijk, PhD

LITIGATION EXPERIENCE

1. Testifying Expert in a Government Accountability Office Contract challenge in the matter of STIDD Systems, Inc., File: B-292075; B-292075.2. "STIDD Systems, Inc. protests the Naval Sea Systems Command's (NAVSEA) award of contracts to Yardney Technical Products and SAFT America, Inc., under request for proposals (RFP) No. N00164-02-R-6914, for lithium-ion battery cells or modules for the Advanced SEAL Delivery System (ASDS). STIDD challenges the evaluation of technical proposals." Entire case was done under a Protective Order. Attorney Contact: Mark Slater or Jennifer Zeien, Slater & Zeien, 1900 L St NW #611 Washington D.C., DC 20036-5055, (202) 467-5900. Expert Report and Rebuttal Expert Reports. No Deposition or Testimony
2. Medtronic, Inc Implantable Defibrillators Litigation, United States District Court of Minnesota, 05-MDL-1726 (JMR/AJB). Pertaining to the failure of Lithium batteries in a high-rate application. Representing the Plaintiff. Attorney Contact: Hunter Scholnik, Rheingold, Valet, Rheingold, Shkolnik & McCartney LLP 113 E 37th Street New York, NY 10016, (212) 684-1880. Expert Report Only.
3. Board of Regents, The University of Texas System, on behalf of The University of Texas at Austin and Hydro Quebec versus Nippon Telephone and Telegraph Company. United States District Court for the Western District of Texas, Cause No. A 01 CA 478 JN. Patent litigation pertaining to batteries based on LiFePO₄ (Lithium Iron Phosphate). Representing the Defendant. Attorney Contact: Gerald C. Conley, Andrews Kurth LLP, 1717 Main St, Suite 3700, Dallas, TX 75201, Tel. (214) 659-4471. Expert Report and Deposition Testimony
4. Paul Martin Davis-Miller, Barbara L. Keeler, Mickey Michel, and Howard R. Miller on behalf of themselves and all others similarly situated, and the General Public versus the Automobile Club of Southern California and Does 1 – 50. Superior Court of the State of California, County of Los Angeles, Case No. BC 398608. Expert pertaining to the application of a battery analyzer for determining the health of a Lead-acid car battery. Representing the Defendant. Attorney Contact: John T. Brooks, Luce Forward Hamilton & Scripps LLP, 600 West Broadway, 26th Floor, San Diego, CA 92101, (619) 699-2401. Expert Reports only
5. GN Netcom, Inc. v. Amperex Technology LTD (ATL), Adjudicated in Hong Kong SAR, China. Pertaining to the failure of a product during use. Representing the Defendant. Attorney Contact: Peter Stern, Morrison & Foerster LLP, Shin-Marunouchi Building, 29th Floor, 1-5-1 Marunouchi, Chiyoda-ku, Tokyo 100-6529, Japan, Phone: +81-3-3214-6642. Expert Reports and Rebuttal Expert Reports only.
6. Milwaukee Electric Tool Corporation, Metco Battery Technologies, LLC, AC (Commercial Offshore de Macau) Limitada, and Techtronic Industries Co. Ltd., versus Hitachi Koki Co., Ltd., and Hitachi Koki USA, Ltd., pertaining to a litigation of patents. Expert Reports, Declarations, and Rebuttals only. Representing the Defendant. Attys: McDermott, Will & Emery.
7. Hitachi Koki Co., Ltd. and Hitachi Koki USA Ltd., Versus Techtronic Industries Co. Ltd., Techtronic Industries North America, Inc., One World Technologies, Inc., Owt Industries, Inc., Milwaukee Electric Tool Corporation, and Ryobi Technologies, Inc., pertaining to a litigation of patents. Expert Reports, Declarations, and Rebuttals. Representing the Plaintiff. Attys: McDermott, Will & Emery.
8. The Gillette Company and the Proctor & Gamble Company, Defendant. Pertaining to battery performance misrepresentation. Representing the Plaintiff. United States District Court for the Middle

Walter A van Schalkwijk, PhD

District of Florida Orlando Division. CASE NO: 6:12-CV-00803-GAP-DAB, Expert Report and Deposition Testimony.

9. Foss Maritime Company vs Corvus Energy Limited and 1169997 Ontario, Ltd., d/b/a Aspin Kemp & Associates pertaining to battery electronics operation that resulted in failure of a large lithium-ion battery system in a marine application. Representing the plaintiff. Settlement offered by the defendant and accepted.
10. Brian Meyers, on behalf of himself and all others similarly situated, versus Garmin International, Inc. and Garmin U.S.A., Inc., in a case of product performance. Representing the defendant. In The United States District Court. District of Kansas, Kansas City Division. CASE NO: 13-cv-2416-CM-GLR Expert Reports.
11. Milwaukee Electric Tool Corporation, et al., versus Chervon America Inc., et al. in a litigation of patents. Representing the defendant. Expert Reports, Declarations, and Rebuttals. Chervon America Inc., et al. Petitioners, versus Milwaukee Electric Tool Corporation, et al., respondents, Declarations and Deposition testimony (x3). Attys: Kirkland & Ellis
12. Samsung SDI Co., Ltd., ASUS Computer International, ASUSTek Computer Inc., Hewlett-Packard Company and Dell Inc., petitioners, versus RYUJIN Patent & Licensing Ltd., Patent Owner. in a litigation of patents. Inter Partes Review. Declaration only. Case Decided on behalf of the petitioner. Attys: Lewis Roca Rothgerber Christie LLP
13. OneD Materials LLC, Petitioner versus Nexxon Limited, Patent Owner, Patent No. 8,597,831. Inter Partes Review. Declarations only to date and Deposition Testimony (x3). Attys: Nixon Peabody.
14. Maxell, Ltd., Maxell Holdings, Ltd, Hitachi Maxell, Ltd. versus Amperex Technology Limited (ATL), not CATL. Representing the defendant. Four patents in suit. Four IPRs and four depositions. Alston & Bird
15. Semiconductor Energy Laboratory Co., Ltd vs Amperex Technology Limited. Representing the defendant in a patent litigation. No written matter submitted as of November 20, 2022.
16. LG Energy Solution, Ltd. versus Molecular Rebar Design LLC, representing the petitioner in a litigation of two patents. Two IPRs only.