Filed on behalf of: Kolon Industries, Inc.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HS HYOSUNG ADVANCED MATERIALS CORP.,
Petitioner,
v.

KOLON INDUSTRIES, INC.,
Patent Owner.

Case IPR2025-00662
Patent 9,789,731

DECLARATION OF DR. DAVID BROOKSTEIN IN SUPPORT OF PATENT OWNER'S PRELIMINARY RESPONSE

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I. Introduction and Background

1. I have been retained as an expert witness by Kolon Industries, Inc. ("Kolon") to provide my analysis and conclusions on certain technical aspects of this dispute. I understand Kolon is the Patent Owner and that HS Hyosung Advanced Materials Corp. ("Hyosung") is the Petitioner in this case. I understand that Petitioner has challenged the patentability of claims 1-7 (the "Challenged Claims") of U.S. Patent No. 9,789,731 (Ex.1001) (the "'731 patent").

2. I am being compensated for my work at my standard consulting rate. My compensation does not depend on the outcome of this proceeding.

3. I have been asked to provide my opinions as to whether the Challenged Claims are patentable. My opinions are set forth in this Declaration.

II. Qualifications

4. I am both a mechanical engineer and a textile engineer with substantial experience in the field of textile and fibrous materials, including in the field of high strength yarns and cords. In forming the opinions expressed in this Declaration, I have considered and relied upon my education, background, and experience. My experience, qualifications, and education are detailed in my *curriculum vitae* ("CV"), a copy of which is attached as Exhibit 2018. My CV also lists my relevant textile patents and identifies parties on behalf of whom I have previously provided expert testimony.

5. I received a Bachelor of Textile Engineering from the Georgia Institute of Technology (“Georgia Tech”) in 1971, a Master of Science degree in Textile Technology from the Massachusetts Institute of Technology (“MIT”) in 1973, and a Doctor of Science degree in the field of Mechanical Engineering from MIT in 1976, with Minor Studies in Management from Sloan School of Management. My doctoral research involved yarn mechanics and manufacturing, which have direct relevance to the subject of the ’731 patent.

6. In 1975, I accepted a position as an Assistant Professor of Textile Engineering at Georgia Tech. I taught and conducted research in the fields of textile engineering and composites engineering. One of the textbooks I used in teaching was “Textile Yarns – Technology, Structure, and Applications,” the relevant chapters of which are attached in Exhibit 2020. I obtained substantial funding from the U.S. Department of Energy during my time at Georgia Tech.

7. In 1981, I accepted a part-time position as an Adjunct Professor in Mechanical Engineering at Northeastern University in Boston. I taught undergraduate courses in statics, dynamics, and mechanics of deformable bodies and material science. I was also an Adjunct Professor during my full-time employment at Albany International Research Co. (formerly Fabric Research Laboratories). *See* ¶8.

8. From 1980 to 1994, I was employed by Albany International Research Co. (formerly Fabric Research Laboratories). I started as a Senior Research Associate, was promoted to Assistant Director in 1983, and was again promoted to Associate Director in 1992. In these positions, I directed all activities of the professional engineering group responsible for contract research, development, and manufacture of advanced composite materials and technical polymeric materials of yarns and fabrics. My textile engineering innovations during this time led to 13 U.S. patents and many other unpatented trade secrets.

9. In 1994, I accepted a position with Philadelphia University (formerly Philadelphia College of Textiles and Sciences). From 1994 to 2010, I was the Dean and Professor of Mechanical Engineering at the School of Engineering and Textiles. From 2010 to 2012, I was the Executive Dean for University Research and Professor of Mechanical Engineering. During my time at Philadelphia University, I held many other positions, including Executive Director of the Institute for Textile and Apparel Product Safety, Executive Director of Pennsylvania Advanced Textile Research and Innovation Center including Biomedical Textile Structures Laboratory, and Executive Director of Research. I was also a Principal Investigator for 8 years on a Department of Defense funded project focused on working with the US Army to develop new garment-based soldier protection systems.

10. From 2002 to 2003, I was a Visiting Scholar at Harvard University Center for Textile and Apparel Research (Division of Engineering and Applied Sciences and Harvard Business School). During this time, I studied trends in patent applications involving textile structures.

11. From 2009 to 2012, I also worked as a part-time consultant at MAG Industrial Automation Systems, where I was an engineering consultant to a worldwide manufacturer of engineered automation systems for the aerospace industry.

12. In 2012, I accepted a position as Dean for Science, Technology, Engineering and Mathematics (STEM) at Montgomery County Community College. In this role, I was Chief Academic Officer for all programs in engineering, physical sciences, biological sciences and computer sciences.

13. In 2013, I accepted a role as Director of Market Development at ICF Mercantile. In this role, I was responsible for technical and market development of antimicrobial, antifungal, and flame-resistant textile fabrics.

14. In 2014, I accepted a role as Professor of Mechanical Engineering and Director of Undergraduate Affairs at the Temple University College of Engineering, and in 2017, I was promoted to Senior Associate Dean for Undergraduate Studies at the Temple College of Engineering. From 2014 to 2024, I was responsible for the senior design capstone courses for all engineering

students and was responsible for engineering program accreditation from the Accreditation Board for Engineering and Technology.

15. In 2024, I retired and became Professor Emeritus of Mechanical Engineering at Temple University College of Engineering, which is my current position.

16. From 2000 to today, I have also owned and operated Brookstein Consulting LLC. In this role, I provide engineering and litigation consulting services in the fields of textiles, mechanical assemblies made from textile materials, garment systems, fibers, yarns, fabrics, and composites.

17. In 1992, I was elected by my peers as a Fellow of The Textile Institute (United Kingdom). In 1993, I was awarded the Techtextil Innovation Prize (Germany). In 1995, I was elected by my peers as a Fellow of the American Society of Mechanical Engineers, which is an honorific awarded to only about 1% of its members. In 1998, I was awarded the ASTM Harold Dewitt Smith Award for textile fiber utilization.

18. I have also been a member of the American Society for Engineering Education, the Institute of Industrial and Systems Engineers, the American Conference of Academic Deans, the Fiber Society, and the Society for Advanced Materials and Processes.

19. I am the named inventor on 13 U.S. patents, all of which relate to structures made using the principles of textile engineering and science. I have also developed numerous trade secret inventions.

20. Based on my education and professional experience, I believe I am an expert in the relevant field of the '731 patent and have been an expert in this field since before the first application for the '731 patent was filed. I am familiar with how a person of ordinary skill in the art ("POSITA") would have understood and used the terminologies found in the '731 patent as of the date of the invention.

III. Summary of Analysis and Conclusions

21. In my opinion, Petitioner and Dr. Rust have failed to show that any claim of the '731 patent is unpatentable. In particular, Petitioner and Dr. Rust have failed to demonstrate that claims 1 and 4 and all dependent claims are rendered obvious by Tamura and Baldwin or Baek, in view of Barnes, Rowan, and Buchanan. In addition, Petitioner and Dr. Rust have failed to demonstrate that claims 1 and 4, and all claims dependent on it, are rendered obvious by Chung, Harikae, and Yokokura, in view of Rowan and Buchanan. This declaration focuses on the deficiencies in Petitioner's and Dr. Rust's analysis for claims 1 and 4. I reserve my right to opine on other claims in this or other proceedings. I explain the bases for my opinion in detail in this Declaration.

IV. Summary Of Materials Reviewed And Considered

22. All of the opinions contained in this Declaration are based on the documents I reviewed and my knowledge and professional judgment. In forming the opinions expressed in this Declaration, while drawing on my experience in the field of technical yarns and cords, I reviewed the following documents as well as the documents cited in this Declaration:

- Petition for *Inter Partes* Review of U.S. Patent No. 9,789,731, and the exhibits to the Petition;
- Ex.2020, Textile Yarns – Technology, Structure, and Applications;
- Ex.2028, IPR2025-00663 Petition;
- Ex.2029, IPR2025-00663 Ex.1003 Dr. Rust Declaration;
- Ex.2030, IPR2025-00664 Petition;
- Ex.2031, IPR2025-00664 Ex.1003 Dr. Rust Declaration;
- Ex.2032, Reuter, U.S. Patent No. 6,799,618; and
- Ex.2033, Zandiyeh, U.S. Patent App. Pub. 2014/0230947.

23. My opinions are additionally guided by my appreciation of how a POSITA would have understood the claims of the '731 patent at the time of the alleged invention, which I have been asked to assume is December 27, 2012.

V. Legal Standards

24. I understand that a patent claim is invalid for obviousness if the differences between the claimed invention and the prior art would have been obvious to a POSITA before the filing date of the claimed invention.

25. I understand that determining whether a prior art renders a patent claim invalid as obvious is a two-step process. First, the claims must be properly construed. Second, the properly construed claim is compared against the prior art to determine whether a POSITA would have found the claimed invention obvious in light of the prior art. I understand that a determination of whether or not a claim would have been obvious requires determining the scope and content of the prior art, ascertaining differences between the prior art and the claims at issues, resolving the level of skill in the pertinent art, and assessing evidence of secondary considerations when such evidence is presented.

26. I understand that in determining the scope of the prior art, there is an analogous art requirement that applies to each reference. That is, a reference qualifies as prior art for an obviousness determination only when it is analogous to the claimed invention. I understand that prior art is analogous if (1) the art is from the same field of endeavor, regardless of the problem address, or (2) when the reference is not within the field of the inventor's endeavor, the reference still is reasonably pertinent to the particular problem with which the inventor is involved.

27. I further understand that a claim involving multiple components is not proved obvious just by demonstrating that each element was independently known in the art. Even when all elements were independently known in the art at the time of invention, the obviousness inquiry must still determine whether one of ordinary skill in the art would have had a reason to combine the known elements as expressed in the claim and have had a reasonable expectation of success in doing so.

28. Although I understand that evidence of motivation to combine in the prior art is not required, I understand that it is still important to identify a reason that would have prompted a POSITA to combine the elements as the invention does.

29. I understand that a prior art reference teaches away from the claimed invention if one of ordinary skill in the art, upon reading the reference, would have been led in a different direction from the path taken by the invention. I further understand that each prior art reference may teach away to different degrees, and thus each reference must be examined for what it in fact teaches. I understand that if a POSITA would not have believed at the time of the invention that a particular combination of prior art references would have had a reasonable expectation of success, such a combination may not be obvious.

30. I understand that, because the obviousness determination is based on the knowledge of one of ordinary skill in the art at the time of the invention, it is impermissible to use the benefit of hindsight or to rely on the teachings of the claimed invention to determine whether a POSITA would have found the invention obvious.

VI. Brief Technical Background

31. Since the invention of automobiles, vehicles have required reinforced rubber tires with specific physical properties to allow for operating the vehicle in accordance with various performance specifications. Just as the automobile industry has advanced significantly since its inception, so too has the tire industry and the industry for reinforcements of rubber for tires.

32. One of the main components that provides the tire with the appropriate strength, stability, and durability is the fiber cord or tire cord. Tire cords make up the cap ply of the tire, which is a layer of rubberized cords that is wrapped circumferentially under the tread of the tire. The physical restriction of the cap ply causes the movement of the belt edge to be significantly reduced. This physical restriction has three very important and significant consequences. First, it reduces stresses and fatigue and loss of properties in the rubber surrounding the belt edges. Second, it reduces the growth of microscopic separations that can develop into larger separations. Third, it reduces tire temperatures, and elevated

temperatures weaken rubber through a process known as ageing. As a result, tires with cap plies are more durable, less likely to fail from belt separations, and therefore safer and create a more comfortable driving experience than tires without cap plies.

33. Improved vehicle performance and road conditions have brought about gradually increasing vehicle driving speed. As a result, tires with cap plies before the invention of the '731 patent experienced problems, including, for example, with stability and durability of the tires.

34. As the '731 patent discloses, "[a]s the driving speed is getting higher due to the improvement of the highway conditions, the deformation of the belt portion of the tire cord occurs thereby causing the degradation of the riding quality. Thus, the cap ply portion to prevent the deformation of the belt portion is getting more important." Ex.1001, 1:37-42.

35. Conventional tire cords were originally made with a single yarn material, such as nylon or rayon. In an attempt to utilize beneficial properties of multiple materials, tire cord manufacturers attempted to combine single yarn materials together into hybrid tire cords. Hybrid cords consist of at least two different yarn types. Figure 6.11 of "Textile Yarns – Technology, Structure, and Applications" (below) shows the expected behavior of yarns at different twist levels (designated by α, which is the helix angle). A POSITA would have known

that helix angle is the angle between the fibers and the longitudinal axis of the yarn or cord.

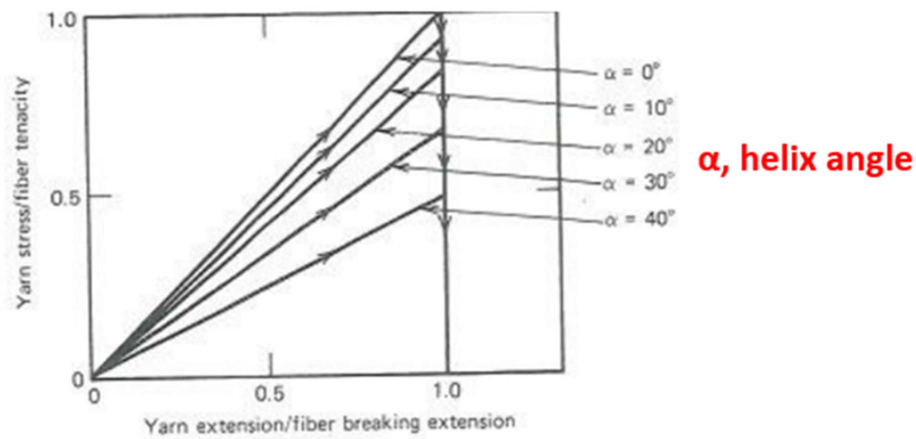
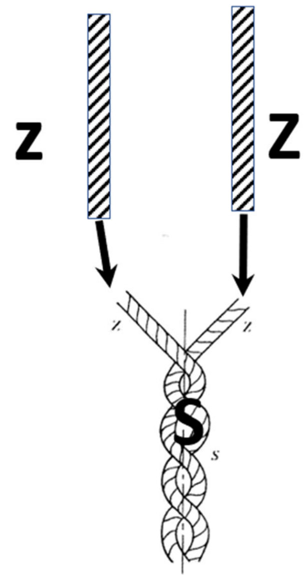


Figure 6.11. Expected behavior of yarns with catastrophic rupture.

Ex.2020 (Textile Yarns – Technology, Structure, and Applications), 62 (annotated). Thus, the tensile strength of a twisted assembly decreases as the amount of twist is increased. Stated another way, the inherent tensile strength of the fibers is not fully realized for a twisted assembly when twist is added. Accordingly, to obtain the full strength of the fibers or filaments, it is common practice to ply two twisted assemblies, both twisted in one direction, in the opposite direction. After this, the "off-axis" individual filaments can be closely aligned along the longitudinal axis of the twisted structure, as shown below:



Ex.2020 (Textile Yarns – Technology, Structure, and Applications), 8 (annotated). Tire cords are generally produced from at least two plies of twisted assemblies that are twisted together.

36. However, prior to the '731 invention, the structure of aramid/nylon hybrid tire cords had many drawbacks. The '731 patent explains:

> According to the conventional method, … when the nylon primarily-twisted yarn and aramid primarily-twisted yarn are secondarily twisted together to form the ply yarn, the nylon primarily twisted yarn is covered by the aramid primarily-twisted yarn. Thus, when the ply yarn is dried and heat-treated after it is submerged into an adhesive solution, significant friction between the ply yarn and the guides and rollers occurs thereby sweeping the aramid primarily-twisted yarn which covers the nylon primarily-twisted yarn to form a loop, and/or the nylon primarily-twisted yarn shrinks causing the shape non-uniformity.

> The loop and shape non-uniformity make the properties of the hybrid fiber cords non-uniform and cause defective products.

Ex.1001, 2:24-39.

VII. The '731 Patent

A. Summary of the '731 Patent

37. The '731 patent, entitled "Hybrid Fiber Cord and Method for Manufacturing The Same," relates to 2-ply aramid and nylon hybrid fiber cord and methods for making it. Ex.1001, Title, Abstract. As detailed above, the '731 patent explains that vehicle performance and road conditions have brought about increased driving speed, leading to a need for fiber cords capable of maintaining stability and durability of tires for high-speed driving. Ex.1001, 1:37-42.

38. Tire cords treated with an adhesive agent, referred to as "dip cords," are widely used as reinforcing materials of rubber products such as tires. One of the essential methods of improving performance of final rubber products is to improve physical properties of fiber cords used as reinforcing materials. Ex.1001, 1:19-26.

39. The '731 patent acknowledges that nylon and aramid are major materials for prior tire cords for cap ply, but each material individually had drawbacks. Ex.1001, 1:42-67. For example, nylon tire cords resulted in flat spots and deformation in the tires, and aramid tire cords posed difficulty with tire molding. Ex.1001, 1:43-67. To address the problems, there were attempts to

develop hybrid fiber cords, but prior art hybrid fiber cords had "loop" and shape non-uniformity, which made the properties of the hybrid fiber cords non-uniform and led to defective products. Ex.1001, 2:37-39. "Loops" were formed as a result of friction between the cord and guides and rollers during a subsequent submerging of the cord in an adhesive solution. Ex.1001, 7:10-18.

40. The inventions of the '731 patent include 2-ply aramid and nylon hybrid fiber cord and a method of manufacturing such a hybrid fiber cord, where the hybrid cord can achieve more uniform physical properties, better strength and fatigue resistance than conventional hybrid cords, while being more efficient to manufacture:

> An aspect of the present invention is to provide a hybrid fiber cord comprising a nylon filament and an aramid filament, which can be made more easily and has more uniform physical properties and better strength and fatigue resistance than the conventional hybrid fiber cords such that it can be used to make an ultra high performance tire.
>
> The other aspect of the present invention is to provide a method for easily manufacturing a hybrid fiber cord comprising a nylon filament and an aramid filament, which has more uniform physical properties and better strength and fatigue resistance than the conventional hybrid fiber cords such that it can be used to make an ultra high performance tire.

Ex.1001, 2:49-61.

41. As the '731 patent explains, the claimed invention addresses prior concerns and provides advantageous effects:

> According to the present invention, the process for manufacturing the hybrid fiber cord can be simplified and various apparatuses can be used since the twist number of the nylon primarily-twisted yarn is identical with that of the aramid primarily-twisted yarn.
>
> Furthermore, by controlling the tensions applied to the nylon and aramid primarily-twisted yarns respectively during the twisting process to make them have identical structure with identical twist number, the present invention can achieve more stable structure than one in which the nylon primarily-twisted yarn is covered by the aramid primarily-twisted yarn. Consequently, the property variableness and defect rate of the hybrid fiber cord can be reduced, and a hybrid fiber cord of improved strength and fatigue resistance which is useful for the cap ply of the tire for high speed driving can be provided.

Ex.1001, 3:32-46. Claims 1 and 4 are independent, and recite:

> **1.** 1[pre] A hybrid fiber cord comprising:
>
> 1[a] a nylon primarily-twisted yarn having a first twist number of 300 to 500 TPM;
>
> 1[b] an aramid primarily-twisted yarn having a second twist number of 300 to 500 TPM; and
>
> 1[c] an adhesive,

1[d] wherein the first twist number is identical with the second number,

1[e] wherein the nylon primarily-twisted yarn and the aramid primarily-twisted yarn are secondarily-twisted together at a third twist number which is identical with the first and second twist numbers and have identical structures with each other in the hybrid fiber,

1[f] wherein the nylon primarily-twisted yarn and aramid primarily-twisted yarn which are secondarily-twisted together with the identical twist number form a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn, and

1[g] wherein the secondarily-twisted yarn is coated with the adhesive, and

1[h] the secondarily-twisted yarn coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association, and has a dry heat shrinkage of 1.5 to 2.5%.

4. 4[pre] A method for manufacturing a hybrid fiber cord, the method comprising:

4[a] a first step for primarily-twisting a nylon filament at a first twist number of 300 to 500 TPM to produce a nylon primarily-twisted yarn;

4[b] a second step for primarily-twisting an aramid filament at a second twist number of 300 to 500 TPM to produce an aramid primarily-twisted yarn;

4[c] a third step for secondarily-twisting the nylon and aramid primarily-twisted yarns together at a third twist number to produce a ply yarn in such a way that the nylon and aramid primarily-twisted yarns have identical structures with each other; and

4[d] coating the ply yarn with an adhesive, and the ply yarn coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association, and has a dry heat shrinkage of 1.5 to 2.5%,

4[e] wherein the first, second and third twist numbers are identical with each other, and

4[f] wherein the third step produces a 2-ply secondarily-twisted yarn consisting of 1-ply of nylon primarily-twisted yarn and 1-ply of aramid primarily-twisted yarn.

Ex.1001, cls. 1, 4 (added claim lettering corresponding to Petitioner's annotations).

B. Person of Ordinary Skill in the Art

42. Petitioner proposes the following description of a POSITA:

A person of ordinary skill in the art ("POSITA") at the time of the '731 patent would have had at least a Bachelor of Science degree in materials science and engineering, textile engineering, chemistry, or an equivalent field, and at least two years of experience with tire reinforcement cord design and manufacture, and/or fiber or polymer

> science and processing. More education can supplement practical experience and vice versa.

Pet. 19 (citations omitted). For purposes of this Declaration, I have applied Petitioner’s definition of a POSITA, but I reserve my right to provide an alternate definition in this or other proceedings. In addition, I note that, while I exceed this level of skill, I am familiar with the qualifications and capabilities of others in the relevant art with this level of skill and am able to provide testimony from the perspective of a POSITA with this level of skill.

C. Claim Construction

43. For purposes of this Declaration, I have not applied any specific construction of any claim term. It is my opinion that Petitioner fails to show the prior art references render the subject matter of the Challenged Claims unpatentable under any reasonable construction, including their plain and ordinary meaning.

VIII. Grounds 1-3: In my opinion, Petitioner and Dr. Rust fail to show that Tamura in view of Baldwin or Baek renders obvious claims 1 and 4

44. Petitioner and Dr. Rust contend that the combinations of Tamura and Baldwin or Tamura and Baek render obvious the ’731 patent’s independent claims 1 and 4. *See* Pet. 19; Ex.1003, ¶¶74-122. Petitioner and Dr. Rust cite Tamura for most of the claim limitations, and Baldwin or Baek as disclosing the identical structure requirement. *See* Pet. 25-41; Ex.1003, ¶¶80-122. But in my opinion,

Tamura does not disclose or render obvious at least the claimed strength retention rate limitations in the independent claims, claims 1 and 4. In my opinion, for at least this reason, Petitioner’s and Dr. Rust’s Grounds 1-3 arguments do not establish obviousness of claims 1 and 4.

A. Summary of Prior Art References

1. Tamura (Ex.1006)

45. Tamura is a published Japanese patent application titled “Large Diameter Rubber Hose.” Ex.1006, Title, [0009]-[0010]. Tamura discloses a relatively long fabric reinforced rubber hose for transporting oil from tankers to port. Ex.1006, Abstract, [0002].

46. Tamura relates to reinforcement fabric for large-diameter rubber hose and focuses on physical properties relevant for this type of reinforcement fabric. Ex.1006, Abstract, [0009]-[0010]. In one embodiment of Tamura, for example:

> [T]he present invention provides a large-diameter rubber hose formed using vulcanized rubber reinforced by compounding fiber fabric and/or fiber cord, characterized in that the fiber fabric and/or fiber cord is composed of a composite fiber of aramid fiber and nylon fiber. …
>
> The large-diameter rubber hose of the present invention maintains sufficient adhesive strength between the rubber layer and the reinforcing material layer even after a long period of vulcanization and hardening, effectively preventing the rubber layer and the

> reinforcing material layer from peeling off during use, and furthermore, when a fluid is passed through the hose, the change in the hose diameter due to the pressure of the fluid is small . . . . In addition, since the composite fiber used in the present invention has high heat resistance, it is possible to shorten the vulcanization time by setting the vulcanization temperature high, thereby improving production efficiency.

Ex.1006, [0011]-[0012].

47. Tamura discloses certain properties of fibers in reinforcement fabrics for hose reinforcements, including tensile force (N/piece) and elongation (%), and strength retention rate after buckling (%). Ex.1006, [0033]-[0036], Table 1. For example, the "Strength retention rate after buckling (%)" property is disclosed in Tamura's Table 2, as shown in the last column in the excerpt below:

		Properties of heat-treated adhesive					
		Force (N/piece)	Elongation at breakage (%)	Dry heat shrinkage rate (%)	Strength (g/d)	Creep (%)	Strength retention rate after buckling (%)
Comparative Example	1	216	21.0	5.8	8.7	4.8	96
	2	216	17.7	6.1	7.3	1.9	87
Embodiment	1	325	10.5	2.5	12.0	0.5	90
	2	326	8.5	2.4	12.0	0.5	88
	3	328	10.0	2.6	12.1	0.6	91
	4	364	10.7	3.0	10.9	0.6	91
	5	390	11.5	3.2	9.9	1.0	90
	6	556	7.0	2.0	14.7	0.5	90
	7	581	8.6	2.1	13.9	0.4	90
	8	539	8.6	2.1	12.9	0.5	94
	9	615	8.8	2.0	12.8	0.5	92
Comparative Example	3	523	5.2	0.0	17.7	0.2	39
	4	462	12.0	4.0	8.9	1.6	89
	5	319	9.5	3.1	10.8	0.5	82
	6	206	17.5	6.0	7.6	3.1	90

Ex.1006, Table 2 (excerpted).

2. Baldwin (Ex.1007)

48. Baldwin, entitled "Tire Cord Reinforcement," relates to a composite cable for use as reinforcement in aircraft tires. Ex.1007, Title, Abstract. Baldwin discloses merge composite cord having yarns with a certain linear density and a shrinkage of 3.6%, as shown in Baldwin's Figure 10 below:

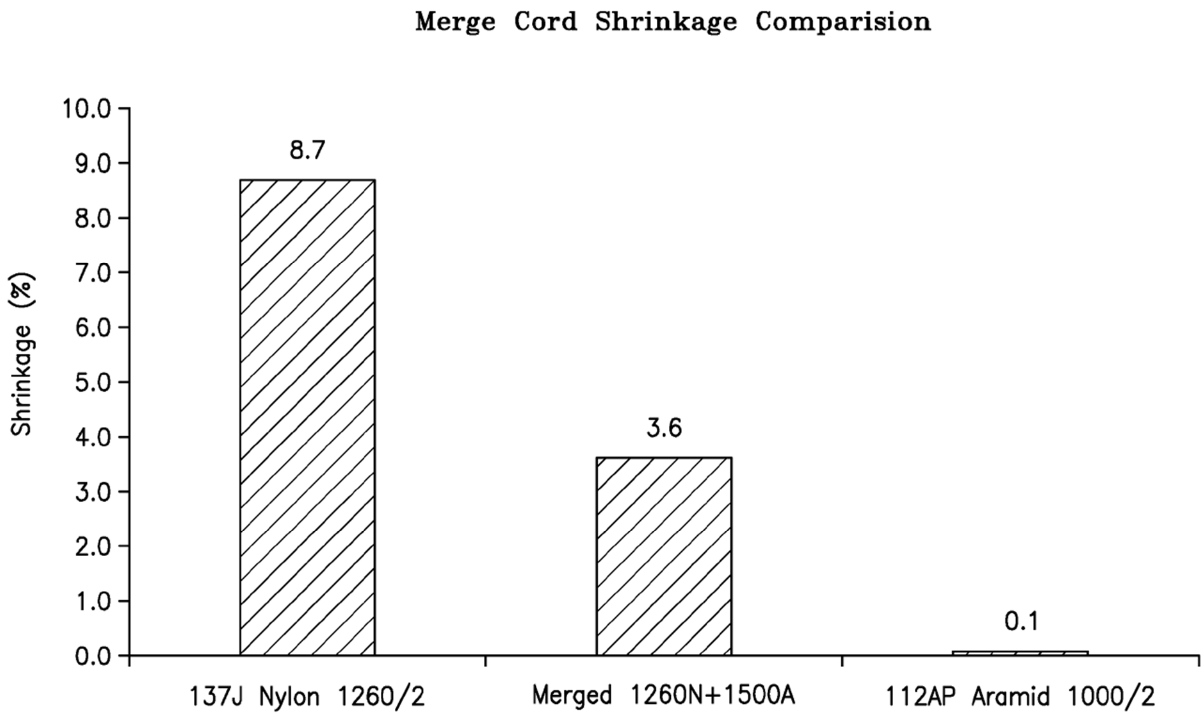


FIG-10

Ex.1007, Fig. 10, [0062]. Baldwin discloses preferred twist numbers for the aramid individually-twisted yarn, the nylon individually-twisted yarn, and the hybrid cord:

> Each aramid yarn is individually twisted in the Z direction. The twist may range from about 3 to about 16 tpi (twists/inch) [about 118 to about 630 TPM] in the Z direction, and more preferably about 6 to about 12 tpi [about 236 to about 472 TPM], and most preferably to about 10.7 tpi [421 TPM] in the Z direction. …
>
> The nylon 2 is individually twisted by a Z twist in the range of about 3 to about 16 [about 118 to about 630 TPM], more preferably from about 3 to about 7 [about 118 to about 276 TPM], and most preferably about 6.2 (tpi) [244 TPM]. The nylon and aramid yarns

> are plied together to form a cable with an S twist in the range of about 3 to about 16 tpi [about 118 to about 630 TPM], more particularly in the range of about 7 to about 10 [about 276 to about 394 TPM], and most preferably about 9.7 twists/inch [about 382 TPM].

Ex.1007, [0062]-[0063].

3. Baek (Ex.1008)

49. Baek, entitled "Aramid-Nylon Complex Fiber Cord for Rubber Stiffner," relates to fiber cord having certain structural stability and adhesiveness qualities. Ex.1008, Title, Abstract. Petitioner and Dr. Rust rely on Baek as an alternative to Baldwin. *See* Pet. 19.

50. Baek discloses 2-ply and 3-ply cords with specific twist number ranges:

> In the present invention, aramid ply of 500 to 2,000 denier and nylon ply of 500 to 2,000 denier can be applied, and the fiber cords of the present invention has a structure of two ply cord made by twisting on ply of aramid and one ply of nylon, three ply cord made by twisting one ply of aramid and two plies of nylon, or three ply cord made by twisting two plies of aramid and one ply of nylon. At this time, the desirable number of twists is 10 to 50 TPI (Twist Per Inch) [394 to 1,968 TPM].

Ex.1008, 3. Baek's Table 1 further discloses aramid cord and composite fiber cord twisted at 43 TPI, which is equivalent to 1,693 TPM (twists per meter), and Baek's

Table 3 discloses aramid cord and composite fiber cord twisted at 35 TPI, which is equivalent to 1,378 TPM. Ex.1008, Tables 1, 2.

B. Tamura does not disclose or suggest the claimed strength retention rate limitation

51. Independent claim limitation 1[h] recites, among other things, that the "the secondarily-twisted yarn is coated with the adhesive, and the secondarily-twisted yarn coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." Independent claim limitation 4[d] similarly recites a method including a step of "coating the ply yarn with an adhesive, and the ply yarn coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." A POSITA would not have found that Tamura discloses or renders obvious at least this limitation of the independent claims.

52. Petitioner and Dr. Rust rely on Tamura's Table 2 and paragraphs [0034]-[0035] to argue that Tamura discloses the claimed strength retention rate limitations. Pet. 34-37, 40; Ex.1003, ¶¶101-105, 116[1]. However, there are several

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[1] For claim limitation 4[d], Dr. Rust makes the reference "*See* limitation [4d]." Ex.1003, ¶116. Dr. Rust appears to reference to this very same paragraph, as there are no other limitation 4[d] prior to paragraph 116.

reasons why, as explained below, a POSITA would not find Tamura to disclose or render obvious the claimed properties.

53. First, Petitioner and Dr. Rust rely on a "Strength retention rate **after buckling** (%)" test in Tamura, not the claimed "strength retention rate" limitation required by the '731 patent's claims, as shown in the excerpt of the Petition and Dr. Rust's declaration below.

		Properties of heat-treated adhesive					
		Force (N/piece)	Elongation at breakage (%)	Dry heat shrinkage rate (%)	Strength (g/d)	Creep (%)	Strength retention rate after buckling (%)
Comparative Example	1	216	21.0	5.8	8.7	4.8	96
	2	216	17.7	6.1	7.3	1.9	87
Embodiment	1	325	10.5	2.5	12.0	0.5	90
	2	326	8.5	2.4	12.0	0.5	88
	3	328	10.0	2.6	12.1	0.6	91
	4	364	10.7	3.0	10.9	0.6	91
	5	390	11.5	3.2	9.9	1.0	90
	6	556	7.0	2.0	14.7	0.5	90

EX1006, TABLE 2 (excepted and color annotations added).

Pet. 37 (annotated in blue circle; other annotations in original); Ex.1003, ¶102 (same). As noted in Petitioner's and Dr. Rust's reference of Tamura's Table 2, Tamura only measures a "Strength retention rate after buckling (%)." Pet. 37 (citing Ex.1006, Table 2); Ex.1003, ¶102 (same). The limitations recited in the '731 patent, however, require a "strength retention rate … after a **disc fatigue test** is performed." Ex.1001, cl. 1[h], 4[d] (emphasis added). Thus, Table 2 of Tamura does not support that Tamura's secondarily-twisted yarn has the required strength retention rate limitation as recited in the claims, because Tamura does not use the same test method. As I explain further below, a POSITA would have understood that the test disclosed in Tamura and the test used in the '731 patent are not the same. A POSITA would have known that the disc fatigue test that is required in the '731 patent does not allow buckling of the cord.

54. A POSITA would have understood that the buckling test in Tamura is different from the disc fatigue test in the strength retention rate limitations of the claims. As I explain below, the claimed disc fatigue test limitations involve "stretching and contracting" the sample "while rotating" it to assess its fatigue resistance, where "the hybrid fiber cord and rubber were vulcanized together to produce [the] sample," (Ex.1001, 9:49-57) but Tamura's buckling test is concerned with the percentage of the original strength that the fabric is able to maintain after it is **bent** numerous times, or the resistance of a cord to buckling, which is a form of structural instability (Ex.1006, [0062]-[0064]).

55. Petitioner and Dr. Rust leave aside the differences between the two tests and claim that the "Strength retention rate after buckling (%)" test in Tamura's Table 2 meets the claim requirements. Ex.1006, Table 2. Petitioner asserts the following:

> Tamura discloses embodiments wherein the secondarily-twisted yarn coated with the adhesive has ***a strength retention rate of 80% or more and a dry heat shrinkage of 1.5-2.5%***. As provided in TABLE 2 [above], embodiment 1 of Tamura includes a strength retention rate of 90% and a dry heat shrinkage of 2.5%; and embodiment 2 includes a strength retention rate of 88% and a dry heat shrinkage of 2.4%.

Pet. 34 (emphasis in original, citations omitted); Ex.1003, ¶102 (verbatim). However, a POSITA would have recognized that Tamura's "Strength retention rate after **buckling** (%)" test is not the same as the claimed "strength retention rate of 80% or more after a **disc fatigue test**." Ex.1006, Table 2; Ex.1001, cls. 1[h], 4[d]. Petitioner and Dr. Rust argue that "Tamura discloses embodiments… [that] has a strength retention rate of 80%," (Pet. 34; Ex.1003, ¶102), but that is not the claimed strength retention rate measured after **a disc fatigue test**.

56. Petitioner and Dr. Rust further rely on Tamura's paragraphs [0034]-[0035] to contend that "Tamura further explains that the disclosed strength retention rates were determined ***after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association***. …" Pet. 35 (emphasis in original); Ex.1003, ¶103 (same). But Tamura's paragraphs [0034] and [0035] do not have any mention or suggestion of a disc fatigue test. Ex.1006, [0034]-[0035]. As I further explain below, a POSITA would not agree with Petitioner's and Dr. Rust's assertion.

57. A POSITA would have understood that Tamura merely mentions the JIS-L 1017 Standard but does not disclose or render obvious the claimed limitation requiring a "strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." Ex.1001, cls. 1[h], 4[d]. Starting with Tamura's paragraph [0034], a POSITA would have understood that it discusses tensile force measured "[i]n accordance with JIS L1017" and dry heat shrinkage rate measured "[a]ccording to JIS L 1017 (Method B)." Ex.1006, [0034]. Neither test corresponds to the recited disc fatigue test that is performed according to JIS-L 1017 method of Japanese Standard Association. In my opinion, Petitioner's and Dr. Rust's assumption that Tamura's mere mentioning of the JIS-L 1017 Standard discloses or renders obvious the claimed strength retention rate measured after a disc fatigue test is incorrect. Tamura's paragraph [0034] is shown below:

> Properties of heat-treated adhesive
>
> A reinforcing fiber fabric was immersed in an adhesive liquid (an aqueous solution of an epoxy compound and an RFL liquid), dried, and then heat-treated to prepare an adhesive heat-treated piece having 8% by mass of the adhesive liquid attached thereto. The adhesive heat-treated piece was evaluated by the following methods (1) to (4).
>
> (1) Tensile force (N/piece) and elongation (%)

> In accordance with JIS L1017, tests were carried out on one fiber cord at a gripping distance of 25 cm and a pulling speed of 30 cm/min, and the force and elongation at break were measured.
>
> (2) Dry heat shrinkage rate (%)
>
> According to JIS L1017 (Method B), the fiber cord with the yarn length accurately measured was left in a dryer set at 180°C for 30 minutes, then removed from the dryer and left for 30 minutes, after which the yarn length was measured and the dry heat shrinkage was calculated.
>
> (3) Strength (g/d)
>
> The force value measured in section (1) was converted from N units to g units, and was calculated by dividing by the total denier number of the fiber cord (0.9 d (denier) = 1.0 dt (decitex)).
>
> (4) Creep (%)
>
> In accordance with JIS L1017, the length of the fiber cord was accurately measured, and then a load of 0.88 cN/dt (for example, in the case of a structure in which two 1670 dt yarns are twisted together, 1670 x 2 x 0.88/100 = 29.4 N) was applied, and the yarn length was measured after leaving it at room temperature for 30 minutes, and the creep rate was calculated.

Ex.1006, [0034]. As shown above, Tamura's paragraph [0034] only discusses tests such as for tensile force, elongation, dry heat shrinkage, and creep, but does not contain any mention or suggestion of the claimed "disc fatigue test performed according to JIS-L 1017." Ex.1006, [0034].

58. A POSITA would have understood that simply referencing the JIS-L 1017 Standard such as in Tamura's tensile force test does not disclose or render obvious the claimed disc fatigue test limitation either. Ex.1006, [0034]. JIS-L 1017, entitled "Test methods for chemical fibre tire cords," includes testing specifications and procedures for a wide range of tests. *See generally* Ex.1036. Below is a sample list of tests that are included in the JIS-L 1017 Standard:

> 3. Items Items shall be as follows.
> (1) Cord gauge
> (2) Moisture percentage
> (3) Fineness based on corrected mass
> (4) Twist
> (5) Breaking strength and elongation percentage
> (6) Load at constant elongation
> (7) Elongation percentage at constant load
> (8) Resistance to incipient tension
> (9) Strength after heating
> (10) Dry-heat shrinkage percentage
> (11) Shrinkage stress in dry-heat condition
> (12) Creep percentage
> (13) Water absorption
> (14) Shrinkage percentage after dipping in boiling water
> (15) Dip pickup
> (16) Solvent extract

Ex.1036, 3-4. Additional tests are listed throughout Informative reference 1 in JIS-L 1017 (Ex.1036, 20-33), including the "Fatiguing strength with disc-type tester."

Thus, a POSITA would have understood that the JIS-L 1017 Standard includes many tests. A reference to JIS-L 1017 by itself therefore does not provide clarity on which of the tests is being performed.

59. Further, Tamura's paragraph [0035] only refers to a bending test named "Strength retention rate after buckling (%)" test in Tamura's Table 2. Ex.1006, [0035]. It does not mention or suggest the JIS-L 1017 Standard or any disc fatigue test. Ex.1006, [0035].

60. A POSITA would have understood that Tamura references a bending test that is different from the claimed disc fatigue test limitation in the '731 patent. Tamura focuses on the "durability and dimensional stability" of a "a large-diameter rubber hose," for which "the rubber layer and the reinforcing layer do not peel off during use, and the change in the hose diameter due to the pressure of the fluid during fluid transport is small." Ex.1006, Abstract. Tamura explains the problem that "large-diameter hoses are generally subjected to high pressure when transporting liquids such as crude oil, [so] they have an inner rubber layer on the inner circumference and an outer rubber layer on the outer circumference, with a reinforcing layer made of synthetic fiber or wire laminated between the inner and outer rubber layers." Ex.1006, [0002].

61. Tamura's "large-diameter rubber hose" may be bent during use, so a POSITA would have understood that Tamura is concerned with the percentage of

the original strength that the fabric is able to maintain after it is bent numerous times. Ex.1006, [0035]. Thus, Tamura focuses on a "Strength retention rate after buckling (%)" test that bends the fabric for 200,000 times, then takes the strength after bending, divides it by the strength before bending, and multiplies by 100 to arrive at the "Strength retention rate after buckling (%)." Ex.1006, [0035]. The relevant passage is excerpted below:

> Properties after vulcanization
>
> (1) Strength retention ate after buckling (%)
>
> Three sheets of the above heat-treated adhesive strip, coated on both sides with 0.6 mm thick NR/SBR unvulcanized rubber, were laminated between two NR/SBR unvulcanized rubber sheets (4.5 mm thick), and the laminate was heated and pressurized for 30 minutes at 1.5 MPa and 145°C to vulcanize and bond the two together, forming the specimen to be evaluated.
>
> The above evaluation specimen was placed on a pulley and subjected to a **bending test** under the following conditions, after which the innermost layer of reinforcing fiber fabric was removed when bent, and its force was measured in the same manner as the force measurement method for the heat-treated adhesive fabric described above, and its retention rate (**strength after bending ÷ strength before bending × 100**) was calculated.
>
> Pulley diameter: 100mm
>
> Load : 5% of breaking force

Number of bends : 200,000 times

Ex.1006, [0035] (emphases added). Petitioner and Dr. Rust confirm that Tamura focuses on the bending of the fabric and the strength of the fabric after bending, as they state "the reinforcing fiber fabric was subjected to **a bending test**," and "the strength retention rate was calculated by dividing the **strength after bending** by the **strength before bending**, multiplied by 100." Pet. 36 (emphases added); Ex.1003, ¶104 (same).

62. A POSITA would have understood that the '731 patent's test required by the claimed strength retention rate limitation is a completely different test than that referenced in Tamura. Whereas Tamura focuses on "a large-diameter rubber hose" for use in "transporting liquids such as crude oil" and its "force and elongation at break," (Ex.1006, Abstract, [0002], [0034]), the '731 patent recites "a hybrid fiber cord" for use in "ultra high performance tire" and properties of these types of hybrid fiber cord (Ex.1001, Abstract, 1:18-31).

63. The '731 patent explains that the hybrid fiber cord and its method of manufacturing leads to "better strength and fatigue resistance than the conventional hybrid fiber cords such that it can be used to make an ultra high performance tire." Ex.1001, 2:49-61. A POSITA would have understood that, whereas a hose may be subject to static forces and to bending, a tire is subject to dynamic stresses that are associated with driving. A POSITA would have understood that because the

'731 patent focuses on a hybrid fiber cord and its method of manufacturing that leads to "better … fatigue properties," it requires evaluation according to the "disc fatigue test … performed according to JIS-L 1017 method of Japanese Standard Associations." Ex.1001, Abstract, cl. 1. As the '731 patent explains, the disc fatigue test focuses on "repeated" "stretching and contracting" the sample "while rotating the sample," where "the hybrid fiber cord and rubber were vulcanized together to produce a sample." Ex.1001, 50-57.

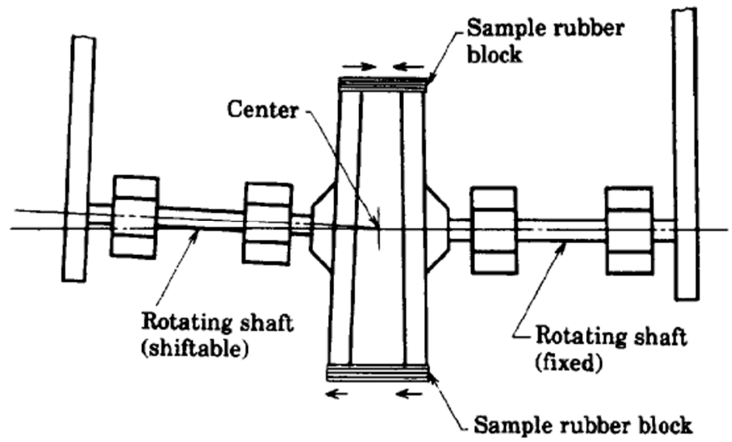
64. The JIS-L 1017 Standard confirms that the disc fatigue test is different from Tamura's bending test. The disc fatigue test is shown in § 2.2.2 of the Informative Reference 1 section of JIS-L 1017, titled "Fatiguing strength with disc-type tester," as excerpted below:

2.2.2 Fatiguing strength with disc-type tester (Goodrich method) The test for fatiguing strength with a disc-type tester (Goodrich method) shall be as follows.

(1) Employ the disc-type fatiguing strength tester shown in Informative reference 1 Fig. 8, attach the rubber block (14), in which a test piece has been buried, on the periphery of 2 discs which have eccentric rotating shaft axis in order to give the block the specified extension percentage and compression percentage (follow the agreement between the parties concerned with delivery).

Note (14) This is a rubber block measuring 5.0 cm to 8.0 cm in length and 1.0 cm to 1.5 cm in width and thickness, and contains a test piece in central position of longitudinal direction.

Informative reference 1 Fig. 8. Disc-type fatiguing strength tester



(2) Then, rotate it for 24 h to 72 h (15) with 1800 rpm to 2800 rpm at specified temperature (16), remove the test piece from the rubber block, and test its strength according to 7.5 (2) of this Standard.

Notes (15) This shall be subjected to agreement between the parties concerned with delivery within the range from 24 h to 72 h.

(16) It shall follow the agreement between the parties concerned with delivery.

(3) Calculate durability percentage by compression•bending according to the following formula.

$$NF_r = \frac{T_d}{T_c} \times 100$$

where, NF_r: durability percentage by compression•bending (%)

T_c: breaking strength of test piece taken from untreated rubber block (N)

T_d: breaking strength of test piece taken from treated rubber block (N)

Ex.1036, Informative Reference 1, 28-29. As explained in JIS-L 1017's disc fatigue test, the test involves "[e]mploy[ing] the disc-type fatiguing strength tester," burying the sample in a rubber block, attaching the sample "on the periphery of 2 discs which have eccentric rotating shaft axis," and repeatedly stretching and contracting the sample while rotating the sample. Ex.1036, 28-29. Because of the fundamental difference between the Tamura bending test that Petitioner and Dr. Rust rely on and the disc fatigue test, a POSITA would not have found Tamura's bending test to disclose or render obvious the '731 patent's claimed requirement for "a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." Thus, a POSITA would have found Petitioner and Dr. Rust to be incorrect in stating that "a POSITA would have understood that the strength retention rates disclosed in TABLE 2 of Tamura (including the strength retention rates for embodiments 1 and 2) were determined ***after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association***, as claimed." Pet. 37 (emphasis in original); Ex.1003, ¶105 (verbatim).

65. A POSITA would have further understood that there are a number of significant differences between Tamura's bending test and the claimed disc fatigue test. One example of the differences between the two tests is that the strength retention rate after disc fatigue test according to JIS-L 1017 does not measure the buckling percentage because the test involves "bur[ying]" a sample cord between two rubber blocks. *See* Ex.1036, 28-29. A POSITA would have understood that burying the sample cord between the rubber blocks prevents the cord from buckling, so the strength retention rate after a disc fatigue test in the '731 patent

does not measure any buckling percentage. However, Tamura emphasizes its measurement of "Strength retention rate after buckling (%)." Ex.1006, [0035].

66. Further, the strength retention rate after a disc fatigue test according to JIS-L 1017 that is recited in the '731 patent involves repeatedly subjecting the samples to "the stretching and contracting steps for 8 hours at 80°C, while rotating the sample at 2500 rpm," which amounts to a total of 1.2 million cycles. Ex.1001, 9:52-59. In comparison, Tamura only requires a total number of "200,000 times" of bending cycles (which, in any event, are not the same as fatigue cycles). Ex.1006, [0035]. Tamura also does not disclose any particular elevated temperature for its bending test. *See* Ex.1006, [0035].

67. The sample preparation between the tests in the '731 patent and Tamura are also different. In the '731 patent's strength retention rate after disc fatigue test pursuant to JIS-L 1017, the test uses "a rubber block measuring 5.0 cm to 8.0 cm in length and 1.0 cm to 1.5 cm in width and thickness, and contains a test piece in central position of longitudinal direction." Ex.1036, 28-29; *see also* Ex.1001, 9:49-10:3. As explained in the JIS-L 1017 Standard, the hybrid fiber cord sample is inserted, or "buried," into the rubber block. Ex.1036, 28; *see also* Ex.1001, 9:49-10:3. In contrast, Tamura's bending test uses "[t]hree sheets of … heat-treated adhesive strip, coated on both sides with 0.6 mm thick NR/SBR unvulcanized rubber, [which] were laminated between two NR/SBR unvulcanized

rubber sheets (4.5 mm thick), and the laminate was heated and pressurized for 30 minutes at 1.5 MPa and 145°C to vulcanize and bond the two together, forming the specimen to be evaluated." Ex.1006, [0035]. A POSITA would have understood that the methods of preparing the samples between the claimed disc fatigue test and the bending test in Tamura are distinct, using different materials, with different pressure, and with different temperature. A POSITA would not find the preparation of the two test specimens to be equivalent.

68. Petitioner and Dr. Rust also fail to show that Tamura evaluates properties of a yarn corresponding to the claimed "secondarily-twisted yarn coated with the adhesive" or "ply yarn coated with the adhesive" as recited in the '731 patent's independent claims 1[h] and 4[d] and thus, these limitations are not disclosed or rendered obvious for this additional reason. Independent claim 1[h] requires that the "**secondarily-twisted yarn** coated with an adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed accordingly to JIS-L 1017 method of Japanese Standard Association." Ex.1001, cl. 1[h]. Independent claim 4[d] similarly requires that "the **ply yarn** coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." Ex.1001, cl. 4[d].

69. Petitioner and Dr. Rust contend that the composite fiber cord in Tamura is the secondarily-twisted yarn—"the composite fiber cord [i.e., ***the secondarily-twisted yarn***]." Pet. 34 (emphasis in original); Ex.1003, ¶100 (verbatim). For independent claim 4, Petitioner and Dr. Rust appear to merely refer back to their arguments for claim 1. Pet. 40; Ex.1003, ¶116. However, the results in Tamura's Table 2 are not results of Tamura's composite fiber cord; instead, Tamura's Table 2 shows the below:

> [Embodiments 1 to 9, Comparative Examples 1 to 6]
>
> Using the fiber cords shown in Table 1 as warp threads **and a reinforcing fiber fabric** with a thread count shown in Table 1 (Polynosic 300 dt/1 (single twist, 300 dt) was used as the weft thread, with a thread count of 4 threads/5 cm), an evaluation specimen was produced in the following manner, and its characteristics were evaluated. The evaluation results are shown in Table 2.

Ex.1006, [0033] (emphasis added). A POSITA would have understood that the fiber cords tested in Tamura are reinforced with the fabric "Polynosic." Ex.1006, [0033]. A POSITA would have known that "Polynosic" is a modified cellulosic type of rayon fiber. Ex.1006, [0033]. A POSITA would have therefore understood that the properties in Tamura's Table 2 do not correspond to the allegedly equivalent "secondary-twisted yarn" of Tamura (i.e., its "composite fiber cord") but rather, the properties evaluated and listed in Table 2 correspond to an evaluation specimen of the composite fiber cord **and** a reinforcing fiber fabric. In my opinion, the testing properties in Tamura do not disclose or render obvious the claimed limitations in the '731 patent, because the tests are not performed on the equivalent materials (i.e., a secondarily-twisted yarn or ply yarn).

70. Thus, because of the numerous differences between Tamura's bending test, which Petitioner and Dr. Rust rely on, and the claimed disc fatigue test, a POSITA would have found that results from Tamura's bending test would not be predictive of the results for the claimed disc fatigue test. A POSITA would not have found that the claimed "strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association" to have been rendered obvious by Tamura.

71. Accordingly, in my opinion, Petitioner and Dr. Rust have not shown that Tamura discloses or renders obvious these limitations in the independent claims 1 and 4 of the '731 patent.

C. Petitioner and Dr. Rust fail to establish a motivation to combine Tamura with Baldwin or Baek to arrive at the claimed invention

72. In my opinion, Petitioner and Dr. Rust also have not shown why a POSITA would have been motivated to combine Tamura with Baldwin or Tamura with Baek to arrive at the claimed invention. Indeed, a POSITA would not have been motivated to do so for at least the following reasons.

73. First, Petitioner and Dr. Rust have not shown that a POSITA would have combined Tamura with Baldwin or Baek to achieve the claim requirements.

The '731 patent claims "a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn" where "the nylon primarily-twisted yarn and the aramid primarily-twisted yarn … have identical structures with each other in the hybrid fiber." Ex.1001, cls. 1[e], 4[c] (similar). A POSITA would have found that Petitioner and Dr. Rust have not provided any reason why Baldwin and Baek would have been combined with Tamura to achieve this claim limitation.

74. Petitioner and Dr. Rust claim that "[t]here are a few distinctive benefits of tensioning and twisting the aramid and nylon yarns to have the same structure," citing references outside of the listed Tamura, Baldwin, and Baek. Pet. 23-24; Ex.1003, ¶75. For example, Petitioner and Dr. Rust rely on references such as Kerawalla (Ex.1016, U.S. Patent No. 3,977,172) and Westhoff (Ex.1017, U.S. Patent No. 4,652,252) for their contentions. Pet. 23-24, Ex.1003, ¶75. However, whereas the claimed invention focuses on "a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn," (Ex.1001, cls. 1, 4) in other words 2-ply hybrid fiber cords, a POSITA would have understood that both Kerawalla and Westhoff are different. Both references focus on 3-ply hybrid fiber cords. For example, Kerawalla discusses in detail: "[a] tire cord (A) was prepared from **three** ends (1500 denier each) of PPD-T yarn." Ex.1016, 2:21-24 (emphasis added). Similarly, Westhoff

discusses that "[a] geometrically stable cord is made by twisting together **three** ends of 2130 denier aramid type 2 yarn together to form a ply." Ex.1017, 2:46-51 (emphasis added); *see also* Ex.1017, 7:1-7 ("**three** ends of 1420 denier zero twist aramid type 2 yarn") (emphasis added). A POSITA would have understood that these references' focus on 3-ply hybrid fiber cords is logical given that the prior art taught advantages of 3- or more ply hybrid fiber cords. Ex.2032 ("Reuter," U.S. Patent No. 6,799,618), 5:4-16; Ex.2033 ("Zandiyeh," U.S. Patent App. Pub. 2014/0230947), [0009]. For example, Reuter teaches that "two yarns of 1100 dtex Aramid are each twisted 14 TPI [twists per inch] in the S direction and the three yarns receive a cord twist of 9 TPI in the S direction." Ex.2032 (Reuter), 5:4-16. As another example, Zandiyeh discloses that "[t]he cord may comprise 2 plies of aramide and 1 ply of polyester twisted together. … Each aramide ply may comprise 3 plies of yarn … Each polyester ply may also comprise 3 plies of yarn." Ex.2033 (Zandiyeh), [0009]. Thus, a POSITA would not have found a motivation combine Tamura with Baldwin and Baek based on Kerawalla and Westhoff, because the fiber cords they disclose are not 2-ply hybrid fiber cord.

75. Second, Petitioner's and Dr. Rust's "motivation to combine" arguments also ignore parts in the cited prior art references that contradict each other and lead away from the claimed limitations. For example, Petitioner and Dr. Rust rely on Baldwin's Figure 1 to contend that Baldwin discloses the claim

limitation that "the nylon primarily-twisted yarn and the aramid primarily-twisted yarn … have identical structures with each other in the hybrid fiber," "where 'the first, second, and third twist numbers are identical with each other.'" Pet. 31-32 (emphasis omitted); Ex.1003, ¶¶94-95; Ex.1001, cls. 1[e], 4[c] (similar). However, Baldwin explicitly teaches that its hybrid tire cord "most preferably" has different twist numbers between the first, second, and third twists:

> Each aramid yarn is individually twisted in the Z direction. The twist may range from about 3 to about 16 tpi (twists/inch) in the Z direction, and more preferably about 6 to about 12 tpi, and **most preferably to about 10.7 tpi [421 TPM]** in the Z direction. … The nylon 2 is individually twisted by a Z twist in the range of about 3 to about 16, more preferably from about 3 to about 7, and **most preferably about 6.2 (tpi) [244 TPM]**. The nylon and aramid yarns are then plied together to form a cable with an S twist in the range of about 3 to about 16 tpi, more particularly in the range of about 7 to about 10, and **most preferably about 9.7 twists/inch [382 TPM]**.

Ex.1007, [0062]-[0063] (emphases added). In other words, Baldwin teaches that each twist is conducted "most preferably" at different twist numbers from each other. Ex.1007, [0062]-[0063]. A POSITA would have understood that Baldwin's preferred difference in twist numbers used to manufacture the cord to not meet the claimed limitations "wherein the nylon-primarily twisted yarn and the aramid primarily-twisted yarn are secondarily-twisted together at a third twist number which is identical with the first and second twist numbers" or "wherein the first, second, and third twist numbers are identical with each other." Ex.1001, cls. 1[e], 4[c], 4[e]. Independent claim limitation 4[e] recites "a third step for secondarily-twisting the nylon and aramid primarily-twisted yarns together at a third twist number … wherein the first, second, and third twist numbers are identical with each other." Ex.1001, cl. 4[e]. Petitioner and Dr. Rust, however, ignore these portions of Baldwin, and do not explain why a POSITA would have departed from Baldwin's preference and seek equal twist numbers, even given Kerawalla and Westhoff.

76. Further, a POSITA would have found that both Petitioner's and Dr. Rust's Baldwin and Baek references teach twist numbers that fall outside the claimed range. Independent claims 1 and 4 of the '731 patent claim a twist number range of 300 to 500 TPM for the nylon primarily-twisted yarn and the aramid primarily-twisted yarn. Ex.1001, cls. 1[a], 1[b], 4[a], 4[b]. But Baldwin teaches that the nylon yarn is "most preferably" twisted at "6.2 (tpi)," which is 244 TPM. Ex.1007, [0062]-[0063]. Baek further teaches that the aramid yarn is to be twisted at 35 twists per inch, which is 1,378 TPM, and the hybrid cord is to be twisted at 43 twists per inch, which is 1,693 TPM. Ex.1008, Tables 1, 3. Thus, both Baldwin and Baek disclose twist numbers that fall outside of the claimed range of the '731 patent, and a POSITA would not have found that these twist numbers disclose or

render obvious the claimed twist number ranges. Petitioner and Dr. Rust do not explain why a POSITA would have departed from these disclosures and seek twist numbers that fall in the claimed ranges, even given Kerawalla and Westhoff, which do not disclose the claimed ranges.

77. Third, Petitioner and Dr. Rust also contend that a POSITA would have been motivated to combine Tamura with Baldwin or Tamura with Baek because "hybrid tire cords can be made faster and easier using direct cable machines, which operate at high speeds." Pet. 24; Ex.1003, ¶76 (verbatim). Petitioner and Dr. Rust cite Rowan as disclosing "direct cable machines" that "combine the ply and twisting step into one operation, thus rendering the tire cord production process more efficient and cost effective," (Pet. 24 (quoting Ex.1015, [0007]); Ex.1003, ¶76 (verbatim)) and Fritsch as disclosing "constituent yarns" having a "twist number which is equal to … the twist number in the parent cabled cord" (Pet. 24 (quoting Ex.1023, [0023]); Ex.1003, ¶76 (verbatim)). Petitioner and Dr. Rust contend that a POSITA would have combined Tamura with Baldwin or Baek because of their disclosure of "identical structures," (Pet. 23; Ex.1003, ¶74) but neither Rowan nor Fritsch discuss the "identical structures" requirement of the independent claim limitations. *See* Ex.1015, [0007]; Ex.1023, [0023]. Neither reference, therefore, supports a "motivation to combine" Tamura with Baldwin or Tamura with Beck. Thus, Petitioner and Dr. Rust have not shown a motivation to

combine their cited references. Petitioner's and Dr. Rust's additional motivation, that "non-uniform (or unbalanced) cord constructions can often lead to uneven stress distribution within the tire and compromise tire performance," (Pet. 24; Ex.1003, ¶77) also does not support a "motivation to combine." They do not support this assertion, which is directly contrary to their assertion that an unbalanced tire cord improves physical properties in other IPRs: "the Fritsch reference published in 2003 … is directed to forming a hybrid tire cord and explains that altering the tension of the yarns can create an 'unbalanced' tire cord, resulting in improved physical properties." Ex.2030 (IPR2025-00664, Petition), 2; *see also* Ex.2030 (IPR2025-00664, Petition), 16, 26, 29; Ex.2031 (IPR2025-00664, Ex.1003 (Rust Declaration)), ¶¶69,96; Ex.2028 (IPR2025-00663, Petition), 1-2, 23; Ex.2029 (IPR2025-00663, Ex.1003 (Rust Declaration)), ¶¶80, 82, 87, 89, 95.

78. Finally, Petitioner and Dr. Rust contend that "Tamura, Baldwin, and Baek are analogous to each other and to the '731 patent" because "[e]ach teaches a tire cord comprising a twisted aramid yarn and a twisted nylon yarn that are twisted together to for a hybrid cord." Pet. 25; Ex.1003, ¶78. But a POSITA would have understood that Tamura is directed to "a large-diameter rubber hose," and does not mention tires or tire cords. *See generally* Ex.1006. A POSITA would thus not have found it obvious to combine the references.

79. Thus, a POISTA would have found that Petitioner and Dr. Rust have not shown a motivation to combine Tamura with Baldwin or Baek to arrive at the claimed invention.

D. Petitioner's and Dr. Rust's Ground 1 analysis fails to show that the "nylon primarily-twisted yarn and the aramid primarily-twisted yarn … have identical structures with each other in the hybrid fiber"

80. A POSITA would have found that Petitioner and Dr. Rust have not shown that claim limitation 1[e] is obvious, which recites "the nylon primarily-twisted yarn and the aramid primarily-twisted yarn are secondarily-twisted together at a third twist number which is identical with the first and second twist numbers and have identical structures with each other in the hybrid fiber." Ex.1001, cl. 1[e]. Claim limitation 4[c] recites similar claim language. Ex.1001, cl. 4[c].

81. Petitioner and Dr. Rust contend that Tamura discloses the nylon and aramid yarns "have identical structures with each other in the hybrid fiber" because "Tamura … discloses a third step for secondarily-twisting the nylon and aramid primarily-twisted yarns together at a third twist number that is identical to the first and second twist number." Pet. 31; Ex.1003, ¶94 (verbatim). However, a POSITA would have understood that Petitioner and Dr. Rust are conflating different claim limitations. The requirement the "third twist number" be "identical with the first and second twist numbers" is a distinct requirement from the "identical structures"

claim limitations. Ex.1001, cl. 1; *see also* Ex.1001, cl. 4 (similar). A POSITA would have understood that the twist number relationship between the individual yarns and the hybrid cord alone does not determine the structure of the cord itself. Instead, other features of the manufacturing process such as the tension applied on the yarns and how the yarns are twisted together determine the structure of the plied cord. As the '731 patent discloses, twisting the nylon primarily-twisted yarn to be covered by the aramid primarily-twisted yarn can result in a conventional method of manufacturing a hybrid cord, regardless of primary twist numbers. Ex.1001, 2:24-36, Fig. 1. Thus, a POSITA would not have found Petitioner's and Dr. Rust's attempt to equate one disclosure in Tamura to two separate claim requirements in the '731 patent to be supported.

82. Thus, Petitioner and Dr. Rust have not shown that Tamura in view of Baldwin or Baek renders obvious claims 1 and 4, and all dependent claims.

IX. Ground 4: In my opinion, Petitioner and Dr. Rust fail to show that Chung in view of Harikae and further in view of Yokokura render obvious claims 1-4 and 6-7

83. In Petitioner's and Dr. Rust's Ground 4, Petitioner and Dr. Rust further argue that Chung in view of Harikae and Yokokura render obvious the claims of the '731 patent. Pet. 62-81; Ex.1003, ¶¶142-193. But a POSITA would not have found Petitioner's and Dr. Rust's proposed combination render the claims obvious. One particular and critical reason is that **none** of Petitioner's and Dr.

Rust's proposed prior art references, Chung, Harikae, or Yokokura, are directed to 2-ply aramid and nylon hybrid fiber cord. In addition, Petitioner's and Dr. Rust's references do not disclose the claimed limitations related to the JIS-L 1017 disc fatigue test.

A. Summary of Prior Art References

1. Chung (Ex.1012)

84. Chung relates to 4-ply and 6-ply aramid and nylon hybrid tire cords. Ex.1012, Summary, 5, Drawings 1-2. As Chung explains:

> The hybrid tire cord of the present invention comprises a step of performing a process of twisting nylon filaments and aramid filaments into a z-twist and an s-twist, immersing the twisted yarn obtained in an adhesive solution, and then drying and heat-treating it, and is characterized in that the nylon filament and the aramid filament are combined and then subjected to a z-twisted process at the same time, or the z-twist process is performed after they are combined.

Ex.1012, 6. Chung's claim 8 further clarifies that its method of manufacturing is for 4-ply or 6-ply tire cords, not 2-ply:

> a) A method for manufacturing a hybrid tire cord, comprising the steps of a) combining nylon filaments and aramid filaments and then twisting them to produce a z-twisted yarn;
>
> b) twisting 2 to 3 strands of the z-twisted yarn to produce an s-twisted yarn;

c) immersing the s-twisted yarn in an adhesive solution and then drying and heat-treating it.

Ex.1012, cl. 8. Chung's Table 1 also emphasizes that the twisting method of its embodiments is "Combining before twisting," meaning the aramid and nylon filaments are combined together before they are twisted:

Category		Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4
Nylon/p-aramid (Weight%)		50/50	60/40	40/60	85/15
Twisting method		Combining before twisting	Combining before twisting	Combining before twisting	Combining before twisting
Nylon filament	Tensile strength (g/d)	9.1	9.1	9.1	9.1
	Elongation at break (%)	20.5	20.5	20.5	20.5
p-aramid filament	Tensile strength (g/d)	21	21	21	21
	Elongation at break (%)	3.5	3.5	3.5	3.5
Twist count (TPM)		360	360	360	360

Ex.1012, Table 1 (highlights added). The reported properties in Chung all relate to 4-ply and 6-ply hybrid tire cords. Ex.1012, 7-10, Embodiments 1-4, Tables 1-3.

2. Harikae (Ex.1013)

85. Harikae, entitled "Pneumatic Radial Tires," relates to a pneumatic radial tire having two fiber reinforcement layers: a shoulder cover layer and a center cover layer. Ex.1013, Title, Abstract. Harikae explains that the shoulder cover layer includes 2-ply hybrid tire cord, and the center cover layer includes 3-ply hybrid tire cord:

[Claim 1]

A pneumatic radial tire having an organic fiber reinforced cover layer wound around the radial outside of a belt layer …, the organic fiber

> reinforced cover layer being composed of a center cover layer as described below in A and a shoulder cover layer as described below in B …
>
> (A) Center cover layer: The cover layer … is constructed using a three-ply composite cord formed by twisting two high-elasticity yarns and one low-elasticity yarn in the same direction, and then twisting them together in the opposite direction to the direction of the first twist.
>
> (B) Shoulder cover layer: A cover layer … is constructed using a two-ply composite cord formed by twisting together one high elasticity yarn and one low elasticity yarn that are each twisted in the same direction.

Ex.1013, cl. 1; *see also* Ex.1013, Table 1. The cover layers together provide support for a pneumatic radial tire. Ex.1013, Table 1.

3. Yokokura (Ex.1014)

86. Yokokura, entitled "Pneumatic Tire," relates to aramid-only tire cord. Ex.1014, Title, Abstract. Yokokura explains that "[i]n this pneumatic tire, at least one of the carcass ply and belt plies or the belt-reinforcement layer is constituted of reinforcing cords being para-aramid cords." Ex.1014, Abstract. Yokokura states that aramid-only cords are good for use in its pneumatic tires, leading to reduced weight and improved durability. Ex.1014, Abstract. Yokokura discloses properties for aramid-only tire cord and does not mention nylon, besides its two

references to nylon when discussing background art. Ex.1014, [0005], [0007], Table 1.

87. Yokokura discloses a "Driving Test on a Drum" for testing sample tires that uses "a load as twice heavy as the load specified in JIS":

> <Driving Test on a Drum> …
>
> Under a load as twice heavy as the load specified in JIS, the [sample] tire was allowed to wheel at 60 km/h on a drum having a diameter of approximately 3 m until the travel distance reached 20,000 km. …
>
> After this driving test, each cord was removed from the corresponding tire and then evaluated for strength in accordance with JIS L 1017 as described above. The measured strength was converted into the retention ratio in % with the strength measured before the driving test being 100%. The greater the value is, the higher the retention ratio is and the better the test result it.

Ex.1014, [0062]-[0064].

B. Chung fails to disclose multiple claim limitations of the challenged independent claims

88. Petitioner and Dr. Rust contend that Chung alone discloses a 2-ply aramid and nylon hybrid fiber cord that is secondarily twisted from a 1-ply nylon primarily-twisted yarn and a 1-ply aramid primarily-twisted yarn. *See* Pet. 63, 72-73, 79-80; Ex.1003, ¶¶144-145, 166-168, 184, 189. However, a POSITA would have found that Chung does not relate to a 2-ply aramid and nylon hybrid fiber

cord but instead discloses 4-ply or 6-ply hybrid fiber cord, and thus does not disclose or render obvious the '731 patent's claims.

89. The relevant portions of claim 1 recite the following:

> 1. 1[pre] A hybrid fiber cord comprising:
>
> 1[a] a nylon primarily-twisted yarn having a first twist number of 300 to 500 TPM;
>
> 1[b] an aramid primarily-twisted yarn having a second twist number of 300 to 500 TPM; …
>
> 1[d] wherein the first twist number is identical with the second number,
>
> 1[e] wherein the nylon primarily-twisted yarn and the aramid primarily-twisted yarn are secondarily-twisted together at a third twist number which is identical with the first and second twist numbers and have identical structures with each other in the hybrid fiber,
>
> 1[f] wherein the nylon primarily-twisted yarn and aramid primarily-twisted yarn which are secondarily-twisted together with the identical twist number **form a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn** …

Ex.1001, cl. 1 (emphasis added).

90. The relevant portions of claim 4 further recite:

> 4. 4[pre] A method for manufacturing a hybrid fiber cord, the method comprising:

> 4[a] a first step for primarily-twisting a nylon filament at a first twist number of 300 to 500 TPM to produce a nylon primarily-twisted yarn;
>
> 4[b] a second step for primarily-twisting an aramid filament at a second twist number of 300 to 500 TPM to produce an aramid primarily-twisted yarn;
>
> 4[c] a third step for secondarily-twisting the nylon and aramid primarily-twisted yarns together at a third twist number to produce a ply yarn in such a way that the nylon and aramid primarily-twisted yarns have identical structures with each other; …
>
> 4[e] wherein the first, second and third twist numbers are identical with each other, and
>
> 4[f] wherein the third step **produces a 2-ply secondarily-twisted yarn consisting of 1-ply of nylon primarily-twisted yarn and 1-ply of aramid primarily-twisted yarn**.

Ex.1001, cl. 4 (emphasis added).

91. A POSITA would have understood that claim 1 recites twisting the 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn to form a 2-ply secondarily-twisted yarn. Ex.1001, cl. 1. A POSITA would have also understood that the method in claim 4 involves twisting the nylon filament in a first direction, twisting the aramid filament in the same first direction, and then twisting the twisted nylon and aramid filaments together in the opposite second

direction to produce the claimed 2-ply secondarily-twisted yarn. Ex.1001, cl. 4. Petitioner and Dr. Rust have not shown that Chung meets multiple limitations.

92. First, claim limitation 1[a] requires "a nylon primarily-twisted yarn having a first twist number of 300 to 500 TPM," and claim limitation 4[a] requires "a first step for primarily-twisting a nylon filament at a first twist number of 300 to 500 TPM to produce a nylon primarily-twisted yarn." Ex.1001, cls. 1, 4. Petitioner and Dr. Rust contend that Chung meets this limitation because Chung discloses "the **hybrid tire cord** … has a twist count in the range of 300 to 500 TPM." Pet. 63 (quoting Ex.1012, 6) (emphasis added), 79; Ex.1003, ¶¶145 (verbatim), 184. However, a POSITA would have understood that the twist number of the *hybrid tire cord* as disclosed in Chung does not disclose or render obvious the claimed twist number of the *nylon component*. Rather, the twist number of the nylon component can differ significantly from the twist number of the hybrid tire cord; for example, Petitioner's Baldwin reference discloses a preferred embodiment where a nylon component is twisted at 6.2 twists/inch and the hybrid cord is twisted at 9.7 twists/inch. Ex.1007, [0063]. Indeed, a POSITA would have found that the disclosure in Chung that Petitioner and Dr. Rust rely on do not disclose the twisting of the nylon filament. Thus, Chung's description of the twist count of the hybrid tire cord does not teach or suggest what the twist count

of the claimed nylon primarily-twisted yarn is or would be, and therefore, Chung does not teach these limitations of claims 1 and 4.

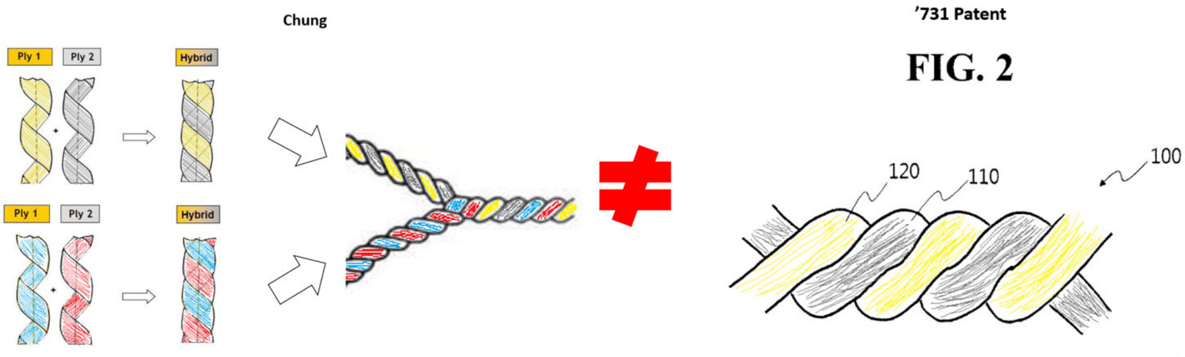
93. Second, claim limitation 1[f] requires "… a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn." Ex.1001, cl. 1[f]. Similarly, claim limitation 4[f] requires that the third step of secondary twisting "produces a 2-ply secondarily-twisted yarn consisting of 1-ply of nylon primarily-twisted yarn and 1-ply of aramid primarily-twisted yarn." Ex.1001, cl. 4[f]. Petitioner and Dr. Rust contend that Chung discloses both limitations. Pet. 72-73, 80; Ex.1013, ¶¶166-168, 189[2].

94. A POSITA would have understood that Chung's process is completely different than that disclosed in the '731 patent, because Chung's process does not produce the claimed 2-ply secondarily-twisted yarn. Petitioner and Dr. Rust summarize Chung using Chung's claim 8, which clarifies the difference. Pet. 56, Ex.1003, ¶64. As Petitioner and Dr. Rust state, Chung's "method of making the hybrid tire cord includes 'a) **combining** nylon filaments and aramid filaments and **then twisting them** to produce a z-twisted yarn; b) twisting 2 to 3 strands of the z-twisted yarn to produce an s-twisted yarn…'" Pet.

[2] As support for Dr. Rust's paragraph 189 on limitation 4[f], Dr. Rust appears to refer to the very same paragraph, "*See* limitation [4f]." Ex.1003, ¶189.

56 (quoting Ex.1012, cl. 8); Ex.1003, ¶64 (verbatim). A POSITA would have understood that Chung’s method involves first combining both nylon and aramid filaments together in the z-direction, which results in a combined nylon and aramid yarn. Ex.1012, cl. 8. Then, Chung teaches to take multiple strands of the z-twisted combined nylon and aramid yarn and twisting those multiple strands of combined yarn in the s-direction to produce the s-twisted yarn. Ex.1012, cl. 8. A POSITA would have understood that the result of Chung’s process is **4-ply** or **6-ply** hybrid fiber cord, including two or three components of 2-ply combined aramid/nylon filaments that are secondarily twisted together. Ex.1012, Summary, 3, 7, (Embodiments 1-4), Drawings 1-2. In contrast, the ’731 patent teaches twisting a nylon filament by itself in a first direction, twisting an aramid filament by itself in that same direction, and not combining the two together until after those first twisting operations occur. Ex.1001, cls. 1, 4. After each primarily-twisted yarn is twisted, the ’731 patent teaches to take one nylon primarily-twisted yarn and one aramid primarily-twisted yarn and twisting those two yarns together, forming a 2-ply aramid and nylon hybrid fiber cord. Ex.1001, cls. 1, 4. A POSITA would have understood that the cord created in Chung’s process is different from the 2-ply cord that is recited in the ’731 patent, and Chung does not disclose or render obvious the hybrid fiber cord and method of its manufacturing taught in the ’731 patent. Below is a comparison between Chung’s 4-ply hybrid fiber cord, adapted from

Petitioner's and Dr. Rust's figure (Pet. 15; Ex.1003, ¶35), as compared to the claimed 2-ply hybrid fiber cord (Ex.1001, Fig. 2):



Pet. 15; Ex.1003, ¶35; Ex.1001, Fig. 2 (colors added). As shown in the Figure above, a POSITA would have understood that the 4-ply cord produced through Chung's method is different from the 2-ply cord recited in the '731 patent.

95. Petitioner and Dr. Rust misunderstand that the z-twisted yarn in Chung is created by combining strands of both nylon yarn and aramid yarn, not by the nylon yarn or aramid yarn itself. Pet. 72-73, 80; Ex.1003, ¶¶167-168, 189. Chung then twists the 2-ply nylon and aramid yarn with one or two additional 2-ply aramid and nylon yarns that result in the 4-ply or 6-ply s-twisted hybrid fiber cord. Ex.1012, Summary, 3, 7 (Embodiments 1-4), Drawing 1-2, Table 1. Chung explains this process in detail throughout its disclosure, for example, in Chung's Summary excerpted below:

> The present invention relates to a hybrid tire cord and a method of manufacturing the same, and more particularly, to a hybrid tire cord in which **nylon filaments and aramid filaments are combined** at a

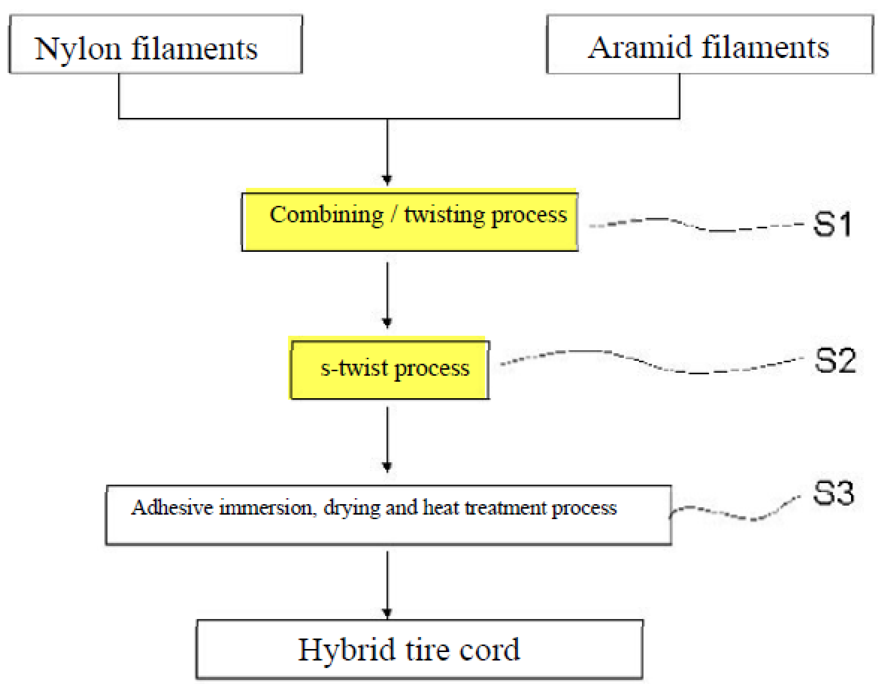
> weight ratio of 10:90 to 90:10 **and then formed into 2 or 3 plies** at a weight ratio of 2:1 to 1:2, and a method for manufacturing the same.

Ex.1012, Summary (emphases added). Chung further explains its process in Embodiment 1-4:

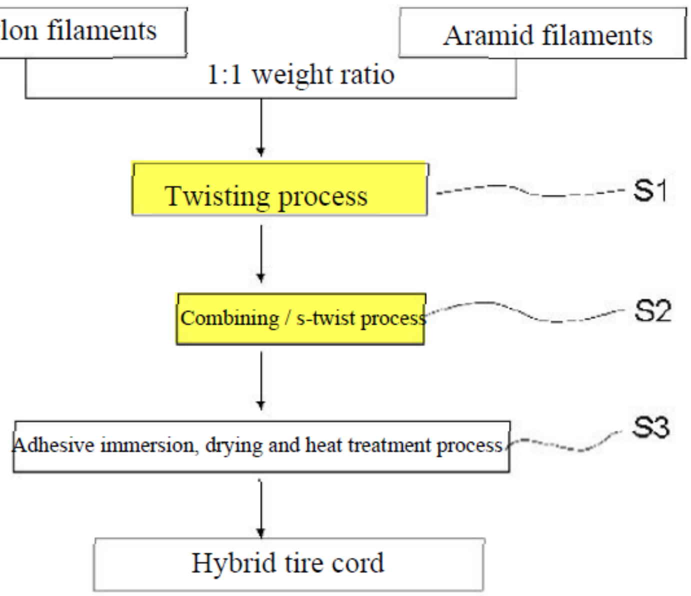
> **Nylon 66 filaments and p-aramid (Kevlar) filaments** having the properties shown in Table 1 below **were passed through a guide, combined and then twisted to produce a z-twisted yarn**.
>
> **The above two strands of the z-twisted yarn were subjected to a twisting process** so that the twist count became 360 TPM, **thereby manufacturing the s-twisted yarn**.

Ex.1012, 7 (Embodiment 1-4) (emphases added). Similarly, Chung's Drawings 1 and 2 make clear this process:

Drawing 1



Drawing 2



Ex.1012, Drawings 1, 2 (highlights added). A POSITA would have understood that the drawings show that the nylon and aramid filaments are first combined and twisted in the highlighted process, and then the aggregated nylon/aramid filaments are twisted in the s-direction. Further, as I explained above, Chung's claim 8 makes this process clear:

> Claim 8.
>
> a) A method for manufacturing a hybrid tire cord, comprising the steps of **a) combining nylon filaments and aramid filaments and then twisting them to produce a z-twisted yarn**;
>
> **b) twisting 2 to 3 strands of the z-twisted yarn to produce an s-twisted yarn**; …

Ex.1012, cl. 8 (emphases added). Similarly, Chung's Table 1 shows that the plies are "[c]ombined before twisting":

Category		Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4
Nylon/p-aramid (Weight%)		50/50	60/40	40/60	85/15
Twisting method		Combining before twisting	Combining before twisting	Combining before twisting	Combining before twisting
Nylon filament	Tensile strength (g/d)	9.1	9.1	9.1	9.1
	Elongation at break (%)	20.5	20.5	20.5	20.5
p-aramid filament	Tensile strength (g/d)	21	21	21	21
	Elongation at break (%)	3.5	3.5	3.5	3.5
Twist count (TPM)		360	360	360	360

Ex.1012, Table 1 (highlight added). Chung's claim 1 also shows that the aramid and nylon filaments are first combined and twisted in the z-direction together, before multiple strands of the combined yarns are twisted in the s-direction, "A hybrid tire cord comprising nylon filaments and aramid filaments, wherein the nylon filaments and the aramid filaments are included at a weight ratio of 10:90 to 90:10." Ex.1012, cl. 1.

96. Thus, a POSITA would have understood that Chung discloses 4-ply or 6-ply hybrid tire cord, which is different from and does not disclose or render obvious the 2-ply cord claimed in the '731 patent. Further, a POSITA would have understood that the 4-ply or 6-ply cord in Chung is not a disclosure of and does not render obvious the 2-ply cord in the '731 patent, because the properties of Chung's 4-ply or 6-ply cord would not be applicable or reflective of properties of the '731 patent's 2-ply cord.

97. Petitioner and Dr. Rust further contend that "Chung discloses that at least in comparative examples 3 and 4, '[a] tire cord was manufactured … [such] that nylon 66 and p-aramid filaments … were subject to a twisting process to manufacture nylon 66 z-twisted yarn and p-aramid z-twisted yarn, and then a combining process was performed." Pet. 72-73 (quoting Ex.1012, 8); Ex.1003, ¶167. However, a POSITA would not find that Chung describes the process by which these comparative examples were made. *See generally* Ex.1012. In addition, a POSITA would have found that these examples expressly teach away from pursuing the claimed invention for multiple reasons. First, Chung's Table 3 shows that the physical properties of Comparative Examples 3 and 4 are "Immeasurable." Ex.1012, 9. Second, Chung's Table 3 also shows that "twisting defects" occurred in making these examples, and that the "[q]uality of the yarn" has "Defects." Ex.1012, 9. Third, Chung explains that making these cords "resulted in a deterioration in the quality of the yarn and twisting defects." Ex.1012, 10. Thus, a POSITA would not have looked to these examples as rendering obvious the claimed invention, and Petitioner and Dr. Rust have not shown that the claim limitations 1[f] and 4[f] are disclosed or rendered obvious.

98. Relatedly, Petitioner and Dr. Rust fail to show that limitation 1[h] and 4[d] are rendered obvious. To contend that claim limitations 1[f] and 4[f] are disclosed, Petitioner and Dr. Rust rely solely on Chung's Comparative Examples

3 and 4. Pet. 72-73, 80; Ex.1013, ¶¶166-168, 189. Claim limitations 1[h] and 4[d] recite, among other things, the claimed "dry heat shrinkage" range property of the secondarily-twisted or ply yarn, specifically, that "the secondarily-twisted yarn coated with the adhesive … has a dry heat shrinkage of 1.5-2.5%," (claim 1[h]) and that "the ply yarn coated with the adhesive … has a dry heat shrinkage of 1.5 to 2.5%" (claim 4[d]). Ex.1001, cls. 1[h], 4[d]. For limitations 1[h] and 4[d], Petitioner and Dr. Rust no longer rely on Chung's Comparative Examples 3 and 4 (Pet. 74-75, 80; Ex.1003, ¶¶172-173), apparently because Chung's Table 3 shows that the "Dry heat shrinkage (%)" of these two examples was "Immeasurable" (Ex.1012, 9). So a POSITA would have understood that even if Chung's Comparative Examples 3 and 4 rendered obvious the claimed "2-ply secondarily-twisted yarn" in limitations 1[f] and 4[f], Petitioner and Dr. Rust have not shown that Chung's "2-ply secondarily-twisted yarn" "has a dry heat shrinkage of 1.5 to 2.5%", as required by claim limitations 1[h] and 4[d] because that property was expressly immeasurable in Chung.

99. Thus, a POSITA would have understood that Petitioner and Dr. Rust have not shown that the Grounds 4-5 prior art references disclose or render obvious the recited twist number of the nylon primarily-twisted yarn (claim limitations 1[a] and 4[a]), and "a 2-ply secondarily-twisted yarn consisting of 1-ply nylon primarily-twisted yarn and 1-ply aramid primarily-twisted yarn" and a third step

which "produces a 2-ply secondarily-twisted yarn consisting of 1-ply of nylon primarily-twisted yarn and 1-ply of aramid primarily-twisted yarn," (claim limitations 1[f] and 4[f]). Ex.1001, cls. 1, 4.

C. Petitioner and Dr. Rust have not shown that the claimed strength retention rate limitation is disclosed or rendered obvious

100. In my opinion, Petitioner and Dr. Rust further fail to show that the proposed combination discloses or renders obvious the claim limitation in independent claim limitation 1[h] that "the secondarily-twisted yarn coated with the adhesive has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." Ex.1001, cl. 1[h]. Independent claim limitation 4[d] recites an analogous limitation. Ex.1001, cl. 4[d].

101. Petitioner and Dr. Rust contend that, "[t]o the extent Patent Owner argues Chung does not teach that the secondarily-twisted (i.e., s-twisted) yarn has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association, Yokokura discloses this limitation." Pet. 75; Ex.1003, ¶174; *see also* Pet. 80; Ex.1003, ¶187. However, Petitioner and Dr. Rust do not cite anything in Chung as teaching the test, nor does Chung mention JIS-L 1017; indeed, Petitioner and Dr. Rust do not argue that the test is rendered obvious by Chung. *See generally* Ex.1012; Pet. 74-77; Ex.1003, ¶¶171-177.

102. As an initial matter, a POSITA would have found that Yokokura is directed to aramid-only cords, and does not disclose or render obvious the claimed strength retention rate of a hybrid fiber cord made of aramid and nylon. Petitioner and Dr. Rust confirm that Yokokura involves aramid-only cord, that "Yokokura teaches … 'reinforcement cords being para-aramid cords.'" Pet. 75 (quoting Ex.1004, Abstract); Ex.1003, ¶175. Petitioner and Dr. Rust refer to Table 5 in Yokokura, pointing to the results for Examples 3-1, 3-2, 3-3, and 3-4 in Table 5. Pet. 76, Ex.1003, ¶175. But Petitioner and Dr. Rust overlook that these examples in Yokokura **do not contain nylon yarn**. Rather, the materials for these examples in Yokokura are aramid yarn only:

TABLE 5

	Comparative Example 3	Example 3-1	Example 3-2	Example 3-3	Example 3-4
Cap/Layer material	Aramid A	Aramid 1	Aramid 2	Aramid 3	Aramid 4
Cord structure (dtex)	1670/2	1670/2	1100/3	1670/2	1100/3
Embedding number (number/50 mm)	50	50	50	50	50
Modulus of elasticity E (cN/dtex) at 25° C. under a load of 49 N	299	200	231	184	296
Tensile strength T (cN/dtex)	13.7	15.1	17.4	14.4	17.6

Ex.1014, Table 5 (annotated). Yokokura confirms that "[a]s shown in Table 5 above, the sample tires according to the examples" "w[ere] constituted of para-aramid cords." Ex.1014, [0088].

103. A POSITA would have understood that Yokokura does not teach or suggest the strength retention rate limitation for a 2-ply aramid and nylon hybrid fiber cord as the claims require. Petitioner and Dr. Rust have not shown how Yokokura's aramid-only cords and their properties are relevant to the claimed hybrid fiber cord. Pet. 75-77; Ex.1003, ¶¶174-176. Indeed, a POSITA would have understood that the substantial difference between Yokokura's aramid-only cords and the claimed hybrid fiber cord means that the properties and measurements of Yokokura do not disclose or render obvious the requirements recited in the claims of the '731 patent. Thus, because Yokokura does not contain any disclosure of a secondarily-twisted yarn consisting of nylon and aramid, it does not disclose or render obvious that "the secondarily-twisted (i.e., s-twisted) yarn has a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association" as recited in claim 1, or a "ply yarn" having "a strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association" as recited in claim 4.

104. Further, contrary to Petitioner's and Dr. Rust's contention, Yokokura also does not disclose or render obvious the claimed strength retention rate limitation, at least because the test recited in the limitation is not found in

Yokokura. Yokokura only discloses a different test, a "Driving Test on a Drum," as excerpted below:

> <Driving Test on a Drum>
>
> Each sample tire was pressurized at room temperature, namely, 25°C. ± 2°C., until the internal pressure reached 294 kPa (3.0 kg/cm^2), allowed to standard for 24 hours, and then adjusted in terms of pneumatic pressure once again. **Under a load as twice heavy as the load specified in JIS, the tire was allowed to wheel at 60 km/h on a drum having a diameter of approximately 3 m until the travel distance reached 20,000 km**. The distance at breaking was measured as the distance limit, and the obtained distance limits were converted into indices with the distance limit of Comparative Example 1-1 being 100. The greater the index is, the longer the distance limit is and the better the test result is.
>
> After this driving test, each cord was removed from the corresponding tire and then evaluated for strength in accordance with JIS L 1017 as described above. The measured strength was converted into the retention ratio in % with the strength measured before the driving test being 100%. The greater the value is, the higher the retention ratio is and the better the test result is.

Ex.1014, [0062]-[0064] (emphasis added). Petitioner and Dr. Rust further rely on Yokokura's paragraph [0082] that discloses the following "Measurement of Residual Strength of Cords," which is largely a repetition of Yokokura's paragraph [0064]:

> <Measurement of Residual Strength of Cords>
>
> After the driving test, each cord was removed from the corresponding tire and then evaluated for strength in accordance with JIS L 1017 as described above. The measured strength was converted into the retention ratio in % with the strength measured before the driving test being 100%. The greater the value is, the higher the retention ratio is and the better the test result is.

Ex.1014, [0081]-[0082] (quoted at Pet. 75-76, Ex.1003, ¶175).

105. Petitioner and Dr. Rust contend that Yokokura's disclosure renders obvious the claimed strength retention rate after a disc fatigue test is performed as recited in the '731 patent's limitations (Pet. 75-77; Ex.1003, ¶¶174-177), but a POSITA would have understood that the two tests are completely different. Yokokura does not identify which test in the JIS-L 1017 Standard its "driving test" is based on, and I do not find Petitioner or Dr. Rust to provide the identification. *See* Ex.1014, [0062]-[0064]. JIS-L 1017 (Ex.1036) also does not include a "driving test." Nothing in Yokokura mentions a disc fatigue test. *See generally* Ex.1014.

106. Instead of disclosing, rendering obvious, or even mentioning the disc fatigue test in JIS-L 1017, Yokokura describes a different test, one which is based on wheeling of a sample tire. Ex.1014, [0062]-[0064] (reporting a "distance limit" after a "driving test"). Yokokura appears to measure cord strength before the driving test (*see* Ex.1014, [0061]) and after the tire is driven on a drum (*see*

Ex.1014, [0064]), and calculates a strength retention ratio based on those two values. However, the disc fatigue test disclosed and recited in the '731 patent's claims involves inserting a sample tire cord into a rubber block, which is repeatedly extended axially and compressed axially while the sample is being rotated. Ex.1001, 9:49-10:3; *see also* Ex.1036 (JIS-L 1017), 28-29 (§ 2.2.2). The JIS-L 1017 disc fatigue test also does not involve using a tire on a drum but instead uses a "rubber block … on the periphery of 2 discs." Ex.1036, 28. Yokokura's "Driving Test on a Drum" does not disclose using any elevated temperature, but the '731 patent teaches that the disc fatigue test is performed at an elevated temperature of 80°C. Ex.1014, [0062]-[0064]; Ex.1001, 9:52-57. Yokokura's "Driving Test on a Drum" does not disclose any sample being rotated but that the tire containing the cord is spinning at "60 km/h on a drum having a diameter of approximately 3 m." Ex.1014, [0063]. A speed of 60 km/h translates to 1,000 meters/minute. The corresponding rotations per minute would be 1,000 meters/minute divided by the circumference of the tire, which is the diameter of the drum (3 m) multiplied by π (leading to around 9.42 m), which would be around 106 rpm. In comparison, the sample in the '731 patent is "rotat[ed]" "at 2500 rpm." Ex.1001, 9:52-57. Thus, a POSITA would have found that Yokokura's "Driving Test on a Drum" is not related to and does not disclose or render obvious the claimed "strength retention rate of 80% or more after a disc fatigue test is performed according to JIS-L 1017 method of Japanese Standard Association." A POSITA would not have understood Yokokura's test, despite Yokokura's mentioning the JIS-L 1017 Standard, to disclose or render obvious using the JIS-L 1017 disc fatigue test as claimed in the '731 patent, because the two testing methods are significantly different. The results of Yokokura's driving test on a drum would not disclose or render obvious what the results of a disc fatigue test conducted according to JIS-L 1017 would be.

107. Petitioner and Dr. Rust also argue that "a POSITA would have been motivated to combine the teachings of Chung, Harikae, and Yokokura" for a cord that meets the claimed strength retention rate of 80% or more after a disc fatigue test according to JIS-L 1017, contending that "Yokokura explains[] '[t]he higher the retention ratio is[,] the better the test result is.'" Pet. 76-77 (quoting Ex.1014, [0082]); Ex.1003, ¶176 (same). But neither Petitioner nor Dr. Rust explains how Yokokura's teachings of an aramid-only cord (*see, e.g.*, Ex.1014, Abstract, Table 5) would apply to Chung's teachings of a 4-ply or 6-ply hybrid cord (*see, e.g.*, Ex.1012, cls. 8, 9, Embodiments 1-4, Table 1) to render obvious the claimed strength retention rate of a 2-ply aramid and nylon hybrid cord. A POSITA would not have found Kwon (Ex.1021) to support Petitioner's and Dr. Rust's motivation to combine argument either, as Kwon, like Yokokura, relates to aramid-only tire cord. Ex.1021, Abstract ("The present invention relates to an aramid tire cord …. The present invention provides an aramid tire cord containing an aramid multi-

filament, … and a manufacturing method thereof."), cl. 1, [11]. Indeed, a POSITA would have found Kwon to *discourage* any motivation to combine or to use nylon in tire cords, as Kwon teaches that "because nylon fibers have a low modulus, **they are not suitable** for tires for racing cars that drive at high speeds or for passenger cars that require good ride comfort." Ex.1021, [3] (emphasis added).

108. Petitioner further contends, and Dr. Rust repeats, that "performing a disc fatigue test (i.e., driving test on a drum) is [*sic*] according to the JIS-L 1017 method of Japanese Standard Association to measure a strength retention rate is old and well known within the art." Pet. 61; Ex.1003, ¶141 (verbatim). Petitioner and Dr. Rust also claim that "the disk [*sic*] fatigue test process set forth in JIS-L 1017 is well within the skill set of an [*sic*] POSITA." Pet 61; Ex.1003, ¶141. However, the claims require that the secondarily-twisted yarn (i.e., the yarn consisting of aramid and nylon) has a specified strength retention rate after a disc fatigue test is performed according to JIS-L 1017, and merely stating that JIS-L 1017 was "old and well known" as Petitioner and Dr. Rust contend does not show that the specific claimed features were well-known or "well within the skill set of" a POSITA. As I explained above, the claimed disc fatigue test according to JIS-L 1017 is not the same as the "Driving Test on a Drum" that Yokokura discloses.

109. Finally, Petitioner and Dr. Rust allege "'a strength retention rate of 80% or more' could have been obtained through routine optimization of the prior

art and is thus not inventive.” Pet. 77; Ex.1003, ¶177 (verbatim). But neither Petitioner nor Dr. Rust provide any support for this conclusory allegation, and neither explains how “routine optimization” would achieve the requisite strength retention rate, when none of their prior art discloses the claimed limitations.

110. Thus, a POSITA would not have found that Petitioner’s and Dr. Rust’s Grounds 4-5 to render the claims obvious.

D. Petitioner and Dr. Rust’s Ground 4 analysis fails to show that the “nylon primarily-twisted yarn and the aramid primarily-twisted yarn … have identical structures with each other in the hybrid fiber”

111. A POSITA would have found that Petitioner and Dr. Rust have not shown claim limitation 1[e] as obvious, that “the nylon primarily-twisted yarn and the aramid primarily-twisted yarn are secondarily-twisted together at a third twist number which is identical with the first and second twist numbers and have identical structures with each other in the hybrid fiber.” Ex.1001, cl. 1. Claim limitation 4[c] recites similar claim language. Ex.1001, cl. 4.

112. Petitioner and Dr. Rust contend that Chung discloses these limitations, arguing that Chung discloses “‘the two types of filaments have ***similar*** structures.’” Pet. 71 (quoting Ex.1012, 6) (emphasis in original); Ex.1003, ¶165 (verbatim); *see also* Pet. 80; Ex.1003, ¶186. Petitioner and Dr. Rust further contend that “a POSITA considering Chung would not have drawn a substantive distinction between ‘similar structures’ and ‘identical structures,’” and that “no two

textiles are 100 percent identical due to the inherent nature of the materials." Pet. 72; Ex.1003, ¶165. But Petitioner and Dr. Rust do not explain how they reached the conclusion that the term "similar" in Chung should be understood to mean "as similar as possible" rather than having differences that make them not "identical." A POSITA would have found that Petitioner and Dr. Rust have not shown that these limitations are rendered obvious.

113. In sum, Petitioner and Dr. Rust have not shown that independent claims 1 and 4 of the '731 patent, and all claims dependent on them, are rendered obvious. In my opinion, the Challenged Claims are patentable.

X. CONCLUSION

All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 14, 2025 in Fort Washington, Pennsylvania.

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David Brookstein