

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

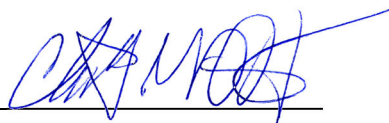
In re Patent of: Eberhardt et al.
U.S. Patent No.: 11,261,566 Attorney Docket No. 59054-0037IP1
Issue Date: March 1, 2022
Appl. Serial No.: 16/980,449
Filing Date: September 14, 2020
Title: CLOTHING FOR A MACHINE FOR PRODUCING A FIBROUS
MATERIAL WEB

DECLARATION OF DR. CHRISTOPHER M. PASTORE

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

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

Dated: 6 June, 2025

By: 

Christopher M. Pastore, Ph.D.

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I, Christopher M. Pastore, Ph.D., declare that:

I. INTRODUCTION

1. I have been retained on behalf of Albany International Corporation (Albany) to offer technical opinions related to U.S. Patent No. 11,261,566 ('566 Patent) (EX1001). I understand that Albany is requesting that the Patent Trial and Appeal Board (Board) institute an *Inter Partes* Review (IPR) proceeding of the '566 Patent.
2. I have been asked to provide my independent analysis of the '566 Patent in light of the prior art publications cited in this Declaration.
3. I am not and never have been an employee of Albany International Corporation. I received no compensation for this Declaration beyond my normal hourly compensation based on my time actually spent analyzing the '566 Patent, the prior art publications cited below, and issues related thereto, and I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the '566 Patent.
4. My analysis here is based on my years of education, research, and experience, as well as my investigation and study of relevant materials, including those cited in this Declaration.
5. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the Patent Owner. Further,

I may consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

6. My analysis of the materials produced in this proceeding is ongoing, and I will continue to review any new material as it is provided. This Declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. QUALIFICATIONS AND BACKGROUND INFORMATION

7. My education and experience are described more fully in the attached curriculum vitae, attached as Appendix A to this declaration. For ease of reference, I have highlighted certain information below.
8. I am over the age of 18 and am competent to write this Declaration. I have personal knowledge or have developed knowledge—based upon education, training, or experience—of the technologies of the matters set forth herein.
9. I am the Assistant Provost, Faculty Development in Classroom Pedagogy and Nexus Learning, and a Professor of Transdisciplinary Studies and Engineering at Thomas Jefferson University in Philadelphia, Pennsylvania. I

am also an Honorary Research Professor in the Department of Clothing and Textiles at Durban University of Technology in Durban, South Africa.

10. I earned a Ph.D. in Materials Science from Drexel University, where I wrote my thesis entitled *A Processing Science Model for Three Dimensional Braiding*. I also have an M.S. in Mathematics from Drexel University and a B.A. in Mathematics from La Salle University.

11. I have written or had my writings included in nearly twenty books related to textiles. I have nearly fifty refereed publications related to textiles. I have produced nearly ninety presentations and non-refereed publications on textiles and fabrics. I have won numerous awards related to my writings in and experience with textiles.

12. I have worked in textile and materials engineering and textile engineering since 1984. I have a broad range of experience in warp and weft knitting, computer modelling of textile structures, defects in fabrics, mechanical properties of textiles, 4D textiles, structural and textile composites, and three-dimensional weaving.

13. Throughout my career I have received a variety of awards. In 2000 I received the *Distinguished Achievement in Basic or Applied Fiber Science* from The Fiber Society. In 2004 I received the *Director's Award* from the National Textile Center.

14. In writing this Declaration, I have considered my own knowledge and experience, including my work experience in the fields of materials science, textile engineering, and processing science.

15. In writing this Declaration, I have analyzed the following publications and materials, in addition to other materials I cite in my declaration:

- U.S. Patent No. 11,261,566 (EX1001), and its accompanying prosecution history (EX1002)
- PCT Publication No. WO 89/12717 (“Sudre”) (EX1004)
- PCT Publication No. WO 2014/172594 (“Lee”) (EX1005)
- U.S. Patent No. 4,806,208 (“Penven”) (EX1006)
- U.S. Publication No. 2006/0162312 (“Patel”) (EX1007)
- PCT Publication No. WO 2009/039633 (“Swaine”) (EX1008)
- U.S. Patent No. 6,712,100 (“Yook”) (EX1009)
- U.S. Patent No. 5,887,630 (“Shipley”) (EX1010)
- U.S. Patent No. 5,167,262 (“Bennett”) (EX1011)
- U.S. Patent No. 5,937,914 (“Wilson”) (EX1012)
- U.S. Publication No. 2015/0096704 (“Straub”) (EX1013)
- U.S. Patent No. 6,531,418 (“Lidar”) (EX1014)
- U.S. Publication No. 2012/0031554 (“Eagles”) (EX1015)
- U.S. Patent No. 9,404,218 (“Xu”) (EX1016)

- U.S. Patent No. 4,026,331 (“Lees”) (EX1017)
- U.S. Patent No. 4,759,975 (“Sutherland”) (EX1018)
- U.S. Patent No. 4,357,386 (“Luciano”) (EX1019)
- U.S. Publication No. 2014/0186579 (“Botelho”) (EX1020)
- Sabit Adanur, Paper Machine Clothing (2d ed. 2017) (“Adanur”) (EX1021)
- Sabit Adanur, From the Faculty: Formed, pressed & dried, Auburn Engineer (May 18, 2018),
<https://ecm.eng.auburn.edu/wp/emag/?p=5167> (EX1022)
- U.S. Patent No. 4,251,588 (“Goetemann”) (EX1024)
- Sabit Adanur, Paper Machine Clothing (1st ed. 1997) (“Adanur-1997”) (EX1025)
- Babaarslan, O., Hacioğullari, S.Ö. Effect of fibre cross-sectional shape on the properties of POY continuous filaments yarns. *Fibers Polym* 14, 146–151 (2013). (EX1026)
- Bjorn Rydin, A new generation of seamed felt, Swedish paper magazine: Nordic cellulose (1992) (EX1027)
- Translated Version of Bjorn Rydin, A new generation of seamed felt, Swedish paper magazine: Nordic cellulose (1992) (“Rydin”) (EX1028)

- Teknisk Information Fran Albany Nordiskafilt, SEAMTECH,
Pressfilter med söm (1996) (EX1029)

16. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the '566 Patent at the time of the earliest possible priority date of the '566 Patent, and I have done so during my review of these materials. The '566 Patent claims the benefit of priority to a German application filed on March 15, 2018 (“the Critical Date”). Counsel has informed me that the Critical Date represents the earliest possible priority date to which the challenged claims of '566 Patent are entitled, and I have therefore used that Critical Date in my analysis below.

17. I have no financial interest in the parties or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

18. In writing this declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of mechanical engineering, computer science, biomedical engineering, and electrical engineering; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I

have analyzed various publications and materials, in addition to other materials I cite in my declaration.

19. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '566 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the Critical Date, or before. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '641 Patent and the prior art discussed below.

III. SUMMARY OF CONCLUSIONS FORMED

20. This declaration explains the conclusions that I have formed based on my analysis. To summarize those conclusions, based upon my knowledge and experience and my review of the prior art publications listed above, I believe that:

- Claims 1, 3, 10-13 are obvious over Sudre and Adanur
- Claim 2 is obvious over Sudre, Adanur, and Shipley
- Claims 4-9 are obvious over Sudre, Adanur, and Straub
- Claim 14 is obvious over Sudre, Adanur, and Lidar
- Claim 15 is obvious over Sudre, Adanur, and Yook
- Claims 1, 3, 10-13 are obvious over Sudre, Lee, and Penven
- Claim 2 is obvious over Sudre, Lee, Penven, and Shipley

- Claims 4-9 are obvious over Sudre, Lee, Penven, and Straub
- Claim 14 is obvious over Sudre, Lee, Penven and Lidar
- Claim 15 is obvious over Sudre, Lee, Penven, and Yook
- Claims 1, 3, and 12-13 are obvious over Sudre and Rydin
- Claim 2 is obvious over Sudre, Rydin, and Shipley
- Claims 4 and 7-9 are obvious over Sudre, Rydin, and Straub
- Claim 14 is obvious over Sudre, Rydin, and Lidar
- Claim 15 is obvious over Sudre, Rydin, and Yook

IV. LEVEL OF ORDINARY SKILL IN THE ART

21. In my opinion, a person of ordinary skill in the art as of the Critical Date of the '566 Patent (hereinafter a "POSITA") as of 3/15/2018 would have had at least (1) a Bachelor's Degree (or a similar Master's Degree, or higher degree) in material science, materials engineering, mechanical engineering, textile engineering, or a related field, and (2) a minimum of two years of working experience in the field of textiles engineering, fibers and textiles manufacturing, or a related field. Additional education could substitute for professional experience, and *vice versa*.

22. Based on my experiences, I have a good understanding of the capabilities of one of ordinary skill. Indeed, I have taught, participated in organizations, and worked closely with many such persons over the course of my career.

For example, from my industry experience, I am familiar with what a skilled person would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience possesses.

Furthermore, I possess those capabilities myself.

V. TECHNOLOGY BACKGROUND AND SUMMARY OF THE '566 PATENT

A. Technology Background

23. Humans have made paper from raw plant materials since ancient times.

EX1025 (Adanur), 5. Although the fundamental process of papermaking has not changed, modern papermakers produce paper on an industrial scale by using continuous papermaking machines called fourdrinier machines.

Id., 5-6. These machines, first developed in the early 1800s, transform pulp into finished paper products. *Id.* The following schematic drawing—published in a 1997 textbook—shows a typical papermaking machine. *Id.*, 13.

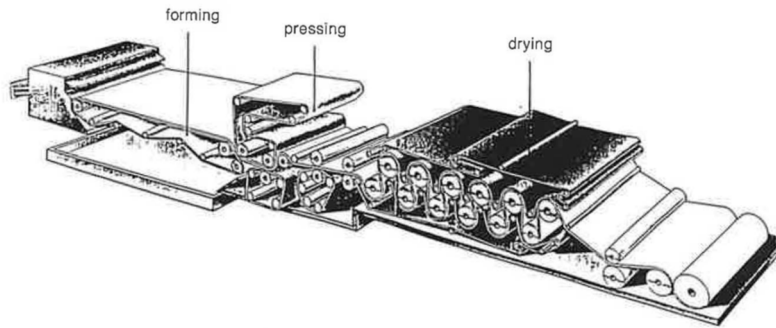


FIGURE 1.10. Schematic of a fourdrinier paper machine.

24. A typical papermaking machine consists of three distinct sections: forming section, pressing section, and drying section. *Id.*, 6. Each section utilizes a continuous belt of specialized fabric, called “paper machine clothing” or PMC, which performs a specialized function in the papermaking process (i.e., assist in forming, pressing, and drying). *Id.*, 6, 24. PMC also acts as a conveyor belt to support and move materials through the machine. *Id.*, 24, 37.

1. *Paper Machine Clothing*

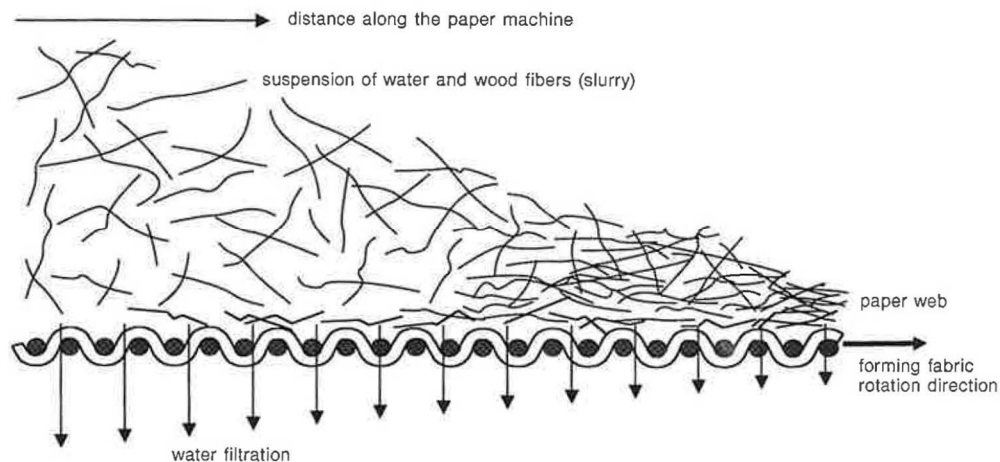
25. The ’566 Patent, and this case, is about PMC. Papermaking machines have used PMC for over 120 years and PMC remains an integral part of the papermaking process today. *Id.*, vii-ix. PMC started as simple weave structures consisting of metal wire, wool, and/or cotton. *Id.*, vii. But, since at least the 1990s, PMC have been highly engineered products made from synthetic materials, such as polyester or polyamide (nylon). *Id.*

Improvements in the manufacture, materials used, and design of PMC over

the years have resulted in increased papermaking speed, more efficient water removal, and improved paper quality. *Id.*, 6, 25. The three basic types of PMC—“forming fabric,” “press felt,” and “dryer felt”—are explained below.

(a) “Forming fabric”

26. The papermaking process starts in the forming section of the papermaking machine. *Id.*, 6. In this section, a slurry of pulp is distributed onto a conveyor belt of specialized porous PMC called “forming fabric.” *Id.* As shown in the schematic below, water filters through the porous forming fabric as the PMC travels through the machine, thus forming a continuous sheet of paper fibers, sometimes called a “paper web.” *Id.*, 13.



(b) “Press felt”

27. Next, the paper sheet moves to the pressing section of the papermaking machine. *Id.*, 24. In this section, specialized PMC called “press fabric” or

“press felt” conveys the sheet between press rollers, as shown in the schematic below. *Id.*, 154.

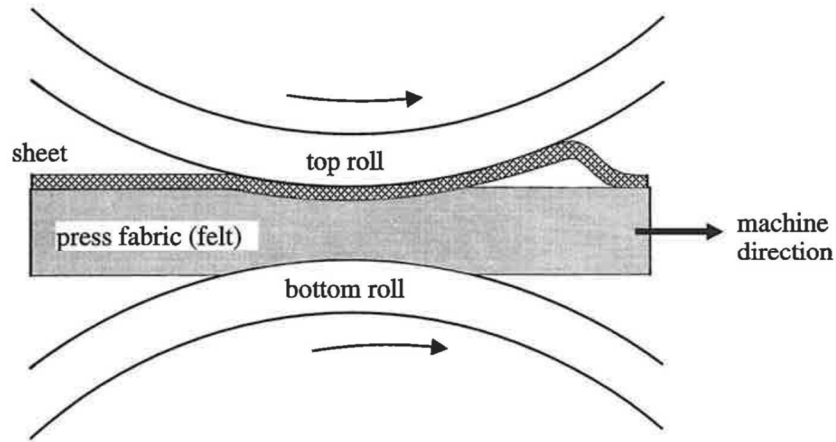
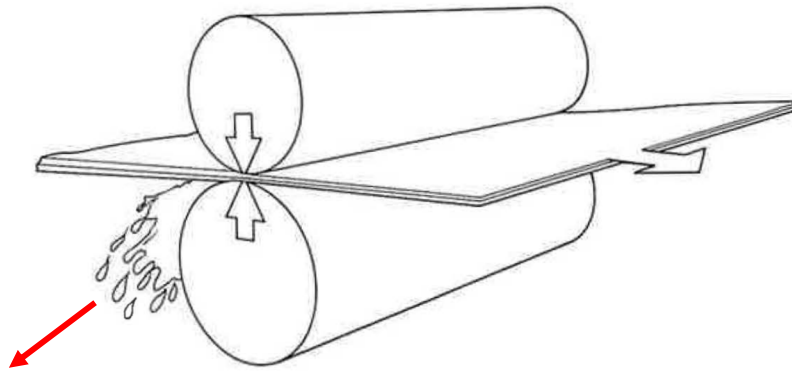


FIGURE 3.1. Schematic of simple press nip.

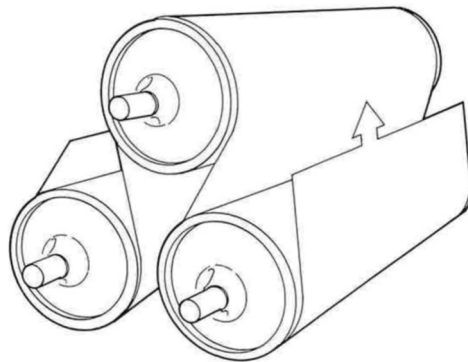
28. The press rollers compress the sheet into the press felt, thereby continuing the water extraction process that begun at the forming section. *Id.*, 24. During compression, water transfers from the sheet into the press felt underneath, and is expressed away, as shown by the red arrow in the annotated schematic below. *Id.*, 14, 24.



29. In addition to extracting water from the sheet, press felt influences the surface texture and finish of the resulting paper product. *Id.*, 24.

(c) “Dryer felt”

30. Finally, the drying section of the papermaking machine removes residual water from the paper sheet. *Id.* Specialized PMC called “dryer felt” conveys the sheet around heated cylinders (shown in the schematic below). *Id.*, 14, 24.



31. Dryer felt presses the sheet tightly against the heated cylinders for drying, resulting in a paper product having the consistency of regular paper. *Id.*, 24.

2. *Threads and Weave Patterns*

32. PMC can be produced by weaving on a loom using many different types of threads¹ and different weave patterns. EX1025, 38-58.

33. The type of threads used depends on the desired properties of the PMC.

Using press felt as an example, the interwoven threads usually are cabled monofilament, plied multifilament, spun yarns, and/or single monofilaments, as shown below. *Id.*, 159.



FIGURE 3.5. Yarn types used in manufacture of base fabrics.

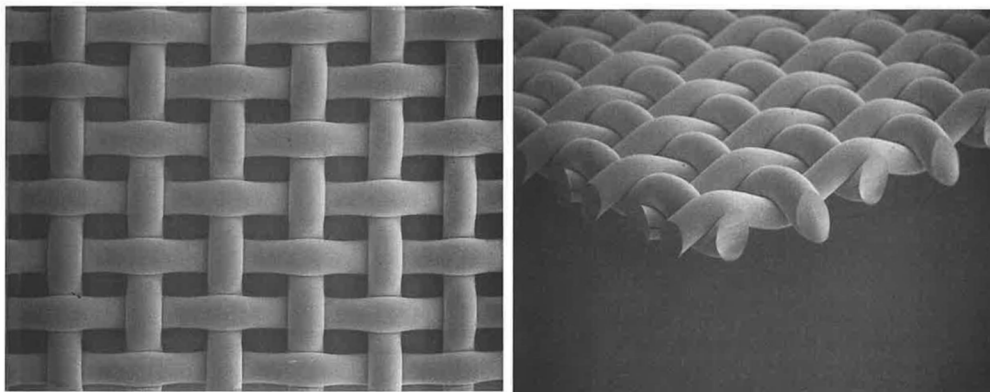
Thread type influences the functional properties of the press felt, including its ability to manipulate pressure, flow resistance, void volume, and compression. *Id.*, 159.

34. Similarly, the number of fabric layers in a PMC may also differ. Press felt, for example, may consist of a single layer or multiple layers of flat-woven fabric, typically called “base fabric.” *Id.* By way of example, the simplest

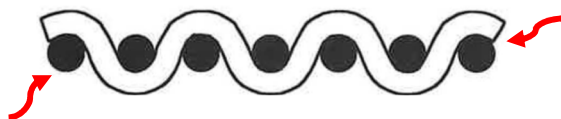
¹ The words “thread” and “yarn” are generally used interchangeably in the art.

weave pattern is a single layer design. *Id.*, 38. In this design, one layer of warp threads (also sometimes referred to as machine-direction (MD) threads) is interwoven with one layer of crosswise weft threads (also referred to as cross machine-direction (CMD) threads). *Id.* The MD threads are so named because, when the PMC is installed on a papermaking machine, these threads extend in the direction the PMC travels along the papermaking machine.

35. The following schematics show photographs of a single layer design from a top view (left) and from a perspective view (right). *Id.*, 41.



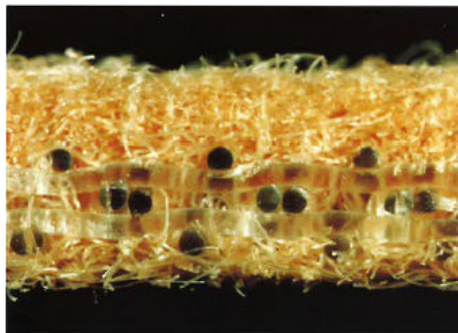
36. The following drawing shows a single layer design from a side view, where the PMC fabric has been cut perpendicular to the machine direction. *Id.*, 40.



In this view, the black circles represent the warp threads (running in the machine direction), while the wavy line represents the weft thread (running

in the cross direction). *Id.*, 38-39. The CD wavy line (weft thread) is interwoven with the MD black circles (warp threads). *Id.*

37. In the context of press felt, the PMC also typically includes a “batt”—a layer of either natural or manmade fibers that are randomly bonded together rather than woven—that surrounds the flat-woven base fabric. *Id.*, 29, 159. The photograph below is a side view cross-section of a portion of a two-layer press felt, where the gold non-woven material surrounding the threads is batt. EX1029, 1, 3-5. Processing, such as the mechanical process (called needling) to attach the batt to the woven base fabric and/or thermal processing, can sometimes result in slight deformations to the thread and/or the weave structure.



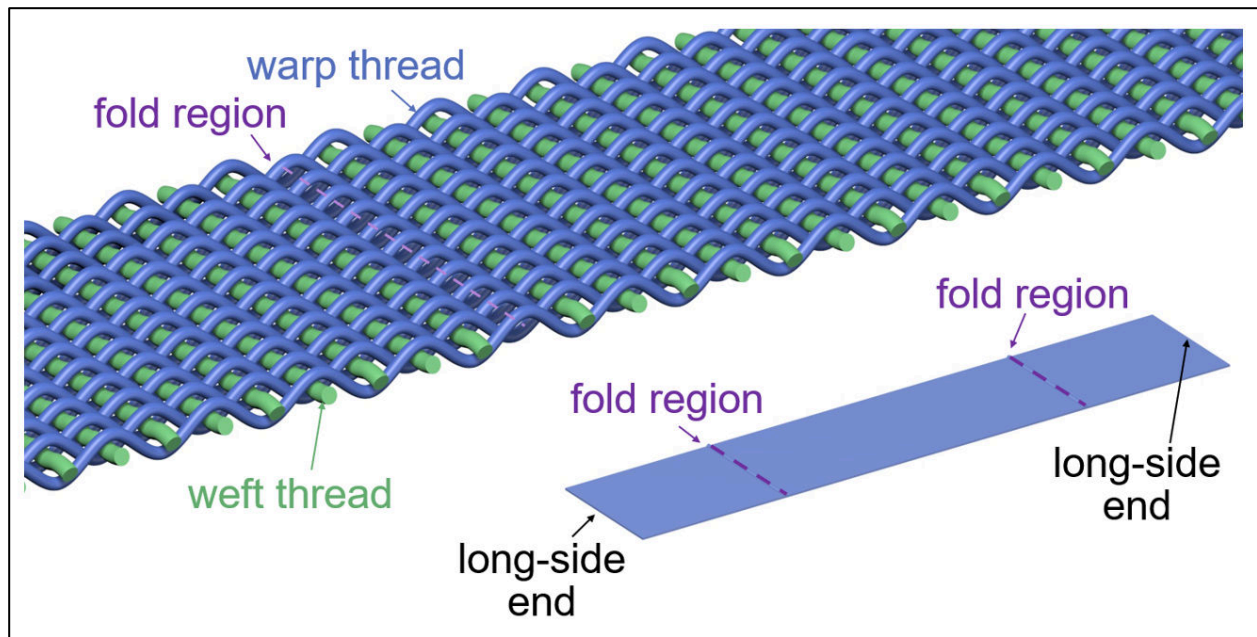
Photographs from Petitioner’s 1996 SeamTech Brochure (EX1029, 1, 3-5)

3. *Seaming PMC*

38. PMC is typically prepared by one of two processes: “flat weaving” or “endless weaving.” *Id.*, 38. As the name suggests, endless weaving produces a continuous round belt. *Id.*, 38-39. Flat weaving, on the other

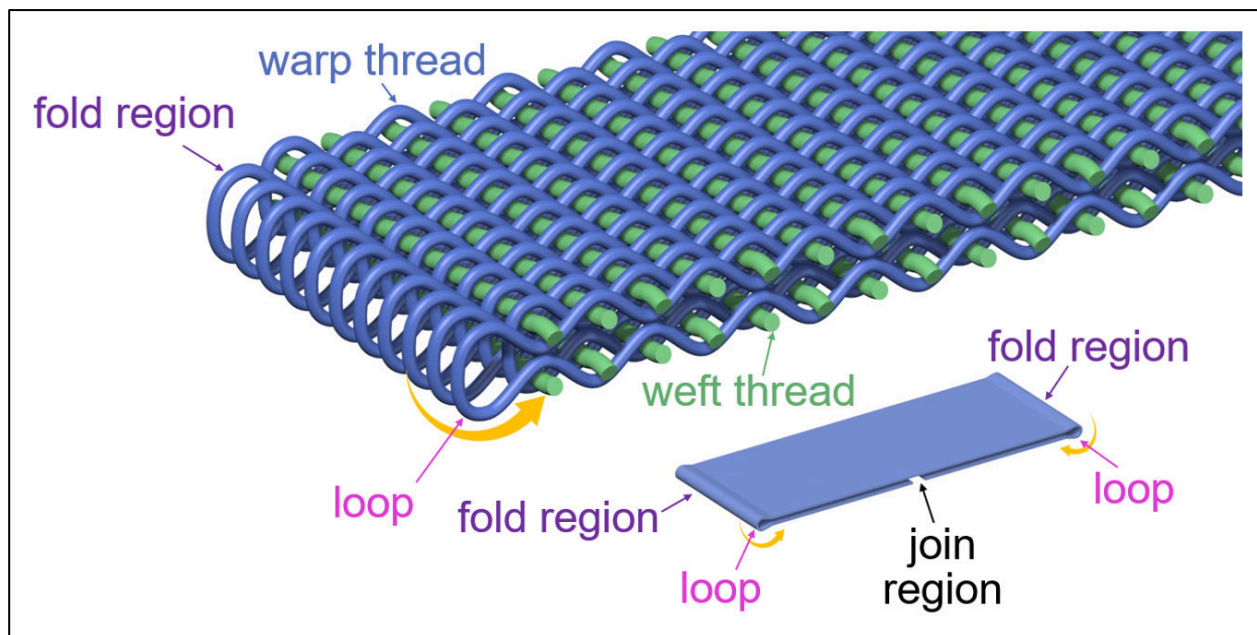
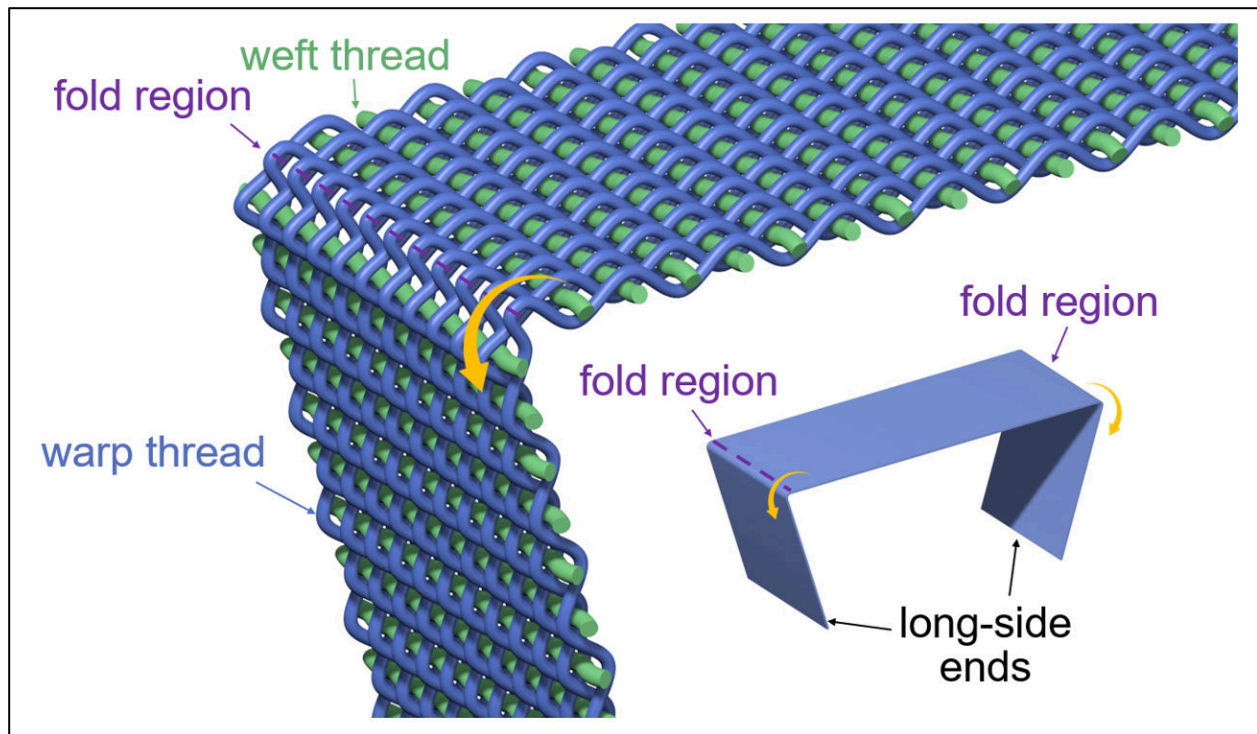
hand, produces a sheet of fabric that can be joined (or “seamed”) at the long-ends to form a continuous belt. *Id.*, 38-39.

39. Continuous fabric belts—whether woven directly in an endless weaving process or formed by joining ends of a flat-woven fabric—have long been used by manufacturers. Petitioner, for example, advertised its SeamTech product—a seamed press felt—in 1996. EX1029, 1, 3, 5. This is the case because continuous belts can be easily installed on papermaking machines by a second seaming process, allowing for fast and efficient installation. EX1025, 159. This second seaming process forms the fabric belt into what is often referred to as an “endless” structure.
40. Below, I have provided illustrations to show the process of making a flat-woven fabric into a continuous fabric belt in a first seaming process, and the subsequent formation of that belt into an endless structure by a second seaming process. This is a conventional PMC process and it is similar to the process in prior-art reference Sudre (EX1004), as well as the approach taken in the ’566 Patent.
41. First, a flat-woven fabric is prepared on a loom as a flat fabric having two free long-ends, as shown below. EX1025 (Adanur), 38-39. The warp threads (blue) run in the machine direction (MD), while the weft threads (green) run in the cross direction (CD).



42. The flat-woven fabric has two fold regions, marked in purple, where the fabric can be folded to produce a two-layer structure. EX1004, 18-21. At the fold regions, some CD threads are removed from the fabric. EX1004, 3:22-23. Accordingly, each fold region shown lacks one or more CD threads, where only MD threads remain.

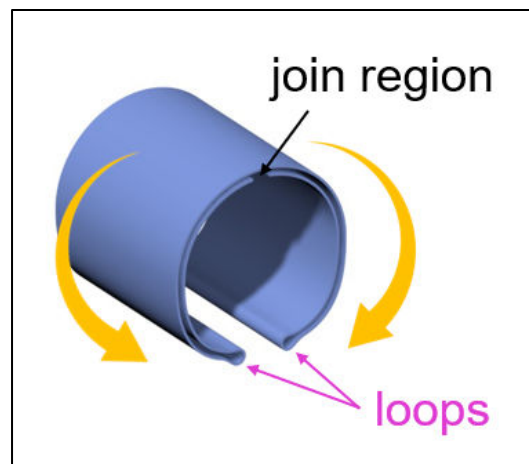
43. The following drawings depict the process of folding the flat-woven fabric to create a two-layer structure. The top schematic shows the fabric beginning to be folded at the fold regions, while the bottom schematic shows the two-layer fabric when the folding is completed.

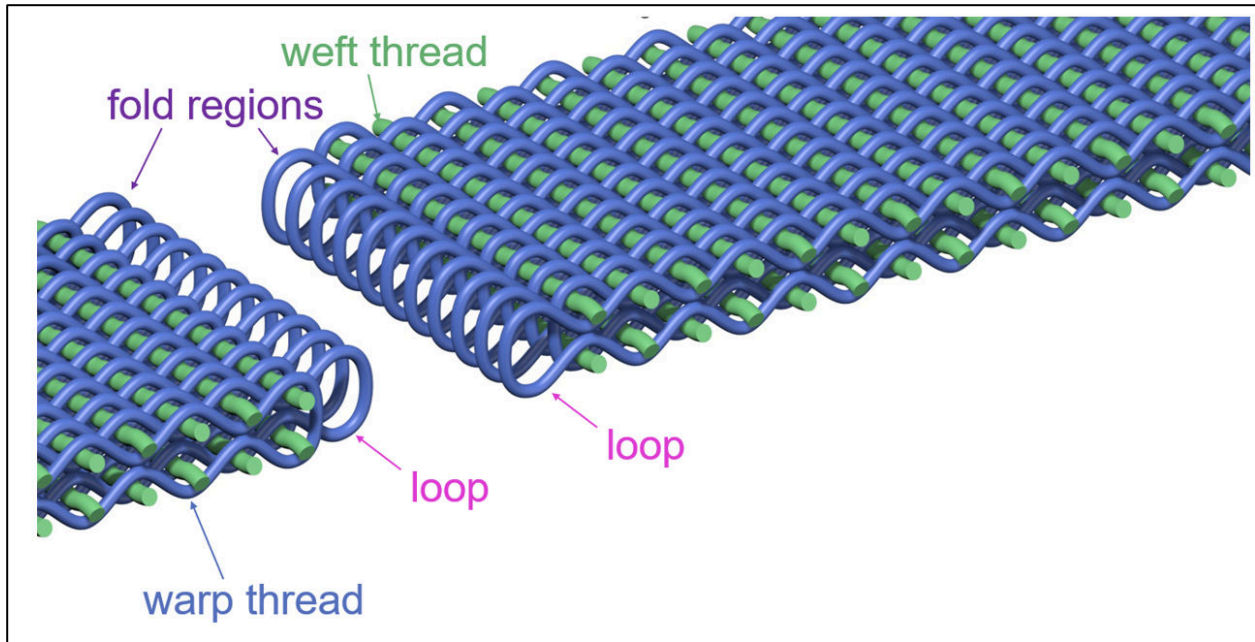


44. In the folded fabric, the free ends substantially abut (illustrated as a “join region”), and can be connected, for instance, by a welding process. EX1004, 3:18-21. This produces a two-layer (“laminate”) structure. Importantly, as a

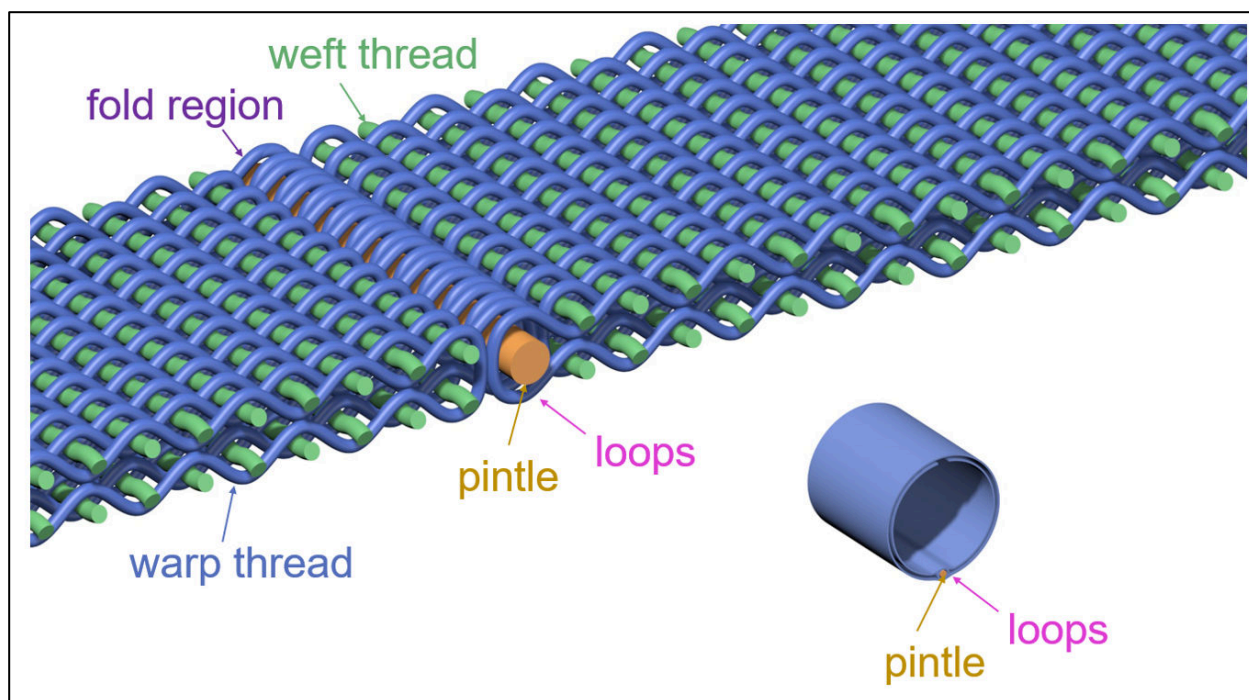
result of folding, “seam loops” formed by the MD threads (in the absence of the CD threads) are created at the fold regions. EX1004, 3:12-21; EX1001, 3:51-52, 8:33-34.

45. To make the two-layer structure “endless” for use on a papermaking machine, the two-layer structure is folded again to bring the seam loops of both fold regions together, as illustrated in the next two drawings. EX1004, 3:22-24; EX1001, 2:56-62. The top schematic shows the entire fabric, folded such that the loops are brought together, and the bottom shows a close-up view of the loops placed in close proximity.

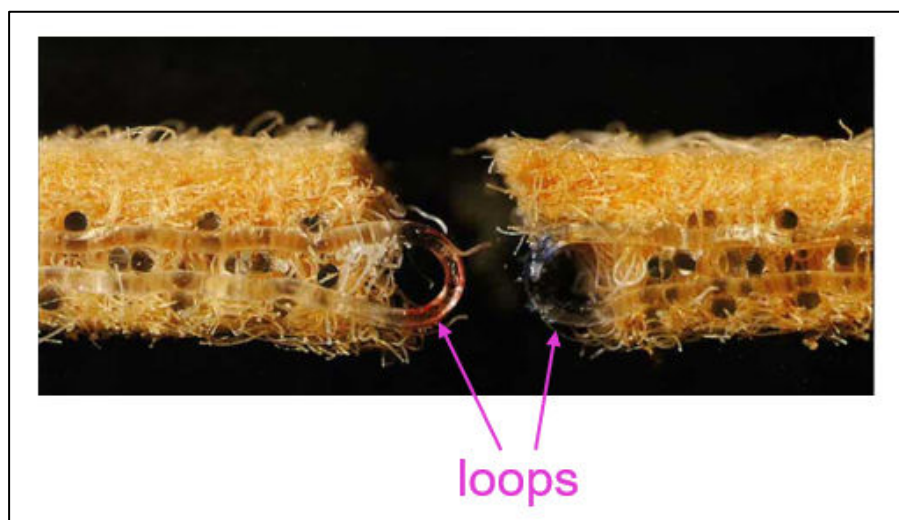




46. The seam loops from one side of the folded two-layer fabric are then interdigitated with the seam loops from the other side. EX1004, 3:24-4:1; EX1001, 1:8-19. This forms a channel that extends through the openings of the interdigitated loops. An “insertion element,” such as a pintle, is then inserted into this channel to bind the two sides together, forming a seam and making the fabric “endless.” EX1004, 3:24-4:1; EX1001, 1:16-19; 3:6-9. This is illustrated in the following drawing, where the pintle (orange) has been inserted through the seam loops to connect the two ends of flat-woven fabric.



47. A photograph of a press felt with translucent seam loops, from Petitioner's 1996 SeamTech brochure, is shown below. EX1029, 1, 7.

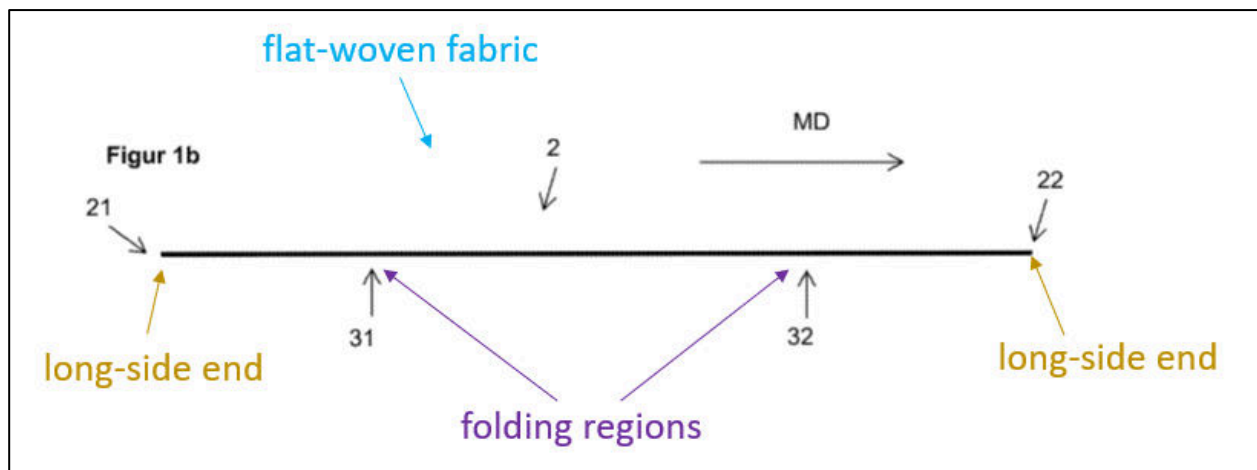
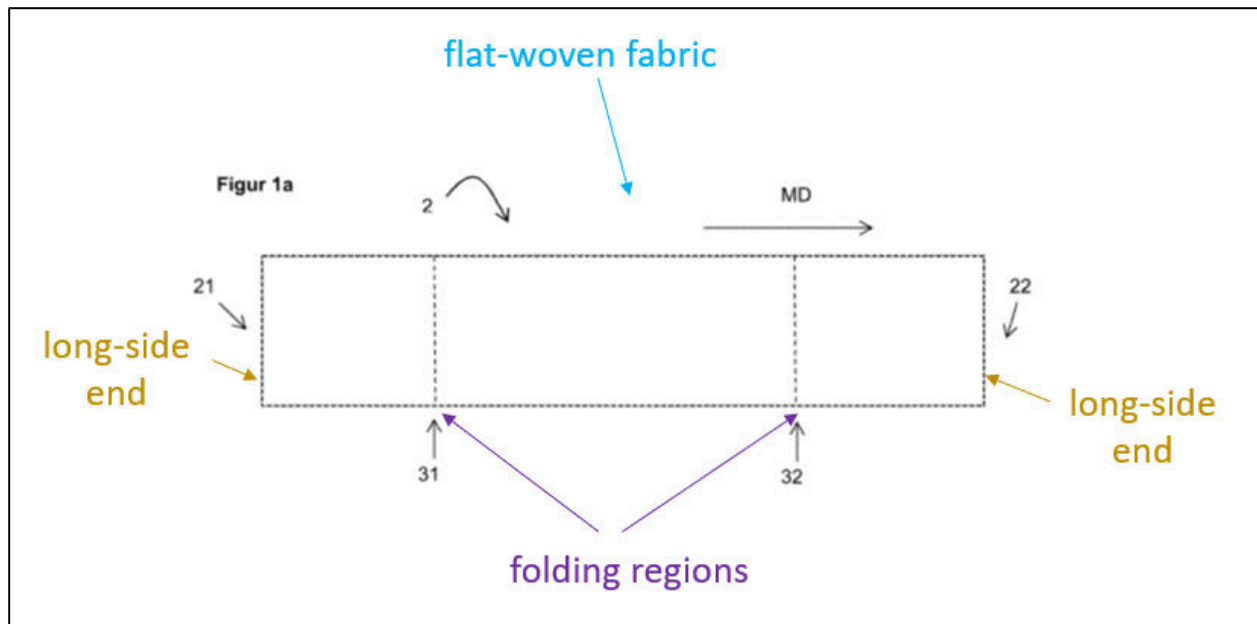


48. Another SeamTech photo (annotated with an arrow, below) shows a pintle (in brown) connecting the ends of the press felt. EX1029, 3, 5.



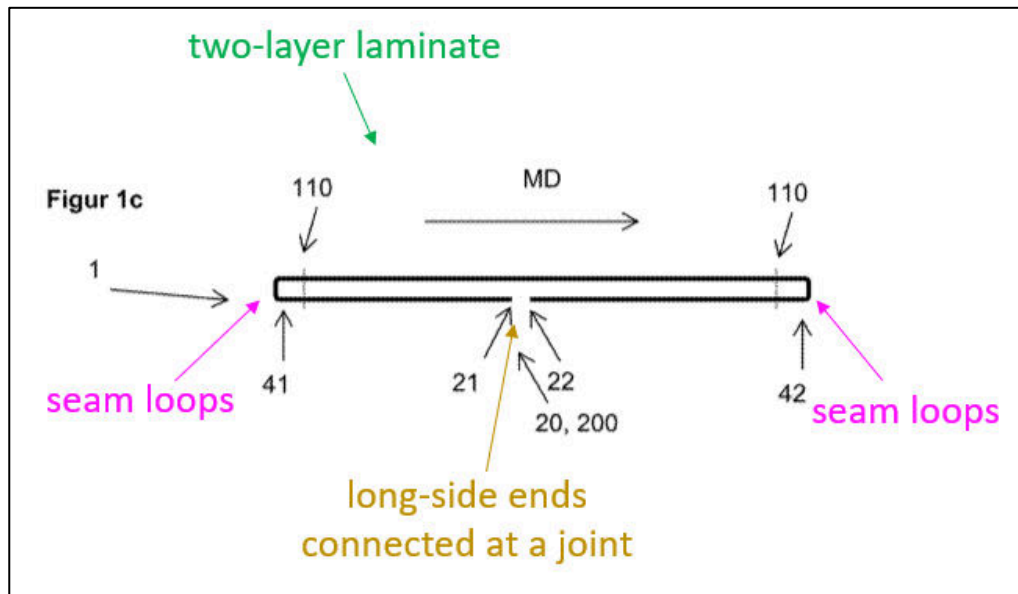
B. Brief Description of the '566 Patent

49. The '566 Patent relates to PMC produced by flat weaving that allegedly “overcomes the quality deficiencies of the prior art.” EX1001, 2:10-11. This object is allegedly “achieved by a clothing in which the diameter (LD) of the seam loops and the diameter (MDYD) of the associated MD threads has a ratio LD/MDYD between 2.5 and 4, in particular between 2.7 and 3.6.” *Id.*, 2:12-16. The '566 patent defines “LD” as the diameter of the seam loops, and “MDYD” as the diameter of the machine-direction (MD) threads (or yarns). *Id.*, 2:63-67.
50. The claimed PMC comprises a two-layer laminate structure formed by seaming (or joining) one or more flat-woven fabrics. *Id.*, 1:8-19. Figures 1a-1c, reproduced below, show the formation of the two-layer laminate structure from a single flat-woven fabric. *Id.*, 8:14-17. Specifically, figures 1a and 1b show a single fabric 2 produced by flat weaving in both top-view (Figure 1a) and side-view (Figure 1b). *Id.*, 8:31-35.



51. The fabric 2 runs in the machine direction (MD) and has two long-side ends 21 and 22. *Id.*, 8:31-33. In this embodiment, regions 31 and 32 represent chosen folding regions. *Id.*, 8:33-34. And at these regions, one or more cross directional (CD) threads are removed, so that only machine direction (MD) threads remain. *Id.*, 8:36-37.

52. The fabric is folded under along the folding regions 31 and 32 so that long-side ends 21 and 22 meet underneath in join areas 20 (or “joint” 200), as shown in figure 1c. *Id.*, 8:38-46.



53. At the join region 20, the long-side ends may abut, overlap, or remain at a distance. *Id.*, 8:41-44. The two layers may also be connected, e.g., by sewing, at “fixing points” 110. *Id.*, 48-51. This forms a two-layer laminate structure 1, as shown in Figure 1c. *Id.*, 8:41. Again, as a result of folding (and removal of the CD threads in the folding regions), “seam loops” formed of MD threads are created at ends 41 and 42. *Id.*, 3:51-55, 8:33-34. The two-layer laminate is then folded again to bring the seam loops together, and a seam is then made “by interengaging the seam loops of the two end sides” and inserting “an insertion element”—i.e., a pintle. *Id.*, 1:16-19; 3:6-9.

54. As noted previously, the seaming process (the use of seam loops and a pintle) is old in the art. The '566 patent purports to improve upon the art by (1) using the claimed LD/MDYD ratio, and (2) by “matching” the “properties of the seam area” to the “‘loop density’ in the seam.” *Id.*, 6:8-10. As to the latter, the '566 Patent states that “the seam loop density (statement in percent) is obtained as a measure of the coverage of the seam area by the MD threads” (*id.*, 6:17-18), and that a preferred seam-loop density is between 64% and 90% (*id.*, 6:36-40).

55. As I will demonstrate below, the claimed LD/MDYD ratio and the seam loop density were already present in conventional seamed press felts.

C. Summary of the Prosecution History of the '566 Patent

56. During prosecution of the '566 patent, the Examiner rejected the claims under 35 U.S.C. § 103 for obviousness over Crook (U.S. Patent Pub. No. 2009/0211722) in view of Lee (U.S. Patent No. 6,189,577). *E.g.*, EX1002, 112-120. After several rounds of claim amendments, the Examiner allowed the claims, stating in the reasons for allowance that the prior art did not teach or suggest a seam having a loop density of between 64% and 90% and a ratio of seam-loop diameter to MD threads diameter between 2.7 and 3.6. EX1002, 13. As I demonstrate below, though the examiner was wrong on

both the loop density and the ratio, because these parameters were already in conventional seamed press felts.

VI. SUMMARY OF THE PRIOR ART

57. In my opinion, claims 1-15 of the '566 Patent are obvious in view of combinations of the references that I have listed in the sections above.

VII. PRIOR ART ANALYSIS

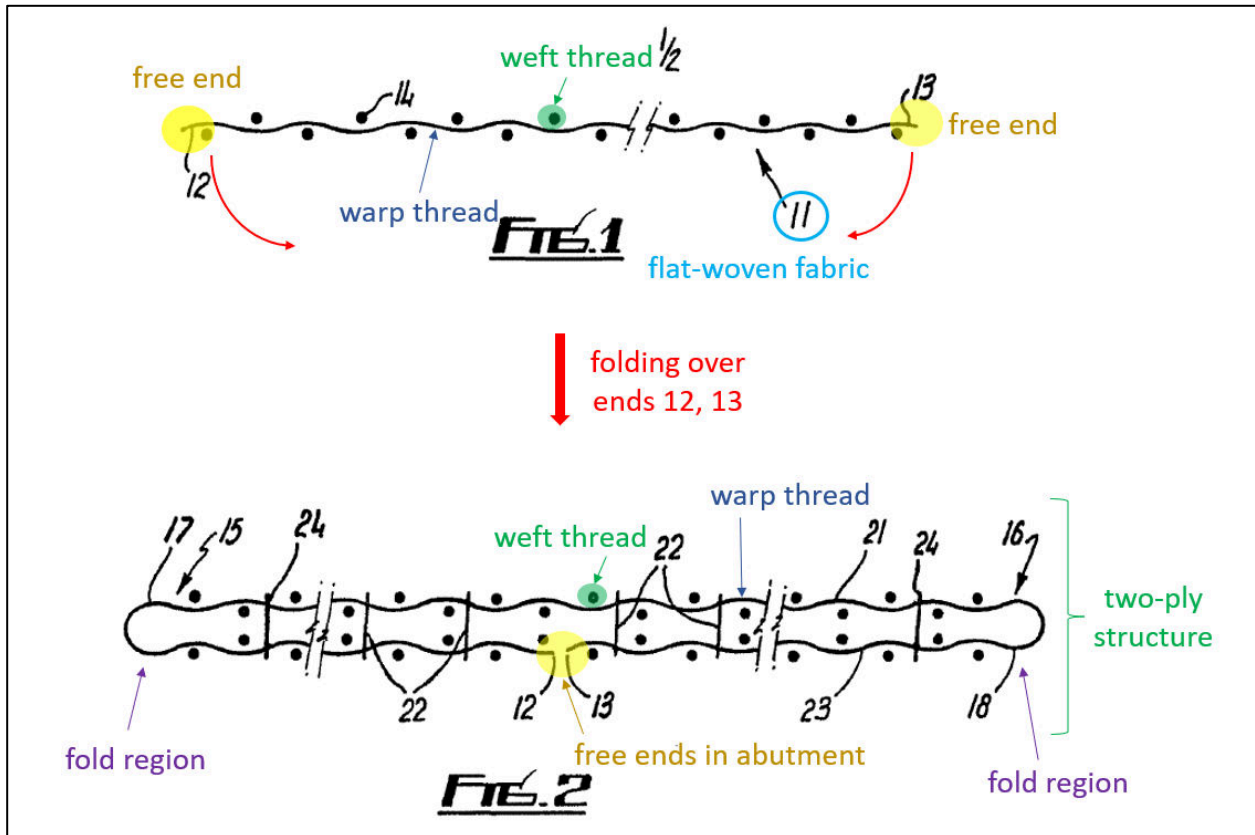
A. [GROUND 1A] – Sudre-Adanur Renders Obvious Claims 1, 3, and 10-13

1. Sudre

58. Sudre is a nearly 40-year old patent that relates to “papermaker’s fabrics” and “a method for the manufacture of a seamed endless structure for use as papermachine clothing or as a base material therein.” EX1004, 1:2-5. Figs. 1-3, which I provide and discuss below, “show[s] successive stages in the production of an endless base material for use in a papermaker’s fabric.” *Id.*, 2:25-3:1.

59. Fig. 1 (below) provides an illustration showing that Sudre’s base material includes “a flat-woven fabric 11,” blue, having two “free ends 12, 13,” yellow. EX1004, 3:13-18. The woven fabric includes warp threads (one of which is shown in Fig. 1) and weft threads (an example highlighted in green) that are interwoven together. *See* EX1004, 1:10-15, 3:22. In Fig. 2 (below), the free ends “are folded over” (as shown by the red arrows) “to define a

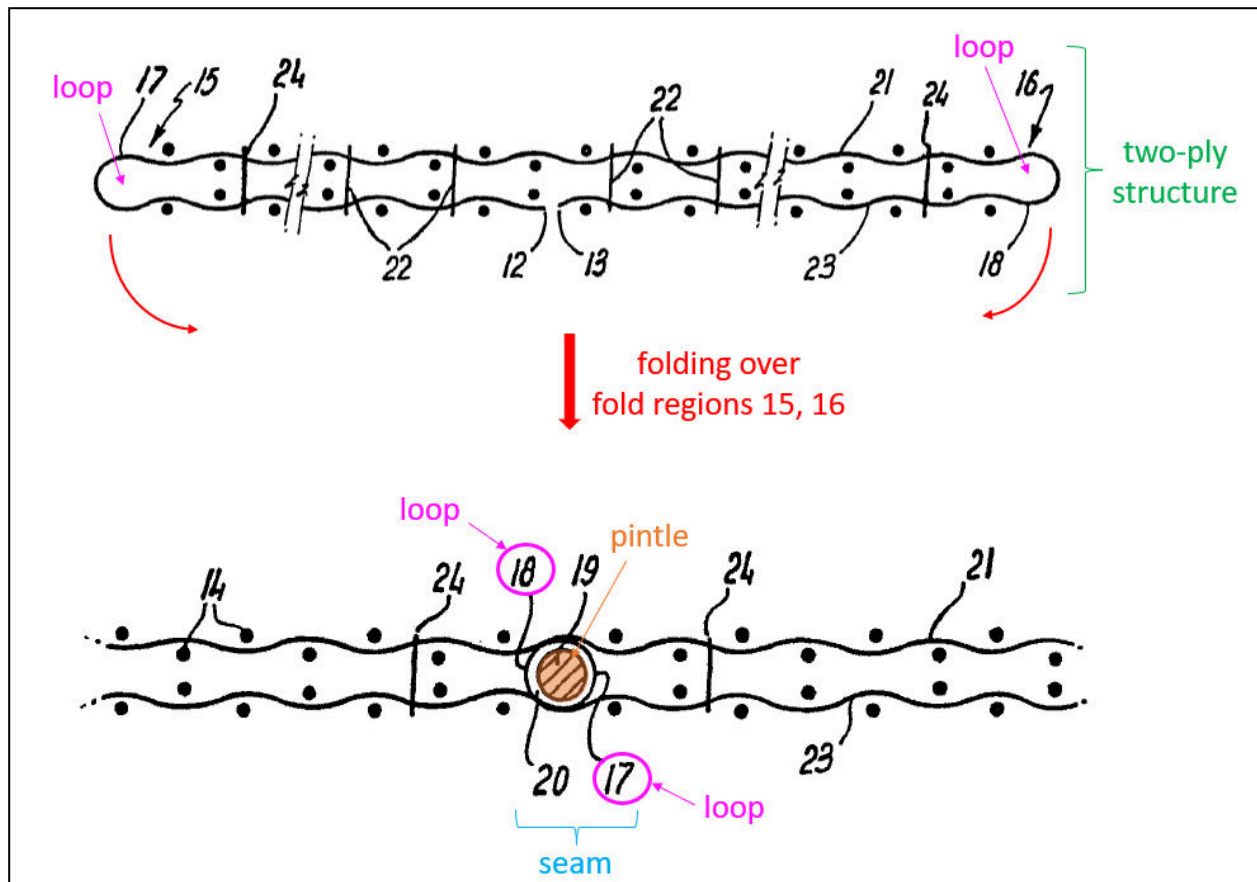
two-ply structure having fold regions 15, 16 [purple], the free ends being brought into substantial abutment.” EX1004, 3:18-21.



Sudre, Figs. 1 and 2 (annotated)

60. Sudre’s methods are consistent with conventional methods used for seamed papermachine clothing. For example, “[w]eft yarns 14 are removed from the fold regions ... to give loops 17, 18 extending outwardly therefrom.”

EX1004, 3:22-24. In Fig. 2 below, warp yarns form loops (show in pink).

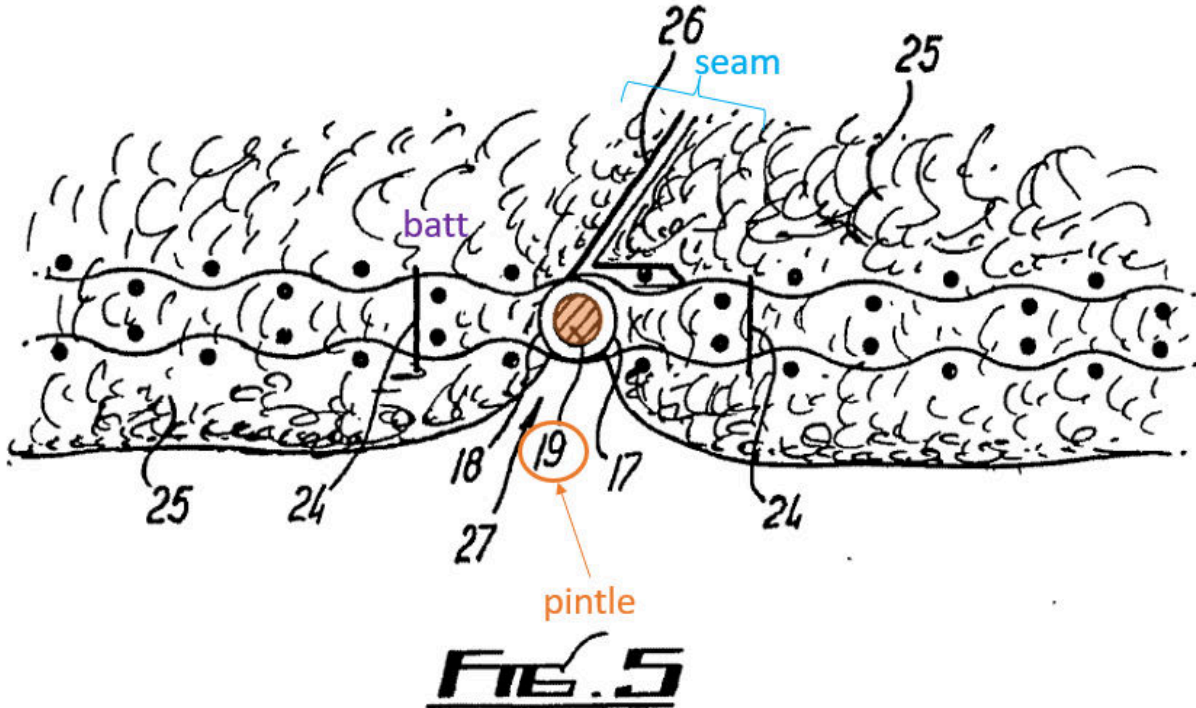


Sudre, Figs. 2 and 3 (annotated)

61. In a next step, Sudre describes that “the two-ply structure [is] brought into endless form by the interdigitation of such loops and the introduction of a pintle wire 19 into the tunnel 20 formed thereby.” EX1004, 3:24-4:1. In other words, the two-ply structure is folded (see red arrows in Fig. 2 *supra*) and the loops on each end of the two-ply structure are brought together. When brought together, the loops are interdigitated, and by aligning the interdigitated loops, a tunnel can be formed along the entire length of the fabric. *Id.* As shown in Fig. 3, a pintle (orange) is inserted into the formed

tunnel and a seam (shown in blue) is formed that extends along the length of the fabric (*see also* Fig. 5, *infra*). *Id.*

62. As shown in a perspective view of Fig. 5 below, Sudre describes that “a textile batt 25 is needled to each face of the endless structure.” EX1004, 5:8-10. Needling the textile batt to the base structure “brings the batt at each face into coherent and homogeneous form through the base structure, and serves also to secure the individual plies of such base structure together.” *Id.*, 5:15-18. This processing yields an endless fabric with the batt needled thereon, resulting in a final product – a press felt for use in papermaking operations.



Sudre, Fig. 5 (annotated)

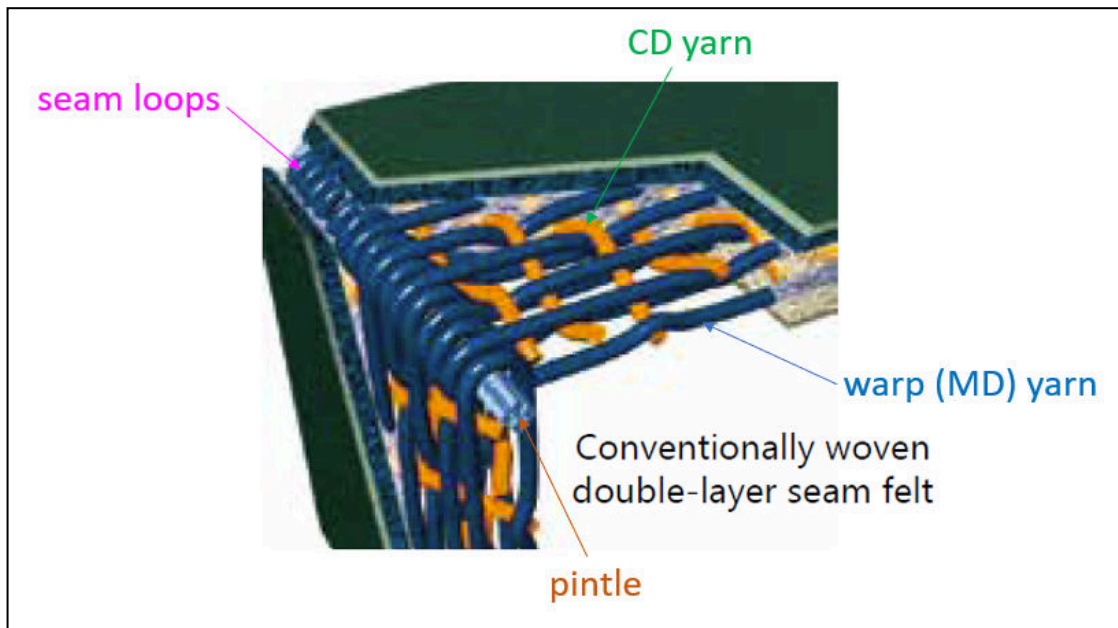
2. *Adanur*

63. *Adanur* is a textbook directed to the papermaking machine clothing and is well-recognized within the papermaking industry. EX1022. *Adanur* describes “papermaking machine clothing” and various “methods of producing base fabrics.” EX1021, 111. This second edition of *Adanur* was developed as a “result of a two-year project that involved many engineers from North America, Europe and Asia working in the field,” including “a group of professionals from AstenJohnson University,” and it “has been the *industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics.*” EX1022. *Adanur* is “the only source in its field and therefore fulfills an important mission throughout the world by *providing valuable and hard-to-find information to the professionals*, as well as academicians, in the pulp and paper related industries.” *Id.*

64. *Adanur* discloses a variety of information relating to machine clothing. *Adanur* includes a chapter directed to the “[m]anufacturing of [p]ress [f]abrics,” which is the fabric used in a “press section” of the papermaking process that occurs in “the paper machine after the forming section.” EX1021, 103. “Press fabrics, in general, consist of two basic components,” including “the base fabric and the batt.” *Id.*, 107. Base fabrics can be

constructed with “single monofilaments.” *Id.*, 107-108. Base fabrics can be constructed to form “a single-layer construction (one layer of MD yarns and one layer of CD yarns)” or “a woven multilayer construction (multiple layers of MD yarns with only one layer of CD yarns).” *Id.*

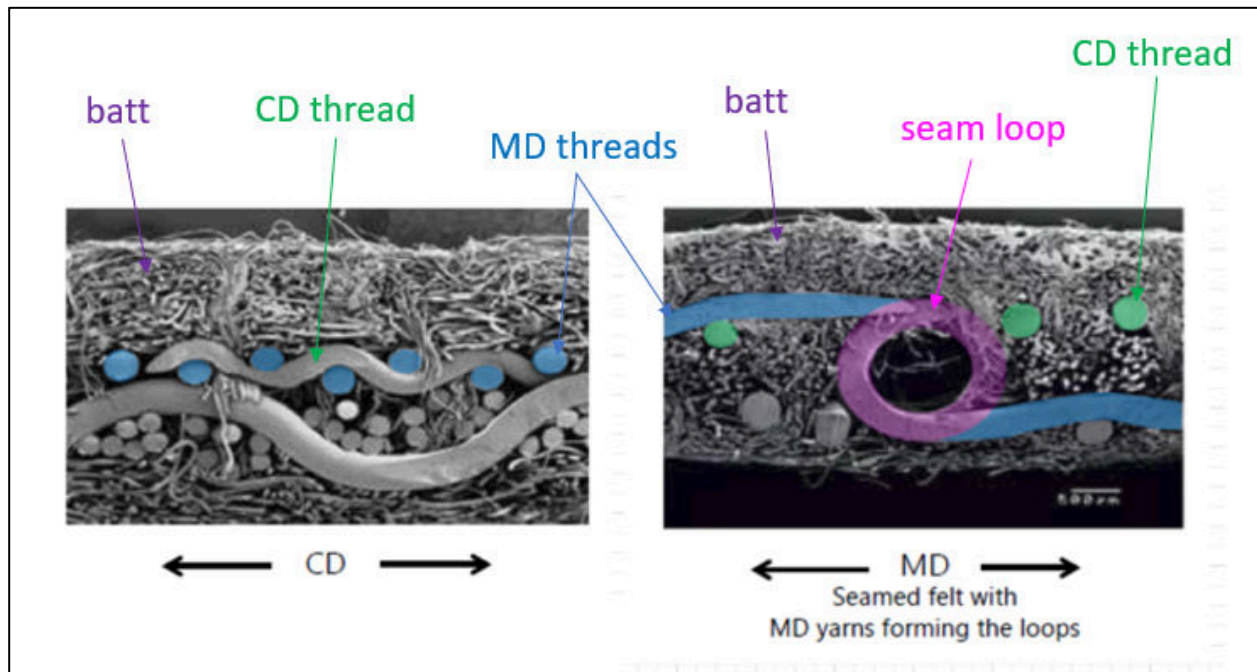
65. Press fabrics, such as “conventional (endless) designs” and “seamed fabrics,” can be “endless or joined with a seam.” *Id.*, 108. Using a “conventional weaving” technique, “[w]oven loop seam fabrics are woven similar to an endless fabric; however, loops are formed at the ends of the fabric.” *Id.*, 113. Figure 3.8 (below) shows a “[c]onventionally woven seam base[]” having “seam loops formed on one edge” and “multiple layers of MD yarns with only one layer of CD yarns that are interwoven to lock the structure together.” *Id.*, 109.



Excerpt from Adanur, Fig. 3.8 (annotated)

66. In the context of press fabrics, Adanur provides exemplary “cross-sections of **actual finished press fabrics**” in Figure 3.15 (reproduced below) that show cross-sections in a cross direction (CD) (shown on left) and a machine direction (MD) (shown on right). *Id.*, 111. As shown, a base fabric includes MD threads (shown in blue) (as seen in the left image) interwoven with CD threads (shown in green). Both MD and CD threads have round cross-sectional shapes. As shown in the left image, the MD threads form seam loops (pink in the right image). Batt (indicated in purple) is needled to the base fabric. As I discuss in more detail in the following paragraphs, I have taken measurements of these images using conventional approaches,

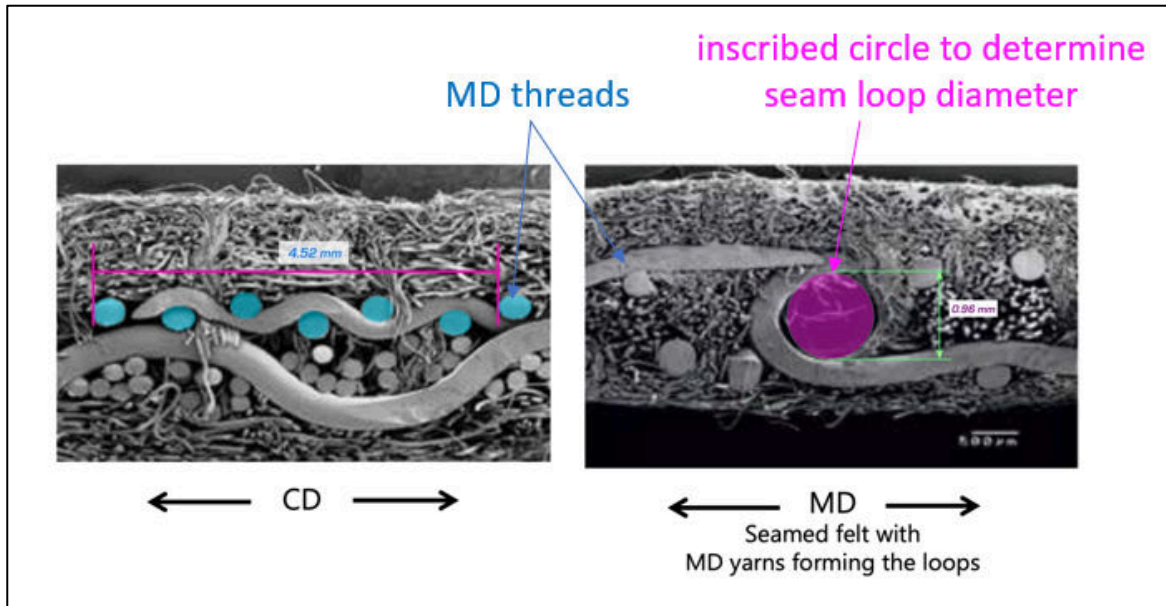
namely, measuring distances and length in pixels and converting pixels to actual lengths (*e.g.*, mm) based on the scale bar that is shown in the image.



Adanur, Fig. 3.15 (annotated)

67. As further illustrated below, I have taken measurements of the “actual finished press fabrics” shown in Adanur. EX1021, 111. My measurements can be readily taken to show that in 2017, before the ’566 Patent’s Critical Date, these exemplary base fabrics had a seam made of MD threads with a diameter of about 0.32 mm present at an MD thread density of about 13.3 threads/cm, and with a loop diameter of about 0.96 mm. EX1021, 111. As discussed further *infra*, these parameters correspond to a loop density of

approximately 85% and a ratio of seam loop diameter to machine direction thread diameter of approximately 3.0.



Adanur, Fig. 3.15 (annotated)

68. Specifically, I measured the loop diameter from the image at right in Adanur's Fig. 3.15, consistent with the process described by the '566 Patent: "To determine the diameter of a seam loop, the largest circle which can be inserted completely into the seam loop is ascertained. The diameter of this circle is then viewed as the diameter of the seam loop." EX1001, 2:46-49. The largest circle that can be inscribed into the seam loop of Adanur's Fig. 3.15, shown *infra* at right, has a diameter of 208 pixels. The 500 μm scalebar in this image can be used to convert pixels to μm or mm. Specifically, the scalebar has a length of 108 pixels, which means that each

pixel corresponds to a length of 4.6 μm or 0.0046 mm. The circle diameter in pixels (208 pixels) can thus be converted to the corresponding actual diameter of 0.96 mm.

69.I measured the diameter of Adanur's MD threads as follows, which I believe a POSITA would have found to be a standard measurement protocol.

Specifically, Adanur's Fig. 3.15 at left shows seven MD threads, which I have highlighted in blue. For each of these threads I measured two diameters (in pixels): one in the horizontal direction and another in the vertical direction. I obtained the following fourteen diameter measurements (in pixels):

Horizontal diameter (pixels)	Vertical Diameter (pixels)
80	59
76	60
75	61
79	65
75	63
77	58
79	65

70.I averaged these measurements and obtained an average MD thread diameter of 69 pixels with a standard deviation of 9.6 pixels.

71.To convert these pixel values to mm, I relied on the scalebar in the image at right. Although these are two different images, it is my opinion that a POSITA would have had reason to understand that their scale is the same.

This is because a MD direction thread is also shown in the image at right, and when I measure the diameter of this thread at various positions along its length, I obtain diameter measurements (in pixels) that are generally consistent with the seven vertical diameter measurements I obtained for the blue-highlighted MD threads at left. Specifically, my measurements for the MD thread in the right image had an average of 62.1 with a standard deviation of 3.0 pixels compared with the vertical diameter measurements of 61.6 with a standard deviation of 2.8 pixels.

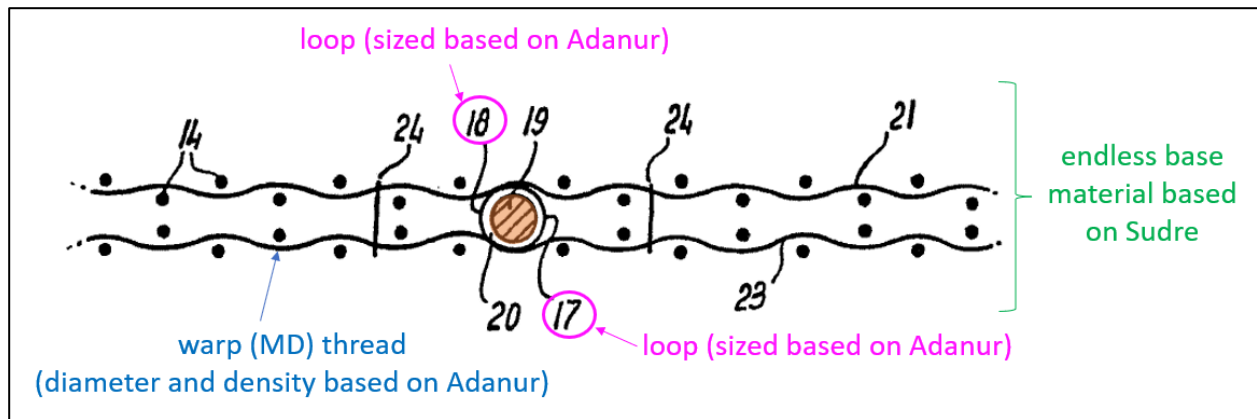
72. Thus, I concluded that it is reasonable to use the scale factor given by the scalebar in the right image to convert the pixel diameters of the MD threads in the left image into mm. With this conversion, based on my pixel measurements (average diameter 69 pixels, and standard deviation 9.6 pixels), I obtained an average MD thread diameter of 0.32 mm, with a standard deviation of 0.04 mm.

73. I also calculated the MD thread density of Adanur's fabric by measuring the distance spanned by size MD threads in the left image, *i.e.*, the distance from the left edge of the first MD thread to the left edge of the sixth MD thread. This distance was 967 pixels, which when converted from pixels to mm according to the scalebar, corresponds to about 4.52 mm. The MD thread density is the number of threads per unit distance, *i.e.*, 6 threads per 4.52

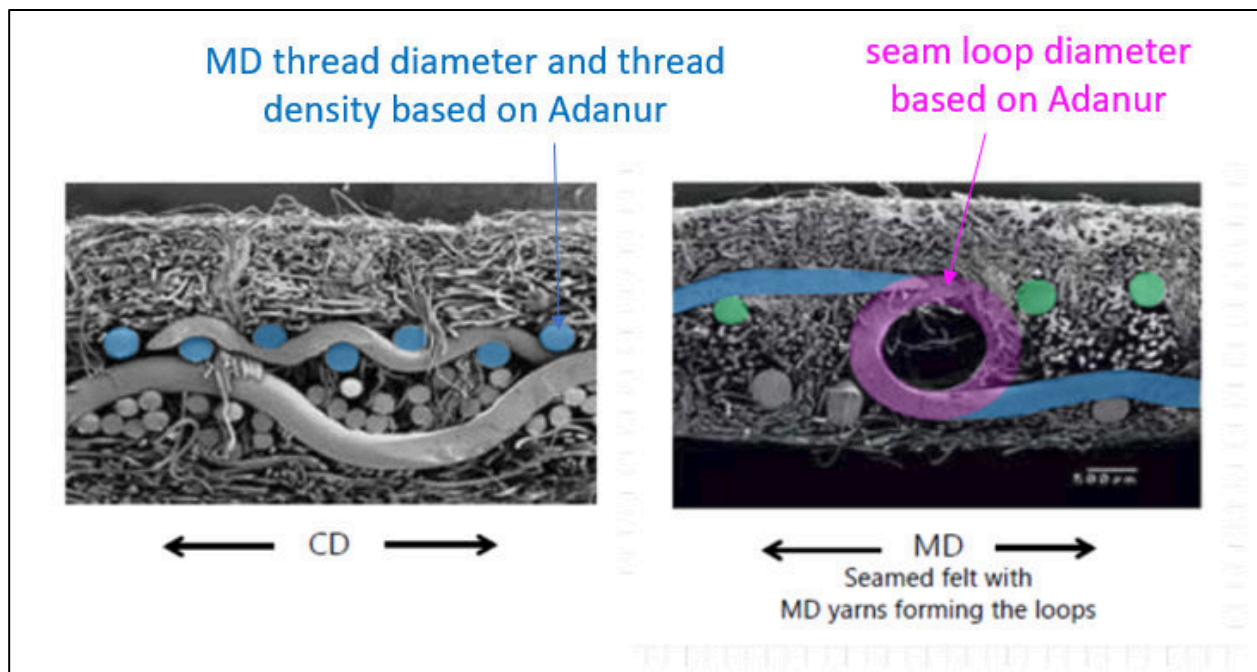
mm, or 13.3 threads/cm. Notably, the thread density can also be expressed in threads per pixel (6 threads / 967 pixels), without needing to take into account the pixel-to-mm conversion based on the scalebar of the right image.

3. *Combination of Sudre and Adanur*

74. The Sudre-Adanur combination is based on the “endless base material” described by Sudre, *e.g.*, the base material addressed in Sudre’s Figs. 1-3. EX1004, 2:25-3:2. In the combination, the round shape and diameter of the machine direction (warp) threads are implemented based on the teachings of Adanur, and are provided in a thread density also based on Adanur, as illustrated in the combination figure *infra*. Specifically, the combination fabric incorporates MD threads with a diameter of about 0.32 mm, and present in a thread density of 13.3 threads/cm, consistent with Adanur’s Fig. 3.15 exemplary press fabric. Also in the combination, the loops are dimensioned based on Adanur’s teachings of an exemplary finished press fabric having seam loops with a diameter of 0.96 mm. *See* EX1021, Fig. 3.15.



Sudre-Adanur composite figure based on Sudre, Fig. 2



Excerpt from Adanur, Fig. 3.15 (annotated)

75. As discussed further *infra*, these parameters correspond to a loop density of approximately 85%, and a ratio of the seam loop diameter to the diameter of the MD threads of approximately 3.0. EX1021, 111.

76. In view of Adanur's indication that finished press fabrics before the Critical Date were associated with these specific example values for MD thread diameter, MD thread density, and loop size (and thus loop density and ratio of seam loop diameter to MD thread diameter), a POSITA would have recognized the applicability of these specific example values to the "endless base material" based on Sudre. EX1004, 2:25-3:2.

77. Both Sudre and Adanur are analogous art to the '566 Patent: it is from the same field of endeavor (e.g., papermachine clothing) and is reasonably pertinent to the problem the '566 Patent was trying to solve (e.g., production of high quality papermachine clothing). See EX1001, 2:7-10.

4. *Motivation for the Combination*

78. As discussed above, Sudre generally describes a method for manufacturing a papermaker's fabric. While Sudre explains that "a papermaker's fabric meeting the *particular requirements of its intended end use* as regards performance characteristics *can be produced from that base fabric in a simple and ready manner*," it does not provide the specific parameters, such as warp thread size and spacing. EX1004, 6:14-17. For this reason, a POSITA would have been motivated to look to other known sources to identify the "particular requirements" of the fabric to obtain the necessary "performance characteristics" for the base fabric. EX1004, 6:14-17.

Moreover, a POSITA would have understood that such particular requirements are generally identified in “a simple and ready manner.”

EX1004, 6:14-17.

79. Generally, a POSITA in search of specific parameters (e.g., warp thread size, warp thread density, and seam loop size) for implementation of a press felt, such as that described by Sudre, would have looked to other references, and, in particular, Adanur because it was a well-known textbook directed to “papermaking machine clothing” and “methods of producing base fabrics,” and moreover, recognized as an “*industry standard for papermakers.*”

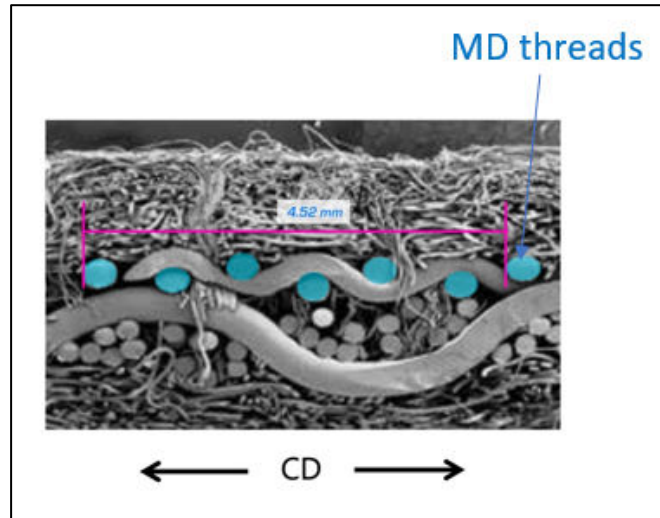
EX1021, 111, EX1022. In fact, a POSITA would have looked to Adanur for obtaining very specific parameters for clothing because it would have been known that Adanur “provid[es] valuable and *hard-to-find information to the professionals.*” EX1022.

80. Furthermore, a skilled person in the art generally would have expected success in dimensioning a press felt such as Sudre’s PMC using dimensions taught by Adanur because Adanur, like Sudre, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics. *See* EX1004, 1:2-5; EX1021, 103. Also, as mentioned above, this is confirmed by Sudre, which states “a papermaker's fabric meeting the particular requirements of its intended end use as regards performance

characteristics can be produced from that base fabric *in a simple and ready manner.*” EX1004, 6:14-17.

(a) Motivation for implementation of warp thread size

81. For the reasons discussed above, a skilled person looking for specific parameter details, such as warp thread size, for Sudre’s fabric would have been highly motivated to seek that information from other well-known references such as Adanur. For example, as shown below, one of the images of Figure 3.15 allows for multiple measurements of machine direction, loop forming thread diameters to be taken. Specifically, seven machine direction loop forming threads can be seen in cross-section in the upper portion of Figure 3.15, shown below. A measurement of thread diameters of the loop forming threads from both images of Figure 3.15 shows a similar pixel count, indicating the scale shown in the other Fig. 3.15 image is likely the same for both images. Seven threads that represent loop threads are shown in this figure. It should be noted that this fabric has been calendared and needle punched, which has slightly deformed the cross-sectional shape of the machine direction threads.



Excerpt from Adanur, Fig. 3.15

82.I traced the thread cross-sections, and measured diameters in the longitudinal and transverse directions for each of the MD threads in the above figures. By doing this, and in conjunction with the scale bar of the other Fig. 3.15 image, I determined that the average diameter of the MD thread is 0.32 mm.

83.By looking at references like Adanur and employing a technique similar to mine, a POSITA would have been motivated to measure and implement, for example, warp threads with a diameter of about 0.32 mm, as taught by Adanur's Fig. 3.15, in a clothing or felt seam that "meet[s] the *particular requirements of its intended end.*" EX1004, 6:14-17. As I explain in further detail below, there would have been multiple reasons to, for example, measure and implement warp threads with a diameter of about 0.32 mm, as taught by Adanur's Fig. 3.15.

- 84.First, the example shown in Fig. 3.15 of Adanur is a scanning electron microscopy (SEM) image of an “actual finished press fabrics” for paper machine clothing that has round warp threads with a diameter of about 0.32 mm. As I have explained above, it would have been relatively easy for a skilled artisan to measure the measurement scale and the MD threads in Fig. 3.15 and determine that the diameter of the MD threads is approximately 0.32 mm. EX1021. One skilled in the art would have been motivated to use warp thread dimensions shown in Adanur and implement those dimensions in Sudre’s fabric because Adanur’s disclosure represents “the *industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics*” and to achieve a clothing or felt seam that will “meet the *particular requirements of its intended end.*” EX1022; see EX1016, 6:8-23, 6:59-64; EX1005, 12 (1st paragraph).
- 85.Second, Adanur teaches using warp threads sizes that are within a range that other known prior art, such as Lee, describe as bring “sufficiently robust so as to withstand the various mechanical and environmental forces to which they may be exposed during use.” EX1005, 26 (2nd paragraph). Based on this information, the advantages of using Adanur’s size of thread to achieve mechanically robust fabrics would have been known to a skilled person.

86. Third, using warp threads in a specified range of dimensions in a papermaker's fabric, based on the warp threads sized taught by Adanur, is merely an application of known techniques to a known system to yield predictable results (papermaker's fabric with a warp thread size in a known range).

87. A skilled person in the art would have expected success in applying the warp threads dimensioned based on Adanur's Figure 3.15 at least because, as noted above, these dimensions were being used for warp threads in "actual finished press fabrics" for papermachine clothing. EX1021, 111. This signifies that Adanur's threads were already in the public domain. Also, it is important to note that Sudre does not provide any reason to deviate from a usage of warp threads of standard size, as described by Adanur. *Id.*

(b) Motivation for implementation of warp thread density

88. For reasons similar to those that I have discussed above, a POSITA would have looked for specific parameter details, such as warp thread density, that are not provided by Sudre in other references. Specifically, the POSITA would have been motivated to look for such information from well-known references, such as Adanur. In doing so, a skilled person in the art would have been motivated to apply a warp thread density of about 13.3 threads/cm, as described by Adanur, in combination with the MD thread

diameter of Adanur's fabric for at least the following reasons that I provide in subsequent sections below.

89. Based on the image of Figure 3.15 shown below, as discussed earlier, it can be readily determined that the average diameter of the warp threads is about 0.32 mm. EX1021, 111. Additionally, it can also be readily determined that the distance occupied by six of these threads is about 4.52 mm, which gives a thread density of about 13.3 threads/cm and a loop density of approximately:

$$\frac{2 \times 6 \times 0.32 \text{ mm}}{4.52 \text{ mm}} = 85\%$$

90. When applying the warp thread density and MD thread diameter, as described by Adanur, the POSITA would form a fabric that has necessary structural parameters that corresponds to a loop density of approximately 85%, as I will later discuss further in element [1.4].

91. First, Adanur's Fig. 3.15 images demonstrate that "actual finished press fabrics" for papermachine clothing had a warp thread density of about 13.3 threads/cm (and a loop density of approximately 85%). EX1021, 111. It would have been relatively easy for a POSITA to measure the measurement scale and the diameters of the MD threads in Fig. 3.15. *Id.*. Since the '566 Patent states that "[w]hen determining the seam loop density, firstly the

number of seam loops per unit length is ascertained,” where “the seam area has twice the number” of the “MD thread density ... as a result of the MD threads of the two ends interengaging. If the number of threads is multiplied by the diameter, then the seam loop density (statement in percent) is obtained,” it can be determined that the warp thread density of Adanur’s fabric was about 13.3 threads/cm and, together with the diameter of about 0.32 mm, corresponded to a loop density of approximately 85%. EX1001, 6:11-18. Accordingly, a POSITA would have been motivated to use warp thread density and loop density based on Adanur in a fabric such as Sudre’s to meet the “particular requirements” associated with “finished press fabrics.” EX1016, 6:8-23, 6:59-64; EX1005, 12 (1st paragraph).

92.Second, the warp thread density provided by Adanur’s Fig 3.15 and, thus, the corresponding loop density advantageously “present[s] an ‘open’ structure to the PS [paper side] surface of the press felt to maximize water removal, permeability and void volume in the completed press felt,” according to other known references such as Lee. EX1005, 26 (2nd paragraph). Water removal, permeability, and void volume of papermachine clothing are parameters that are important for efficient manufacture of high-quality paper products.

- 93.Third, the warp thread density provided by Adanur's Fig 3.15 and, thus again, the corresponding loop density "allow the two sets of loops from the opposing ends of the fabric to be capable of being intermeshed without any undue distortion," according to references such as Lee. EX1005, 26 (2nd paragraph). This allows the formation of a high-quality seam. *Id.* Adanur's warp thread and loop density provide parameters for papermachine clothing with low-profile seams that yield high-quality paper products without artifacts that would be caused from distortions in the seam.
- 94.Fourth, the warp thread density and corresponding loop density disclosed by Adanur, according to Lee, offer the benefit of "provid[ing] the necessary seam tensile strength to the assembled press felt." EX1005, 26 (2nd paragraph).
- 95.Fifth, a POSITA would have been motivated to implement the combination fabric to have a warp thread density and corresponding loop density based on the teachings of Adanur because this applies known methods to a known system to yield predictable results. In other words, a skilled artisan would have been motivated to provide warp threads/loops in a specified range of densities in the context of papermachine clothing (known method) to a papermaker's fabric (known product) to yield a papermaker's fabric with a

warp thread density and corresponding loop density in a known range (predicted results).

96. One would have expected success in implementing Adanur's warp thread density and corresponding loop density because Adanur, like Sudre, pertains to papermachine clothing, and, in particular, to seamable press felts made from flat woven base fabrics, as discussed *supra*. EX1004, 3:13-18. Also, Sudre does not restrict its weave configuration or warp thread density, nor does it indicate any incompatibility with the teachings of Adanur. *Id.*

(c) Motivation for implementation of loop size based on Adanur's teachings

97. For reasons similar to those discussed above, a POSITA seeking specific parameter details, such as loop size, that are not disclosed from references, like Sudre, would have been motivated to similarly seek such information from well-known references, such as Adanur. In particular, a skilled person would have been motivated to implement the combination fabric to have seam loops with a diameter of about 0.96 mm, as taught by Adanur for at least the reasons that I have provided in the sections below. A fabric to have seam loops with a diameter of about 0.96 mm, in combination with the MD thread diameter of Adanur's fabric, would yield a clothing having a ratio of loop diameter to MD thread diameter of approximately 3.0, as I discuss later in greater detail in element [1.5].

- 98.First, Adanur's loop size and the corresponding ratio of loop diameter to MD thread diameter in Fig. 3.15 represents "actual finished press fabrics" for papermachine clothing. EX1021, 111. Also, it would have been easily ascertainable that such fabrics had a seam loop diameter of about 0.96 mm and the diameter (LD) of the seam loops and the diameter (MDYD) of the associated MD threads has a ratio (i.e., ratio LD / MDYD) of about 3.0. Accordingly, a POSITA would have been motivated to use Adanur's loop ratio in Sudre's fabric consistent with a standard practice, *e.g.*, for compatibility with standard weaving processes and other manufacturing techniques. Also, Adanur's disclosure represents "the **industry standard for papermakers**" and "for manufacturing of forming, pressing and drying fabrics." EX1022. Notably, a loop/MD thread diameter ratio of about 3.0 is consistent with other indications of conventional dimension for papermachine clothing. *See* EX1017, 2:19-36. For instance, this is because loops that are too large can lead to an oversized seam that can cause formation of artifacts in the resulting paper products, while loops that are too small can lead to excessive strain on the threads, potentially resulting in failure.
- 99.Second, Adanur's loop size was consistent with conventional seam loop sizes for papermachine clothing disclosed by other known prior art

references (e.g., Penven discloses 50 mils, which is about 1.27 mm). *See* EX1006, 3:64-66 (“a typical seam in a papermaker’s fabric having an internal void diameter of about 50 mils”). Another motivation factor would have been that a standard seam loop size would be compatible with conventionally sized pintles.

100. Third, seam loops sized to match the pintle size form a low-profile seam that allows for manufacture of high-quality, defect-free paper products. Indeed, “any irregularity in the supporting fabrics can cause corresponding irregularities in the paper sheet, including marking, reducing the quality of the eventual finished sheet,” and to promote uniformity, “the pintle [should] ... have the minimum clearance with the insides of the interdigitated loops.” EX1008, 2:7-19; *see* EX1007, Abstract (“The pintle is configured to substantially fill the voids in the fabric loops when inserted so that a smoother seam is achieved that significantly reduces marks on the resultant paper”).

101. Fourth, a POSITA would have been motivated to implement seam loops (and ratio of seam loop diameter to MD thread diameter) dimensioned based on the teachings of Adanur because doing so is merely the application of known techniques to a known system to yield predictable results. In other words, a POSITA would have been motivated to implement seam loops and

its corresponding ratio of seam loop diameter to MD thread diameter dimensioned based on the teachings of Adanur because doing so would merely apply seam loops of a specified dimension in a specified ratio with the diameter of the MD threads to a papermaker's fabric, based on the teachings of Sudre, to yield a papermaker's fabric with seam loops of a specified size and with a specified size ratio.

102. A skilled person would have expected success in dimensioning the seam loops and a corresponding loop ratio based on the teachings of Adanur at least because, as noted above, these dimensions were conventional for papermachine clothing seam loops, and thus the implementation, and its compatibility with standard pintles, was well-developed. Moreover, Sudre describes no reasons for why its seam loops or pindle cannot use seam loops of standard size. *Id.*

(d) Motivation for incorporation of warp threads with a round cross-section

103. A POSITA would have been motivated to incorporate warp threads with a round cross-section, as taught by Adanur, in the combination fabric for at least the following reasons.

104. First, threads with a round cross-section are commonly used as warp threads in papermachine clothing, and a POSITA would have been

motivated to use round warp threads in the combination fabric consistent with that standard practice.

105. Second, threads with a round cross-section are less expensive than threads with cross-sections of other shapes, and thus a POSITA would have been motivated to incorporate round threads for economic reasons.

106. Third, yarns with a round cross-section have more uniform properties and higher strength than filaments with more complex shapes, and a POSITA would have recognized the advantages of using uniform, robust yarns, *e.g.*, in forming durable papermachine clothing. *See* EX1026, Abstract (“round, tetra and octolobal cross-sectional shapes lead to production of yarn with high tenacity and breaking elongation”), 151 (“Good features such as high tenacity, high breaking elongation and low unevenness were obtained with round cross-sectional shaped yarns”).

107. Fourth, threads with a round cross-section are less likely than threads of other cross-sectional shapes to be adversely affected by twisting that can occur during weaving. Often, warp yarns twist over the long length of a loom during the weaving process. If the yarn has a non-round cross-section, these twists can lead to local changes in thickness of the papermachine clothing, causing irregularities in the clothing surface that can lead to imperfections in the paper that is produced using such papermachine

clothing. However, twisting in yarns with a circular cross-section does not create a significant change in thickness, and thus quality of the resulting paper products can be maintained. A POSITA would have been motivated to use round warp threads to reduce the likelihood of a twisting-related impact on the texture of the papermachine clothing, thereby facilitating the manufacture of higher quality paper. *Id.*

108. Fourth, a POSITA would have been motivated to implement warp threads with a round cross-section in the combination fabric because doing so is merely the application of known techniques (warp threads with a round cross-section in the context of papermachine clothing) to a known system (a papermaker's fabric such as that taught by Sudre) to yield predictable results (papermaker's fabric with round warp threads).

109. A POSITA would have expected success in incorporating warp threads with a round cross-section in the combination at least because, as noted *supra*, threads with a round cross-section were commonly used as warp threads in papermachine clothing, and thus the usage and implementation of such threads was well-developed. Indeed, Sudre imposes no requirements on its warp threads that would indicate any reason to deviate from the usage of standard, round threads. *Id.*

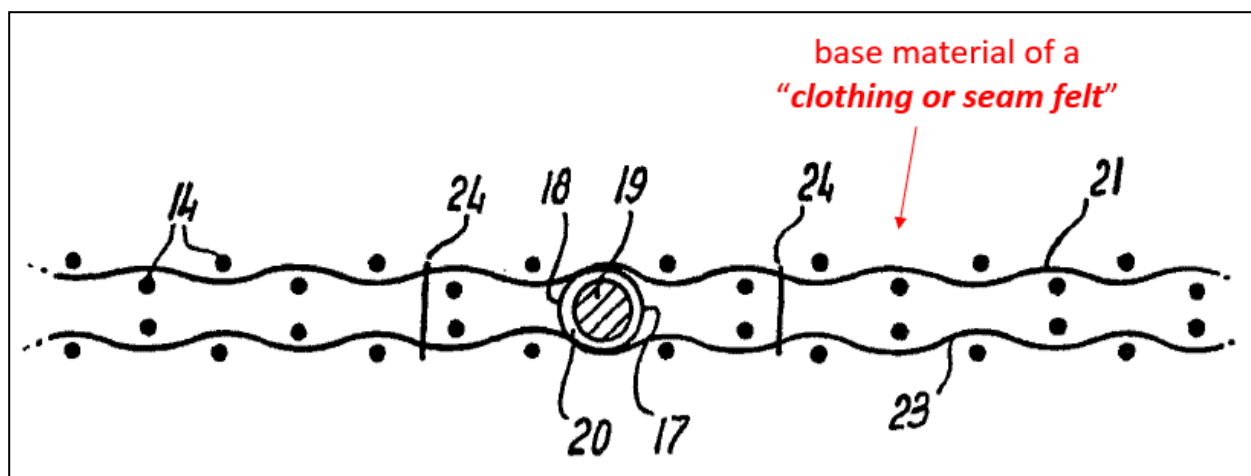
5. *Analysis*

(a) Claim 1

[1.0] A clothing or a seam felt for a machine for producing a fibrous material, paper, board, tissue or pulp web, comprising:

110. The preamble is obvious based on the combination of Sudre and Adanur. For example, Sudre describes “a papermaker’s wet felt,” *i.e.*, “papermachine clothing” (***a clothing or seam felt***)². EX1004, 3:13-18. Sudre also describes in Figs. 1-3 (Fig. 3 *infra*) “successive stages in the production of an endless base material for use in a papermaker’s fabric.” *Id.*, 2:25-3:2; *see* 1:2-5 (“The invention concerns papermaker’s fabrics and has more particular reference to a method for the manufacture of a seamed endless structure for use as papermachine clothing or as a base material therein”), Abstract (“A method for the manufacture of a papermaker’s fabric”), 1:22-24, 2:18-19, 5:8, claim 1.

² Throughout this Petition, claim elements are indicated in boldface and italics.



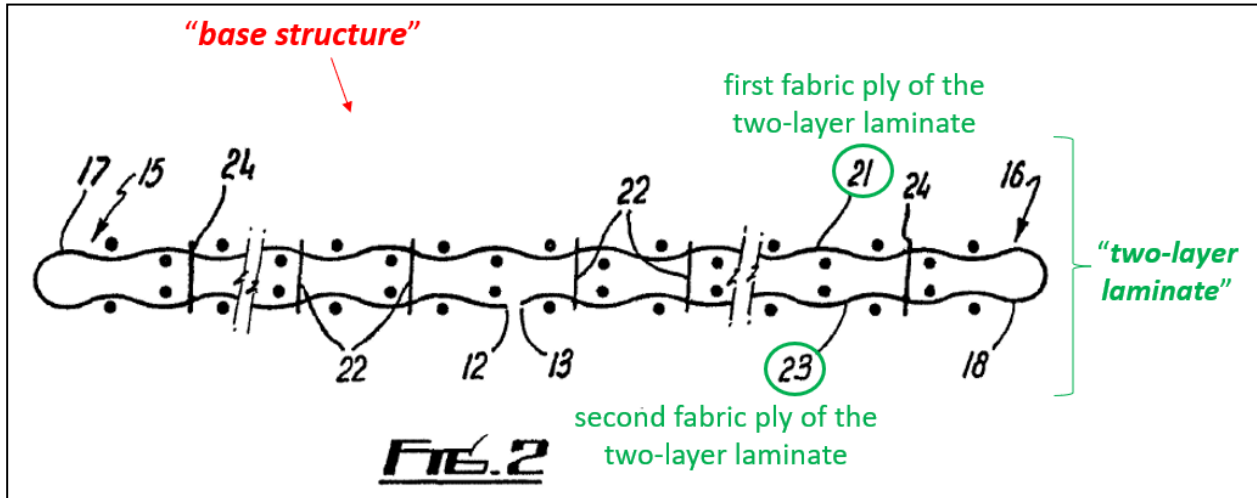
Sudre, Fig. 3 (annotated)

111. Papermaker's fabrics are used in papermaking machines for manufacture of paper products (*for a machine for producing a fibrous material, paper, board, tissue or pulp web*). See EX1021, 103; EX1013, [0002].

[1.1] a base structure including a two-layer laminate structure formed of one or a plurality of flat-woven fabrics, said base structure having two end sides;

112. Based on the teachings of Sudre and Adanur, the combination clothing includes “a base material for use in the manufacture of a papermaker's wet felt” (*a base structure*). EX1004, 3:13-15; see 1:22-26, 2:25-3:2 (“an endless base material for use in a papermaker's fabric”), 3:9-11 (“the seam region of base fabrics”), 5:20-21 (“a base structure for combination with a textile batt in the manufacture of a wet end fabric”), 5:23-25 (“a two-ply papermaker's fabric comprising a flat-woven ... structure brought into endless form”), 6:11-17, Abstract, claim 1. As shown

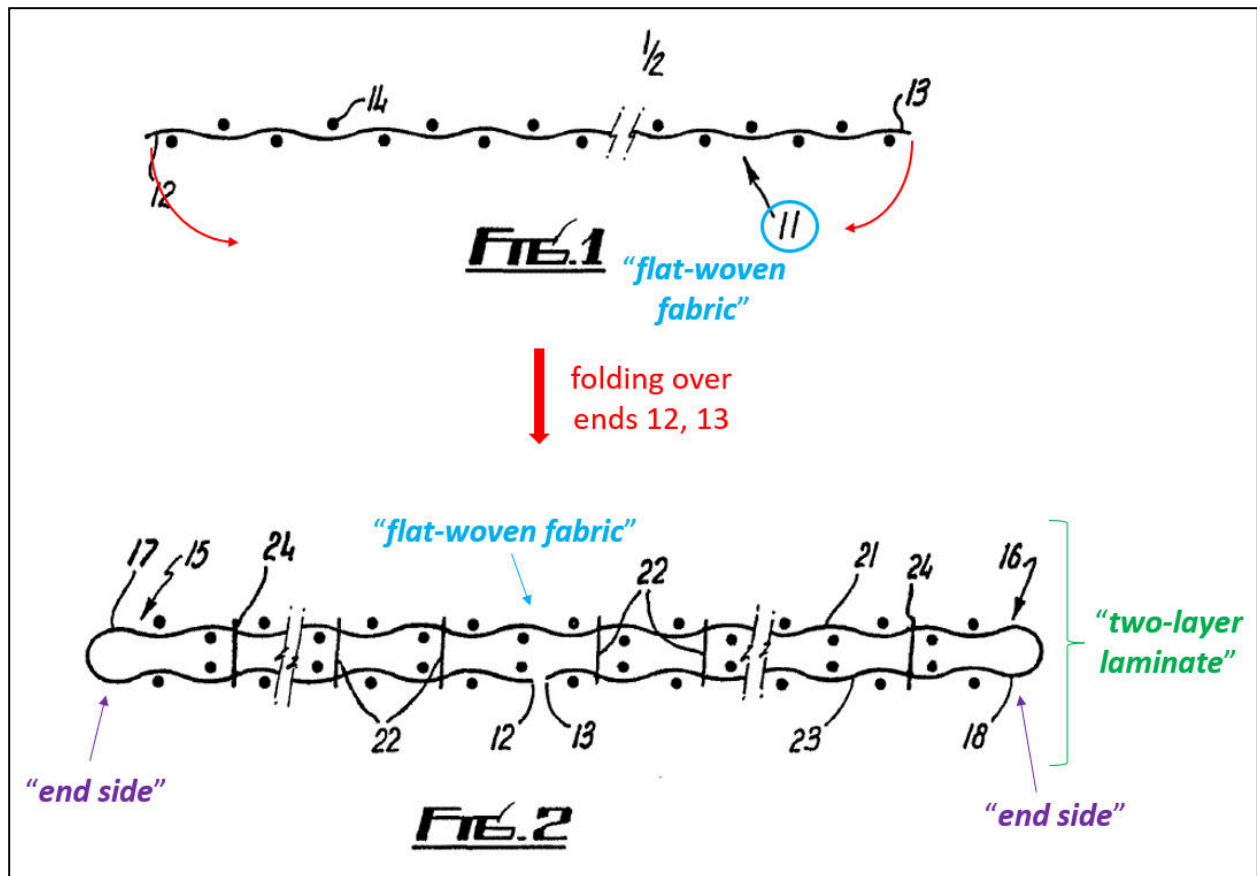
in Fig. 2 below, the base material in the proposed combination is depicted in red. Fig. 2 provides one “stage[] in the production of an endless base material for use in a papermaker’s fabric,” e.g., the base material of Fig. 3. EX1004, 2:25-3:2.



Sudre, Fig. 2 (annotated)

113. Sudre describes that the “base material ... comprises a flat-woven fabric 11,” the ends of which “are folded over to define a two-ply structure” (*base structure including a two-layer laminate structure*), which is depicted in green font in Fig. 2 (above). EX1004, 3:18-19; *see* 1:25-2:1 (“providing a fabric of plural, superimposed layer configuration throughout substantially the full longitudinal extent thereof”), 2:5-6 (“the superimposed fabric layers are two in number”), Abstract (“a multiply fabric”), claim 1, claim 3. As shown in Fig. 2, the two-ply structure includes “two fabric plies 21, 23.” EX1004, 4:4.

114. As shown below, the “two-ply structure” is made by “fold[ing] over” the “free ends 12, 13” of “a flat-woven fabric 11 of open weave construction” such that “the free ends [are] brought into substantial abutment” (*two-layer laminate structure formed of one ... flat-woven fabric[]*). EX1004, 3:14-19, Figs. 1-2; *see* 2:25-3:2 (“Figs. 1 to 3 respectively show successive stages in the production of an endless base material ... comprising a flat-woven single layer structure”), claim 5 (“bringing a flat-woven structure into plural layer configuration to define fold regions at the respective opposite ends thereof”), 4:2-3. As an example, the single layer flat-woven fabric 11 (*flat-woven fabric*), which is depicted in blue in Fig. 1 (below), is folded (as indicated by the red arrows *infra*). *See* EX1004, 4:2-7. This folding forms the “two-ply structure” (*two-layer laminate structure*) of Fig 2. *Id.* Some parts of the flat-woven fabric makes up a first ply of the two-layer laminate structure (*e.g.*, fabric ply 21) and other remaining portion of the flat-woven fabric makes up a second ply of the two-layer laminate structure (*e.g.*, fabric ply 23). *Id.*



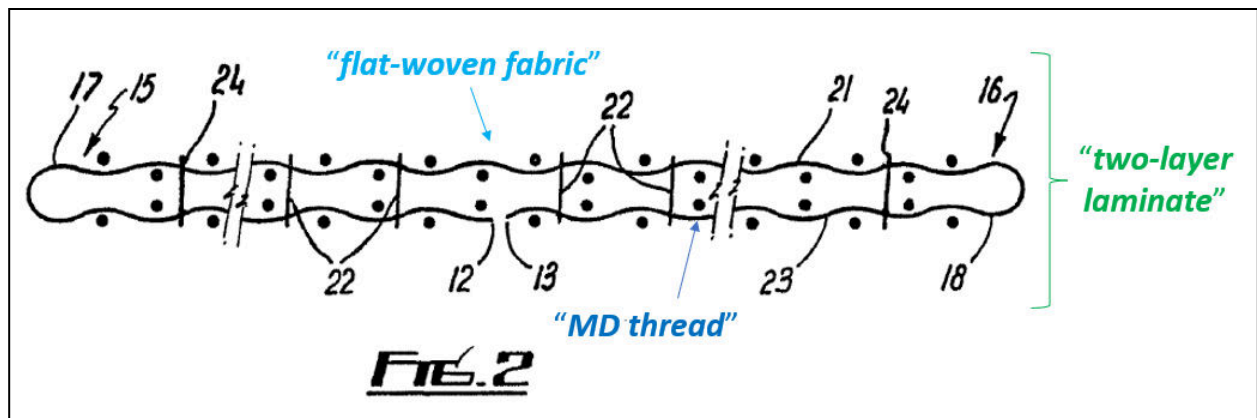
Sudre, Figs. 1-2 (annotated)

115. As shown above in Fig. 2, Sudre explains that “two-ply structure [has] fold regions 15, 16” (*end sides*), depicted in purple, at its two opposite ends (*said base structure having two end sides*). EX1004, 3:18-19; *see* 1:25-2:2 (“providing a fabric of plural, superimposed layer configuration throughout substantially the full longitudinal extent thereof and having fold regions at the respective opposite ends thereof”), claim 5 (“bringing a flat-woven structure into plural layer configuration to define fold regions at the respective opposite ends thereof”), claim 1.

[1.2] said laminate structure having MD threads being monofilaments with a round cross section forming seam loops at said two end sides of said base structure, said seam loops interconnecting said two layers of said laminate structure, said seam loops having a diameter LD and said associated MD threads having a diameter MDYD;

MD threads in the combination

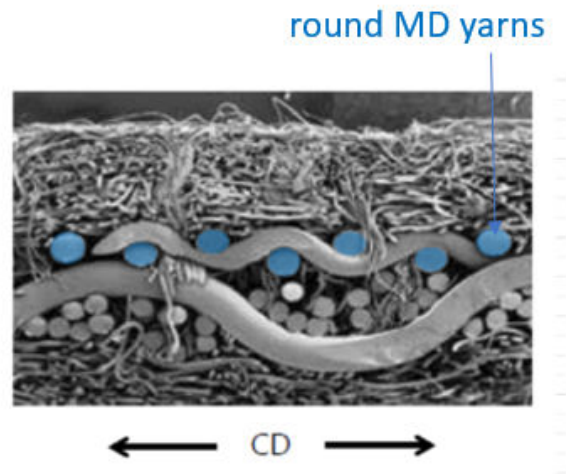
116. Based on the teachings of Sudre and Adanur, the flat-woven fabric of the combination laminate structure includes “warp yarns” that “extend in the machine direction of the eventual papermaker’s fabric.” EX1004, 1:10-12. These warp yarns, one of which is associated with dark blue annotations in Fig. 2, *infra*, extend in a machine direction and therefore correspond to **MD threads**.



Excerpt from Sudre, Fig. 2 (annotated)

117. Sudre describes that “such machine direction yarns will ordinarily comprise monofilament yarns” (**MD threads being monofilaments**). EX1004, 4:23-25.

118. As I have also discussed above (§IV.A.3-4, *supra*) and based on the teachings of Adanur and as illustrated in Fig. 3.15 (below), the monofilament MD threads in the combination have a round cross section (*MD threads being monofilaments with a round cross section*). See EX1021, Fig. 3.15 (*infra*).

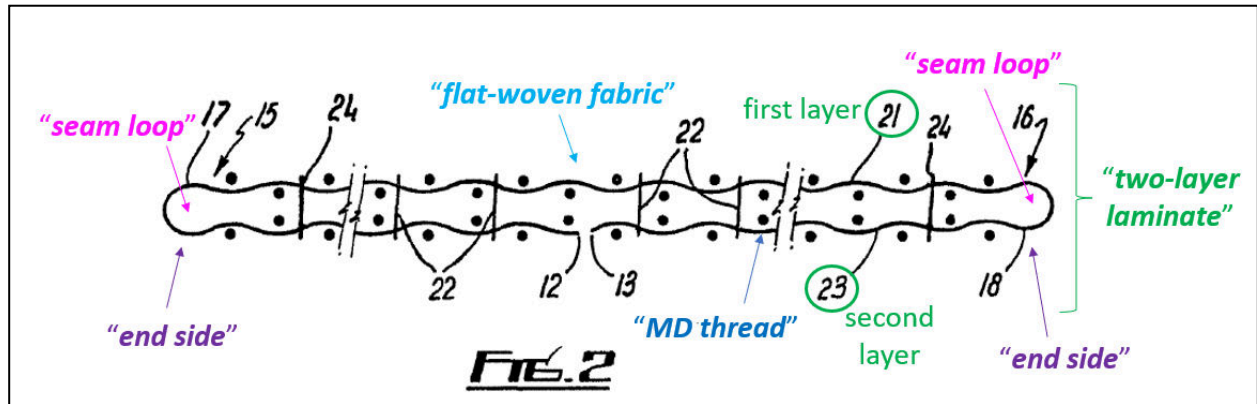


Adanur, Fig. 3.15 (annotated)

Seam loops in the combination

119. In the combination of Sudre and Adanur, Sudre describes that “[w]eft yarns 14 are removed from the fold regions 15, 16 ... to give loops 17, 18 extending outwardly therefrom” (*seam loops at said two end sides of said base structure*). EX1004, 3:22-24. That is, the loops (*seam loop*) are formed at the fold regions (*end sides*; see [1.1], *supra*). See EX1004, Abstract (“removal of cross-machine direction yarns (14) in such fold

regions thereby to create seam-forming loops (17, 18)”). I have marked these seam loops in pink in Fig. 2, reproduced and annotated below.

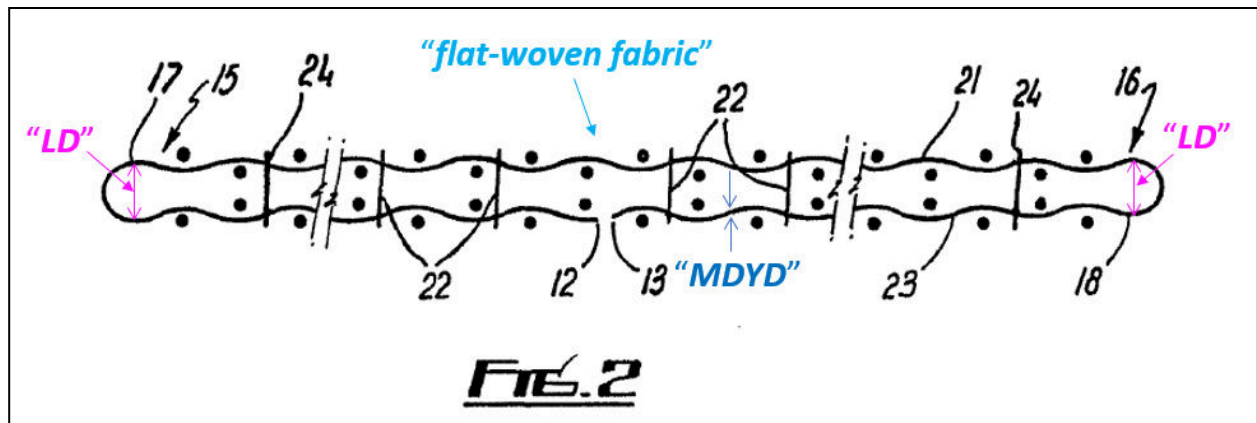


Excerpt from Sudre, Fig. 2 (annotated)

120. As I discussed above, and as was conventional for seamable press felts, the seam loops are formed by the MD threads: “In the event that the machine direction yarns are to form loops at the respective fabric ends for interdigitation and receipt of a pintle wire” (*MD threads ... forming seam loops*). *Id.*, 4:21-23; see 2:2-4 (“removing cross-machine direction yarns from said fold regions to leave machine-direction loops thereat”), claim 1 (“removing cross-machine direction yarns from said fold regions to leave machine-direction loops thereat”), claim 5 (“bringing a flat-woven structure into plural layer configuration to define fold regions at the respective opposite ends thereof and removing cross-machine direction yarns from said fold regions to form loops thereat”). That is, the seam loops are formed of

MD threads that extend from the first layer to the second layer of the laminate structure, thus interconnecting the two layers. See EX1004, Fig. 2.

121. The inside diameter of the seam loops (*said seam loops having a diameter LD*), which I have indicated in Sudre's Fig. 2, reproduced below, is based on the teachings of Adanur. See EX1021, Fig. 3.15. I discuss this further in element [1.5]. The MD threads that form the seam loops have a diameter (*associated MD threads having a diameter MDYD*), also indicated in Fig. 2, that is also based on the teachings of Adanur, as discussed in [1.4], *infra*. See EX1021, Fig. 3.15.



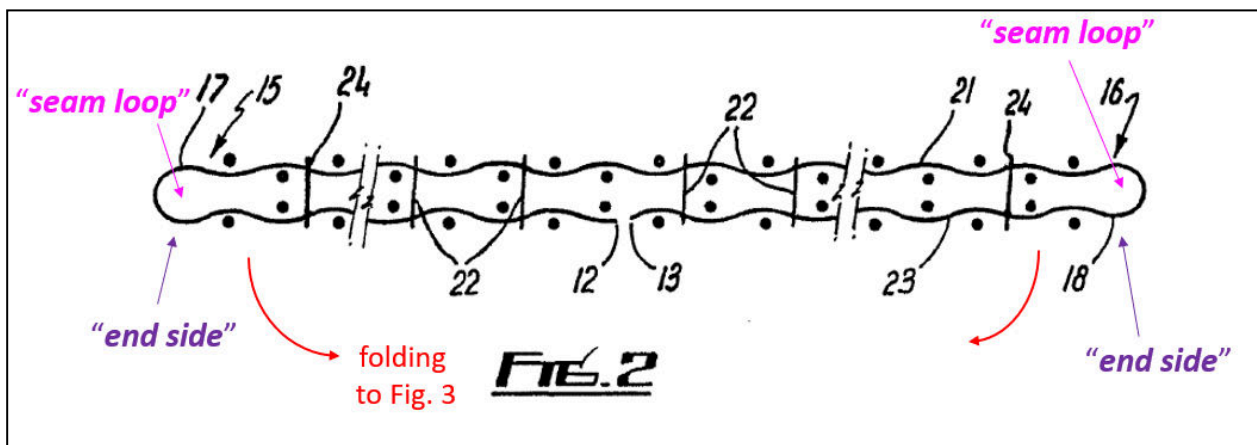
Excerpt from Sudre, Fig. 2 (annotated)

[1.3] a seam interconnecting said end sides to make the clothing endless, said seam being formed by interengaging said seam loops of said two end sides and an insertion of an insertion element;

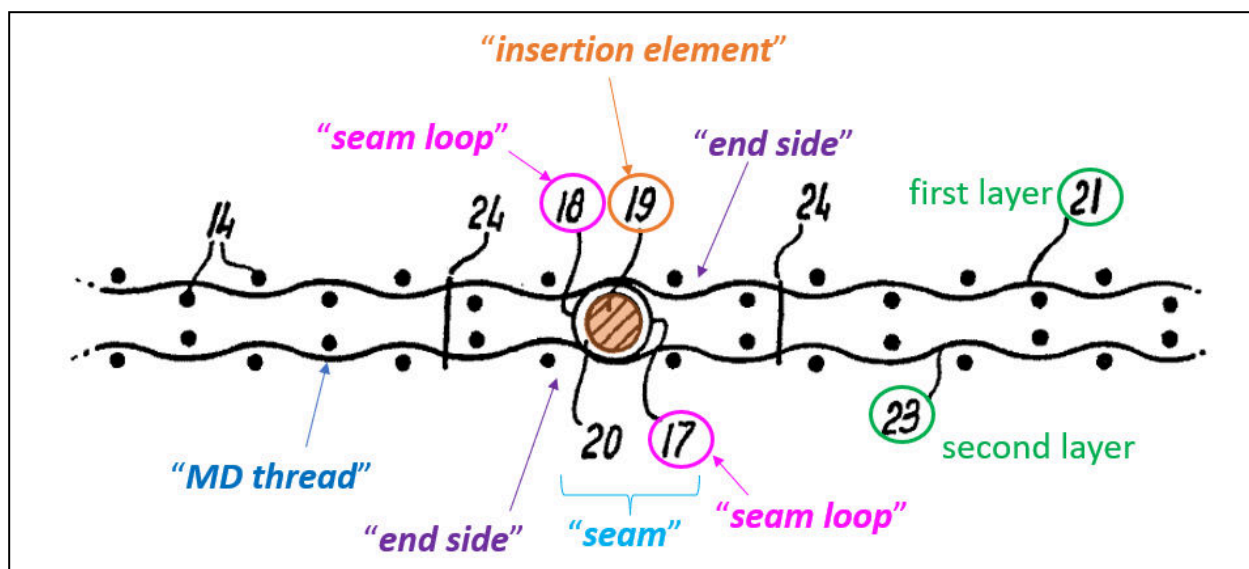
122. Based on the teachings of Sudre and Adanur, in the combination, “the two-ply structure” (*i.e.*, the two-layer laminate base structure; *see* [1.1], *supra*) of Sudre's Fig. 2 is “brought into endless form by the interdigitation

of such loops” (*interengaging said seam loops of said two end sides*).

EX1004, 3:24-26, Fig. 3, *infra*. In other words, Sudre’s two-ply structure is folded, as depicted by the red arrows in Fig. 2. As I shown in Fig. 3 (below), the folding allows the loops at the fold region 15 (*end side*) to interdigitate with the mating loops at the fold region 16 (*end side*). See EX1004, Abstract, 1:14-18, 2:13-17, 3:9-10.



Sudre, Fig. 2 (annotated)

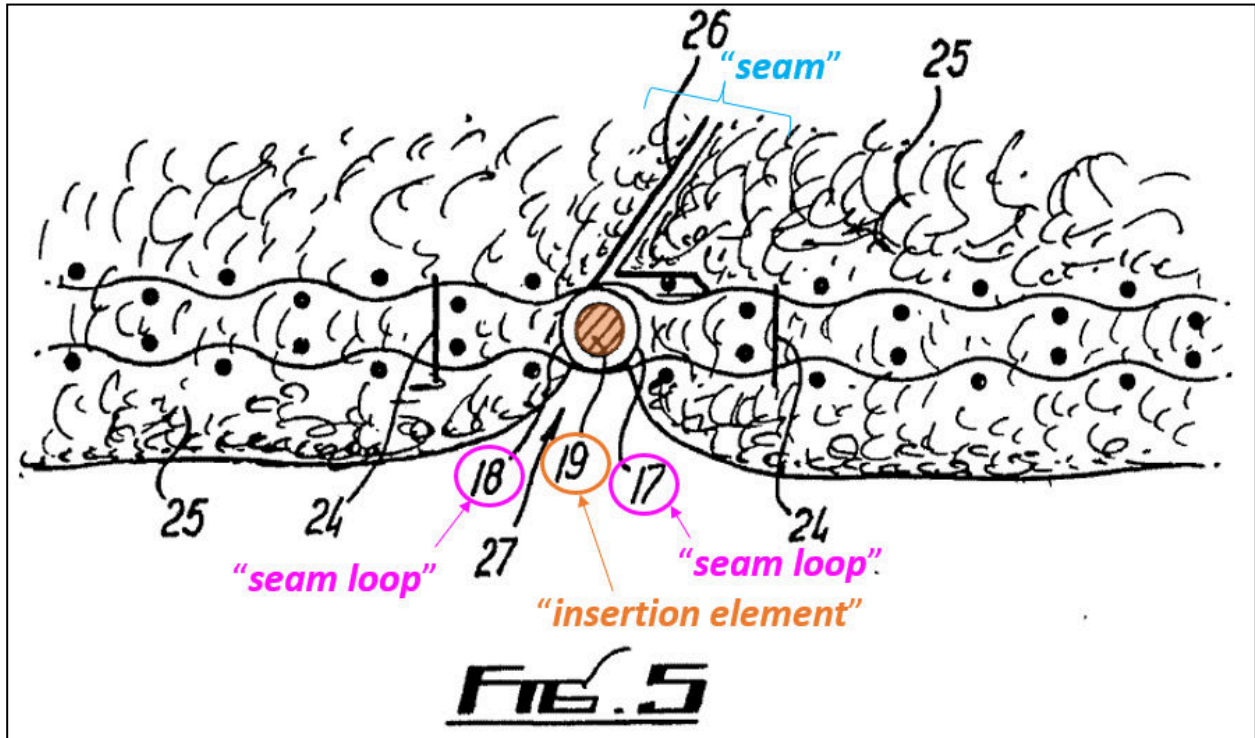


Sudre, Fig. 3 (annotated)

123. Also, Sudre describes “the introduction of a pintle wire 19 into the tunnel 20 formed thereby” (*insertion of an insertion element*). EX1004, 3:26-4:1. As I have depicted in orange in Fig. 3 (above), the pintle wire corresponds to an *insertion element* that is positioned into the tunnel formed by the interengaging loops. See EX1004, 4:21-24 (“In the event that the machine direction yarns are to form loops at the respective fabric ends for interdigitation and receipt of a pintle wire”), Abstract, 1:14-18.

124. A seam is formed by loop interdigitation and the pintle wire insertion: “The loops (17, 18) may be interdigitated directly to receive a pintle wire into engagement and thus form a seam” (*said seam being formed by interengaging said seam loops ... and an insertion of an insertion element*), blue in Fig. 3 (*supra*) and Fig. 5 (*infra*). EX1004, Abstract; see

2:13-17 (“The loops of the respective fold regions may be brought into mutual interdigitated relationship directly to receive a pintle wire in the tunnel formed thereby, thus to form a seam”), 3:9-10 (“Fig. 5 shows the seam region of base fabrics of the kind shown in Figs. 1 to 3”), 1:14-18.



Excerpt from Sudre, Fig. 5 (annotated)

125. Furthermore, the seam functions to *interconnect said end sides* when the loops of the two end sides become interdigitated. See EX1004, Abstract, 2:13-17. Alternatively/additionally, the seam *interconnects said end sides* in that positioning of pintle wire binds the loops and the two end sides together. See EX1004, Abstract, 2:13-17.

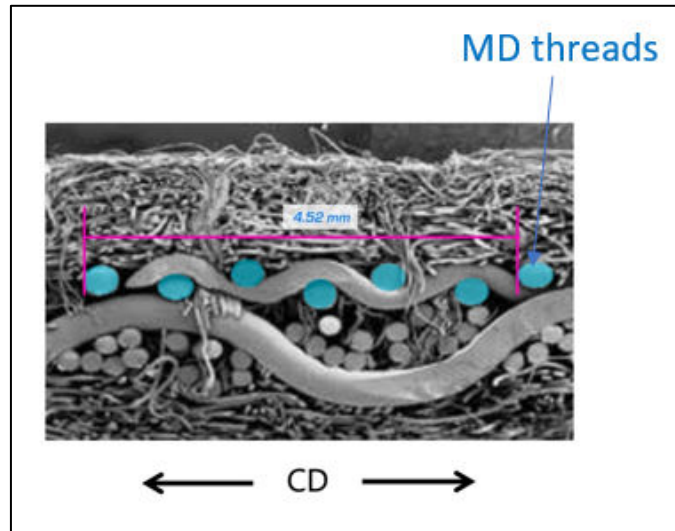
126. As a result, the formed seamed fabric is *endless*, e.g., in that the connection of one end side to the other at the seam forms the clothing into a continuous loop. See EX1004, 2:26-3:1 (“an endless base material for use in a papermaker’s fabric”), 1:3-4 (“a method for the manufacture of a seamed endless structure for use as papermachine clothing”), 2:12 (“endless base material”), 5:9-10. Sudre describes the formation of the seam: “the two-ply structure being brought into endless form by the interdigitation of such loops and the introduction of a pintle wire.” EX1004, 3:24-26.

[1.4] said seam having a loop density of between 64% and 90%; and

127. Based on the teachings of Sudre and Adanur, the loop density of the combination clothing includes dimensional parameters described by Adanur. In particular, the loop density is implemented based on Adanur’s MD thread density and the diameter of the MD threads in the combination fabric. See EX1001, 6:11-18.

128. As I explained earlier in my declaration, measurements can be taken from Adanur’s exemplary “actual finished press fabrics” shown in FIG. 315 to show that these exemplary base fabrics, which existed before the ’566 Patent’s Critical Date, had MD threads with a diameter of about 0.32 mm. The MD thread diameter was determined by measuring radii in the longitudinal and transverse directions of each of the highlighted MD threads,

yielding an average diameter of 0.32 mm and a standard deviation of 0.04 mm. EX1021, 111. This MD thread diameter is implemented in the combination fabric.



Adanur, Fig. 3.15 (annotated)

129. In the combination fabric, a MD thread density based on Adanur's "actual finished press fabrics" is applied. EX1021, 111. As shown in the figure above, six MD threads in Adanur's fabric span a distance of about 4.52 mm. Based on the span distance and the number of threads, the MD thread density is calculated to be about 13.3 threads/cm.

130. The loop density is calculated by multiplying twice the thread density times the MD thread diameter, consistent with the '566 Patent. See EX1001, 6:11-18. In the combination, the fabric (with 13.3 MD threads/cm and 0.32

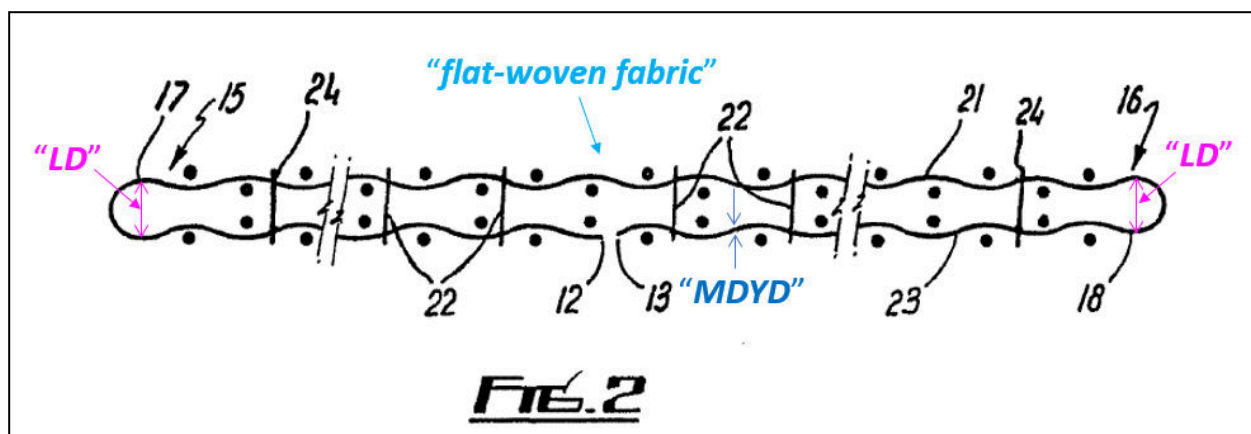
mm diameter MD threads based on Adanur) has a loop density of approximately 85%.

131. This loop density (85%) falls within the claimed loop density range (*said seam having a loop density of between 64% and 90%*).

132. The '566 Patent states that “the seam loop density of a clothing can change during the production process,” and “thermal method steps can lead to shrinkage of the clothing in the transverse direction.” EX1001, 6:27-30. The '566 Patent also specifies that “[t]he values of the seam loop density indicated in this application relate to the finished clothing, if not otherwise specified.” *Id.*, 6:33-35. The loop density, which I discussed above, is based on dimensions associated with an “actual finished press fabric[],” which a POSITA would have recognized as depicting a press felt after completion of all relevant fabrication processing, and thus after any thermal treatment. EX1021, 111.

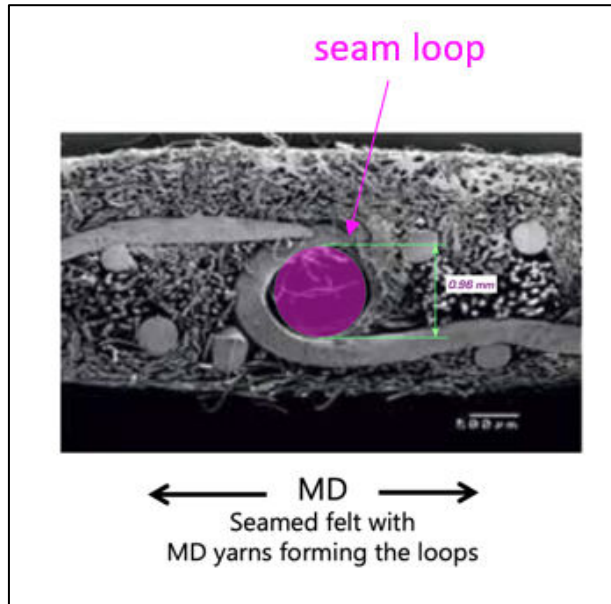
[1.5] said diameter LD of said seam loops and said diameter MDYD of said associated MD threads having a ratio LD/MDYD of between 2.7 and 3.6.

133. As I have shown and depicted in Sudre’s Fig. 2 (below), the inside diameter of the seam loops (*said diameter LD of said seam loops*) and the diameter of the MD threads that form the seam loops (*said diameter MDYD of said associated MD threads*).



Excerpt from Sudre, Fig. 2 (annotated)

134. As I have discussed above, measurements of Adanur’s exemplary “actual finished press fabrics” can be readily taken to show that these exemplary base fabrics, which existed before the ’566 Patent’s Critical Date, had seam loops with a diameter of about 0.96 mm. The loop diameter was measured based on the disclosure of the ’566 Patent, which states that “To determine the diameter of a seam loop, the largest circle which can be inserted completely into the seam loop is ascertained. The diameter of this circle is then viewed as the diameter of the seam loop.” EX1001, 2:46-49. EX1021, 111. This seam loop diameter is implemented in the combination fabric.



135. Since the combination fabric has an MD thread diameter MDYD of about 0.32 mm (*see* [1.4], *supra*) and a seam loop diameter LD of about 0.96 mm, and therefore has a ***ratio LD/MDYD*** of 0.96 mm/0.32 mm, *i.e.*, about 3.0. *See* EX1021, Fig. 3.15.

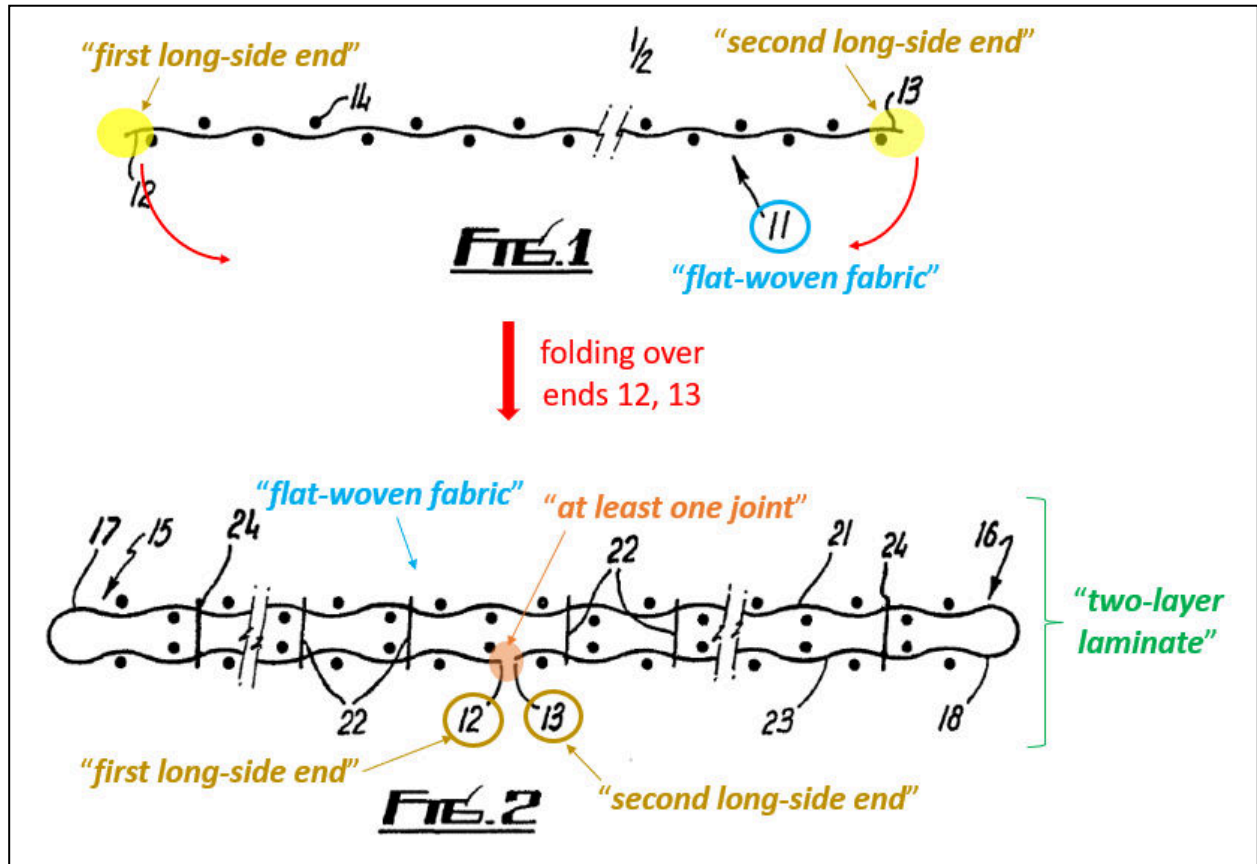
136. This ratio (3.0) falls within the recited range of ratios (***a ratio LD/MDYD of between 2.7 and 3.6***).

(b) Claim 3

[3.0] The clothing according to claim 1, wherein each of said flat-woven fabrics has a first and a second long-side end, said two-layer laminate structure has at least one joint at which two of said long-side ends are interconnected, and said interconnected long-side ends belong to an identical flat-woven fabric or to different flat-woven fabrics.

137. In the Sudre-Adanur combination, Sudre’s “flat-woven fabric 11” (***said flat-woven fabric[]***) has “free ends 12, 13” (***a first and a second long-***

side end), which I have indicated in yellow in Fig. 1, below. EX1004, 3:14-18.



Excerpt from Sudre, Figs. 1 and 2 (annotated)

138. Sudre describes that “[t]he free ends are folded over to define a two-ply structure” (*said two-layer laminate structure*) such that “the free ends [are] brought into substantial abutment.” EX1004, 3:18-20. This folding, indicated by the red arrows in Fig. 1, results in the “two-ply structure” of Fig. 2 (reproduced above). *Id.* Sudre also describes that “the free ends [are] joined,” thus forming *at least one joint* (orange) *at which [the two] long-side ends are interconnected*. EX1004, 1:7-8; *see* 7:2-5 (“in the case of flat

woven structures the ends thereof, for example ends 12, 13 in Fig. 2, may be joined together as by a spiral beam or in any other manner”), 5:26-6:1 (“In the case of a flat-woven structure, the free ends may be secured together”).

139. The joined free ends 12, 13 belong to the same flat-woven fabric 11 (*said interconnected long-side ends belong to an identical flat-woven fabric*). See EX1004, 1:7-8, 3:18-20, 5:26-6:1, 7:2-5, Figs. 1-2.

(c) Claim 10

[10.0] The clothing according to claim 1, wherein said diameter of said MD threads is between 0.15 mm and 0.7 mm.

140. Based on Adanur, the MD thread diameter of the combination fabric is about 0.32 mm, which falls within the claimed diameter range (*said diameter of said MD threads is between 0.15 mm and 0.7 mm*). See EX1021, Fig. 3.15; *see also* my discussion above for element [1.4].

(d) Claim 11

[11.0] The clothing according to claim 10, wherein said diameter of said MD threads is between 0.3 mm and 0.5 mm.

141. Based on Adanur, the MD thread diameter of the combination fabric is about 0.32 mm, which falls within the claimed diameter range (*said diameter of said MD threads is between 0.3 mm and 0.5 mm*). See EX1021, Fig. 3.15; *see also* my discussion above for element [1.4].

(e) Claim 12

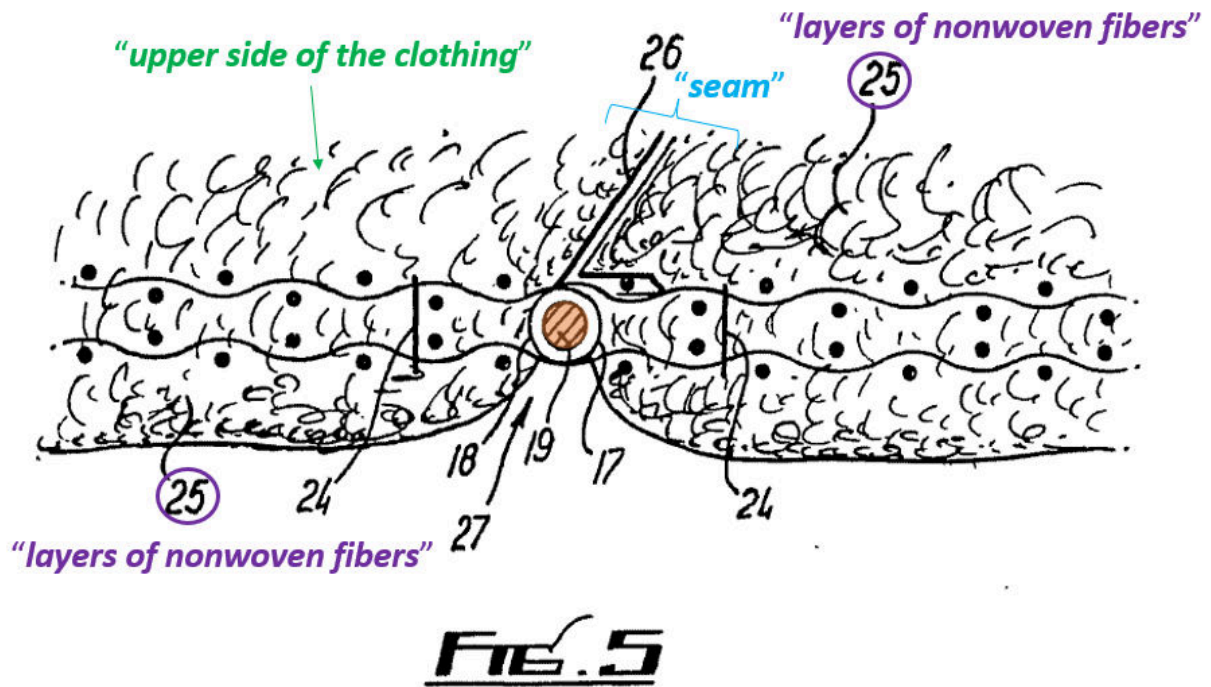
[12.0] The clothing according to claim 1, wherein said loop density of said seam is between 72% and 86%.

142. Based on Adanur, the loop density of the combination is about 85%, which falls within the claimed loop density range (***said loop density of said seam is between 72% and 86%***). See EX1021, Fig. 3.15; see also my discussion above for element [1.4].

(f) Claim 13

[13.0] The clothing according to claim 1, which further comprises one or a plurality of layers of nonwoven fibers disposed at least on an upper side of the clothing for contacting the web.

143. In the Sudre-Adanur combination, Sudre describes that “a textile batt 25 is needled to each face of the endless structure.” EX1004, 5:8-9. The textile batt, which I have indicated in purple in Fig. 5, reproduced below, corresponds to ***a plurality of layers of nonwoven fibers***, as discussed in the next paragraphs. See EX1004, 5:19-20 (“the invention is concerned primarily with the production of a base structure for combination with a textile batt in the manufacture of a wet end fabric”), claim 7 (“needling a textile batt to one face at least of the plural layer structure”), 2:10-12 (“a textile batt is needled to at least one side of the endless base material”), 3:9-11 (“Fig. 5 shows the seam region of base fabrics ..., a textile batt having been applied to each face thereof”).



Excerpt from Sudre, Fig. 5 (annotated)

144. A POSITA would have understood, or at least found obvious that textile batt is composed of *nonwoven fiber* given that batt is, conventionally, nonwoven fiber. For instance, this is corroborated by EX1009, 3:15-17 (“a staple fiber batt”); EX1019, 3:52-55 (“a batt of the non-woven, staple fibers 24”); EX1014, Abstract (“A batt fiber layer containing a non woven array of yarns”).

145. The textile batt (*nonwoven fibers*) is “needed to each face of the endless structure,” as illustrated in Fig. 5, above, *i.e.*, ***disposed at least on an upper side of the clothing***. EX1004, 3:9-11; *see* 3:9-11 (“Fig. 5 shows the seam region of base fabrics ..., a textile batt having been applied to each

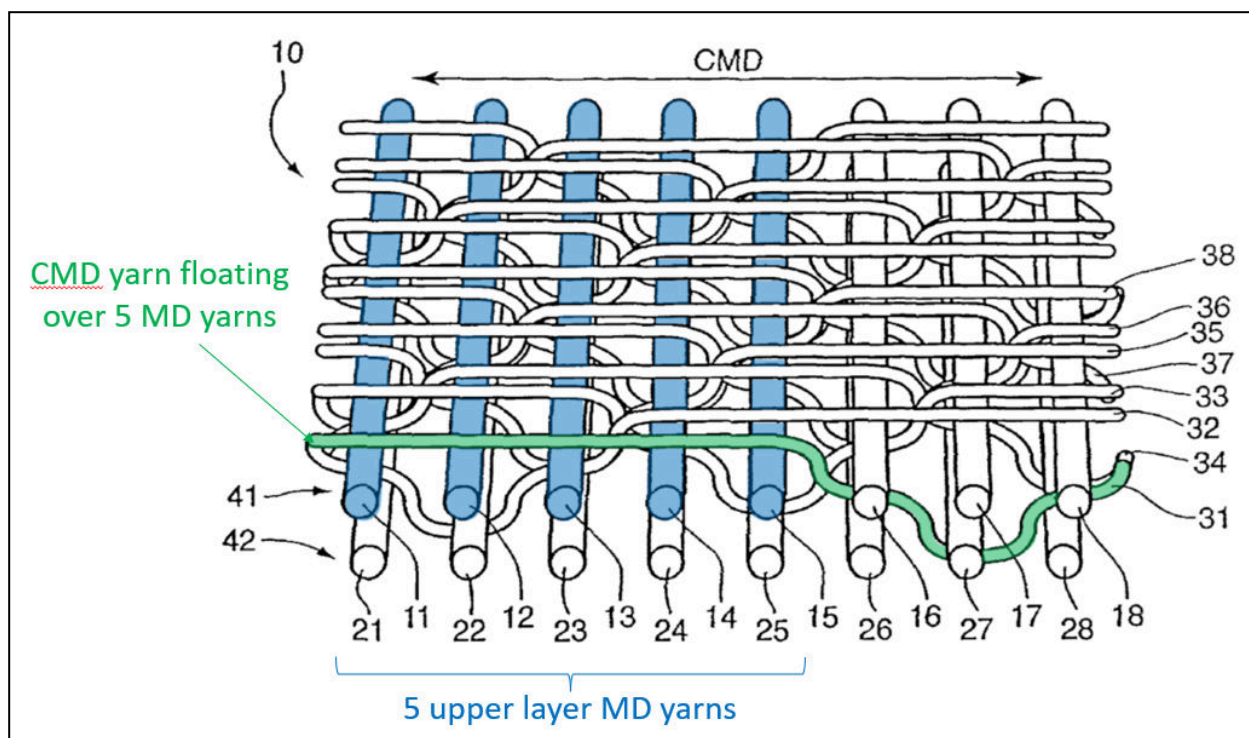
face thereof”), 6:14-16 (“The needling operation brings the batt at each face into coherent and homogeneous form through the base structure”), claim 7 (“needling a textile batt to one face at least of the plural layer structure”), 2:10-12 (“a textile batt is needed to at least one side of the endless base material”).

146. The textile batt is provided in layers, *e.g.*, at least one layer applied to each of the two faces of the endless structure (*a plurality of layers of nonwoven fibers*), as illustrated in Fig. 5. *See* EX1004, 3:9-11 (“Fig. 5 shows the seam region of base fabrics ..., a textile batt having been applied to each face thereof”), 6:14-16 (“The needling operation brings the batt at each face into coherent and homogeneous form through the base structure”).
147. One side of the combination fabric is “the machine side ... 27” that faces the papermaking machine, and the other side is “the paper side ... 26” (*an upper side of the clothing*), which I have indicated in green in Fig. 5, that faces and contacts the paper (*the web*). EX1004, 5:12-14. Both sides of the combination fabric include the textile batt and thus the batt on the paper side contacts the paper (*for contacting the web*).

B. [GROUND 1B] - Sudre-Adanur-Shipley Renders Obvious Claim 2

1. Shipley

148. Shipley, like Sudre and Adanur, “relates to papermakers fabric,” and specifically to “the weave construction of ... press felts.” EX1010, 1:7-9. Shipley’s fabric, shown in Fig. 1, which I have reproduced below, can be a “flat woven fabric,” and has “a system of MD [machine direction] yarns interwoven with a system of CMD [cross-machine direction] yarns in a select repeat pattern.” *Id.*, 2:64-66. The MD yarns, five of which I have shaded in dark blue, are “arranged in two layers 41, 42” and the CMD yarns, one of which is shaded in green, are interwoven with the MD yarns. *Id.*, 2:64-66.



Excerpt from Shipley, Fig. 1 (annotated)

149. Shipley’s “[t]he weave pattern ... repeats with respect to eight stacked pairs of MD yarns 11-18 and 21-28 and eight CMD yarns 31-38.” *Id.*, 3:6-8. One example of this repeat pattern is described as follows, with reference to the five blue MD yarns and one green CMD yarn that I annotated above in Fig. 1: “CMD yarn 31 [green] floats over MD yarns 11-15 [blue], then continues between top layer MD yarn 16 and bottom layer MD yarn 26, then forms a knuckle under bottom layer MD yarn 27, then continues between top layer MD yarn 18 and bottom layer MD yarn 28, then repeats by continuing over the next top layer MD yarn beginning a new float of five MD yarns.”

Id., 3:13-18. Other CMD yarns follow a similar pattern with respect to different sets of MD yarns, as can be seen from the figure.

2. *The Sudre-Adanur-Shipley Combination*

150. In the Sudre-Adanur-Shipley combination, the “flat-woven fabric” of the combination (which is based on Sudre, as I discussed above for element [1.1]) is woven as taught by Shipley. EX1004, 3:13-18. Specifically, the combination flat-woven fabric includes a “weave pattern ... [that] repeats with respect to eight stacked pairs of MD yarns ... and eight CMD yarns,” where “[e]ach of the CMD yarns in the repeat floats over five upper layer MD yarns, between one pair of stacked upper and lower MD yarns, under the next lower layer MD yarn, between the next pair of upper and lower MD yarns and then continues to float over the next five upper layer MD yarns in its repeat.” EX1010, 3:6-13; *see* Figs. 1-3. For instance, a weave pattern such as the one I discussed above for Shipley’s Fig. 1 is implemented in the combination fabric.

151. Like the ’566 Patent, Shipley relates to papermachine clothing, and generally aims to produce high quality papermachine clothing.

3. *Motivation for the Combination*

152. It is my opinion that a POSITA would have been motivated to implement the weave pattern of the combination fabric based on Shipley—

e.g., such that each CMD thread is woven over multiple MD threads—for at least the following reasons.

153. First, a weave pattern based on Shipley “permits low flow resistance which allows for greater ease in water removal from the aqueous paper web.” EX1010, 2:26-28. Good water handling characteristics of a press felt are relevant to the ability to manufacture high-quality paper products using such a press felt. For instance, a press felt that does not permit efficient water removal can result in pooling of water during paper manufacture, and this can result in the manufacture of paper of poor quality, *e.g.*, paper with water damage, artifacts, or paper that is structurally weakened. A POSITA would have been motivated to implement a weave pattern such as Shipley’s in order to minimize water-related defects in the paper making process.

154. Second, Shipley explains that its weave pattern enhances “[c]ompaction resistance of the press felts,” improving the durability and longevity of the felts. EX1010, 2:28-29. For instance, a press felt that is resistant to compaction has a longer usable lifetime in a papermaking machine before its compaction necessitates replacement. A POSITA would have been interested in enhancing the lifetime of a press felt both to reduce the consumption of press felts, and also because replacement of press felts in the papermaking plant is a time-consuming and expensive endeavor.

155. Third, weave patterns based on Shipley are “resilient maintaining the void volume and cleanability of the press felts,” which likewise contributes to the longevity of the felts. EX1010, 2:29-31. Again, a POSITA would have been motivated to enhance the lifetime of the press felt to reduce consumption and to avoid the need for frequent replacements.
156. Fourth, such weave patterns provide the press felt with “durable pressing uniformity,” which “results in a greater propensity for sheet smoothness and enhanced drying.” EX1010, 2:31-34. Smooth press felts are advantageous in the manufacture of high-quality paper products with few artifacts or distortions. For instance, a press felt that is textured or that has nonuniform surface structure can impart artifacts onto the resulting paper products, which is undesirable.
157. Fifth, the use of floats (*e.g.*, as in Shipley’s weave pattern, in which each CMD thread is woven over multiple MD threads) was conventional in the context of press felts, and a POSITA would have been motivated to implement floats simply because doing so was standard practice. For instance, floats are illustrated in Figs. 2-3 of EX1011; and described at 2:14-19 of EX1012.
158. Sixth, a POSITA would have been motivated to implement a weave pattern based on Shipley’s teachings simply because weave patterns

involving floats were conventional in the context of press felts, and because their implementation would lead to the predictable and straightforward result of a press felt having a weave pattern that involves CD floats.

159. It is also my opinion that there are several reasons why a POSITA would have expected success in implementing a weave pattern including floats, such as that described by Shipley, in the combination fabric.

160. First, Shipley, like Sudre and Adanur, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics. *See* EX1010, Abstract.

161. Second, a POSITA would have expected success simply because floats in seamable press felts were conventional, for instance, as I indicated above in citing to EX1011 and EX1012.

162. Third, a POSITA would have expected success in integrating the teachings of Shipley into the combination fabric because the MD thread diameter of Shipley's fabric overlaps with these parameters in the combination fabric—that is, with the MD thread diameter as taught by Adanur, which I discussed for element [1.4]. Specifically, Shipley describes that for “a base fabric for a press felt,” the MD threads are “single monofilament nylon yarns having a diameter of 0.010”-0.020” [about 0.25-

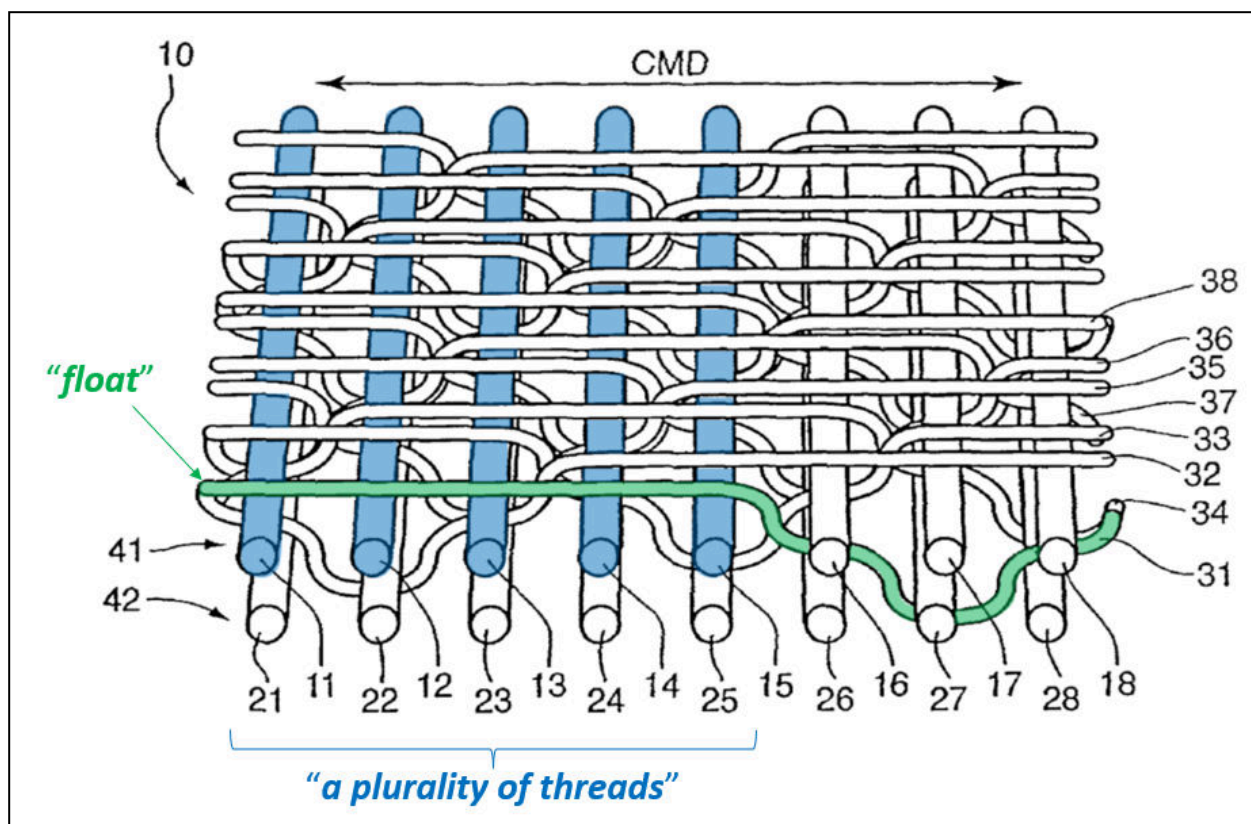
0.5 mm],” which is consistent with the 0.32 mm MD thread diameter of the combination fabric. EX1010, 3:48-52; *see* EX1021, Fig. 3.15.

4. *Analysis*

(a) Claim 2

[2.0] The clothing according to claim 1, wherein at least one of said flat-woven fabrics have floats extending over two or a plurality of threads.

163. The combination flat-woven fabric is woven based on the weave pattern described by Shipley, which is shown in Fig. 1, reproduced and annotated below. Specifically, in the combination flat-woven fabric, “[e]ach of the CMD yarns in the repeat floats over five upper layer MD yarns” (*floats extending over two or a plurality of threads*), as can be seen by the green CMD thread extending over the blue-shaded MD threads 11-15. EX1010, 3:8-12; EX1018, 3:30-35. One such CMD thread (*float*), shaded green in Fig. 1, “floats over MD yarns 11-15,” shaded in navy blue (*extends over ... a plurality of threads*). EX1010, 3:12-18; *see* Abstract (“The second system of yarns define a five float repeat on the paper carrying side of the fabric”), 2:9-11 (“The weave structure ... contains a long CMD float to enhance CMD support”), claim 1 (“each CMD yarn of the CMD yarn system repeat pattern weaving over five successive upper layer MD yarns to define a five yarn float”), 3:19-28.

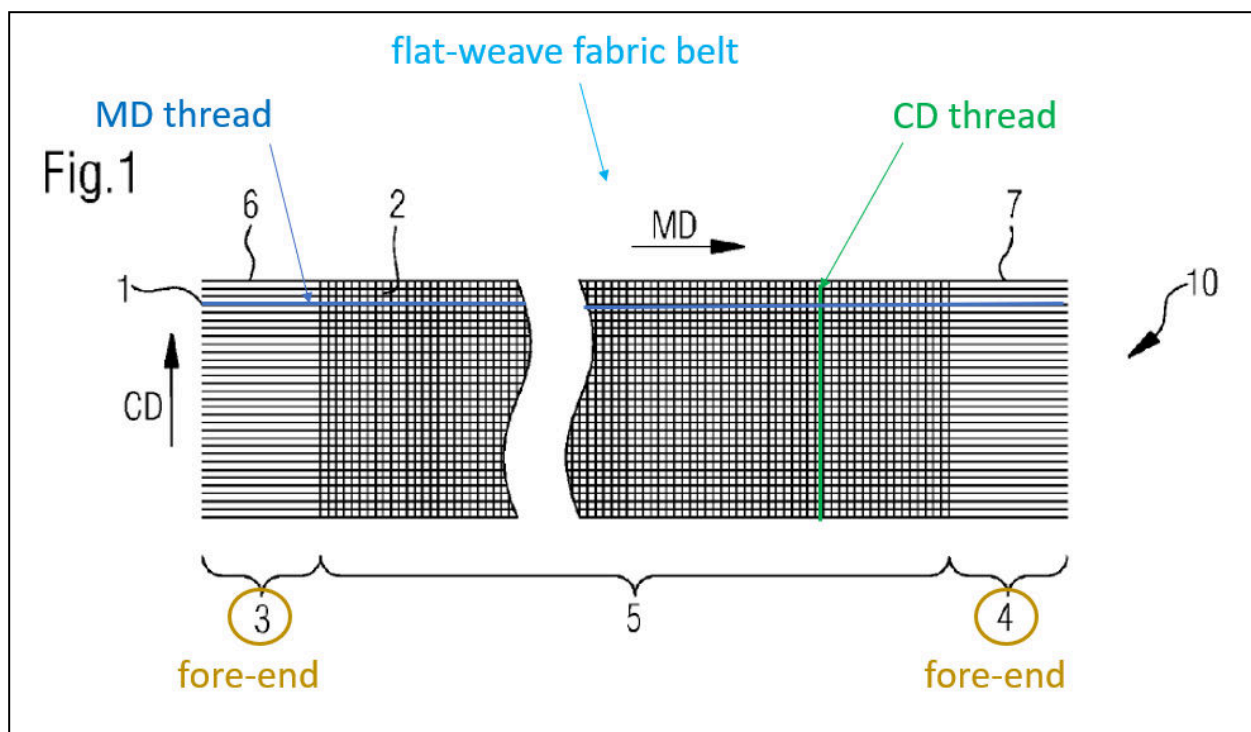


Excerpt from Shipley, Fig. 1 (annotated)

C. [GROUND 1C] – Sudre-Adanur-Straub Renders Obvious Claims 4-9

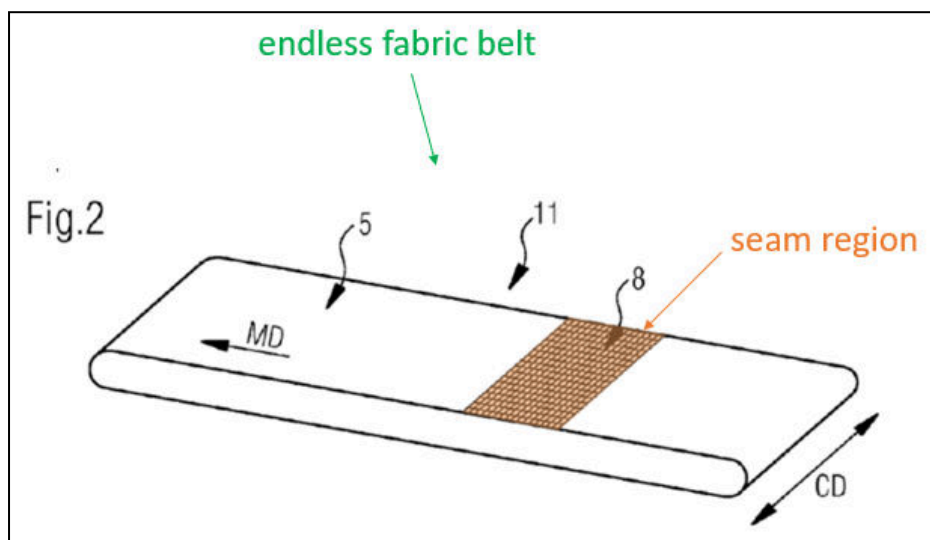
1. Straub

164. Like Sudre and Adanur, Straub describes a press felt fabrication process that starts with a “flat-weave fabric belt 10,” as shown in Fig. 1, which I have reproduced and annotated below. As was conventional for press felts, Straub’s fabric belt is composed of “machine direction threads 1,” one of which I have indicated in dark blue, and “machine cross-direction threads 2 [one indicated in green] extending perpendicularly to these [MD threads].” EX1013, [0054].



Excerpt from Straub, Fig. 1 (annotated)

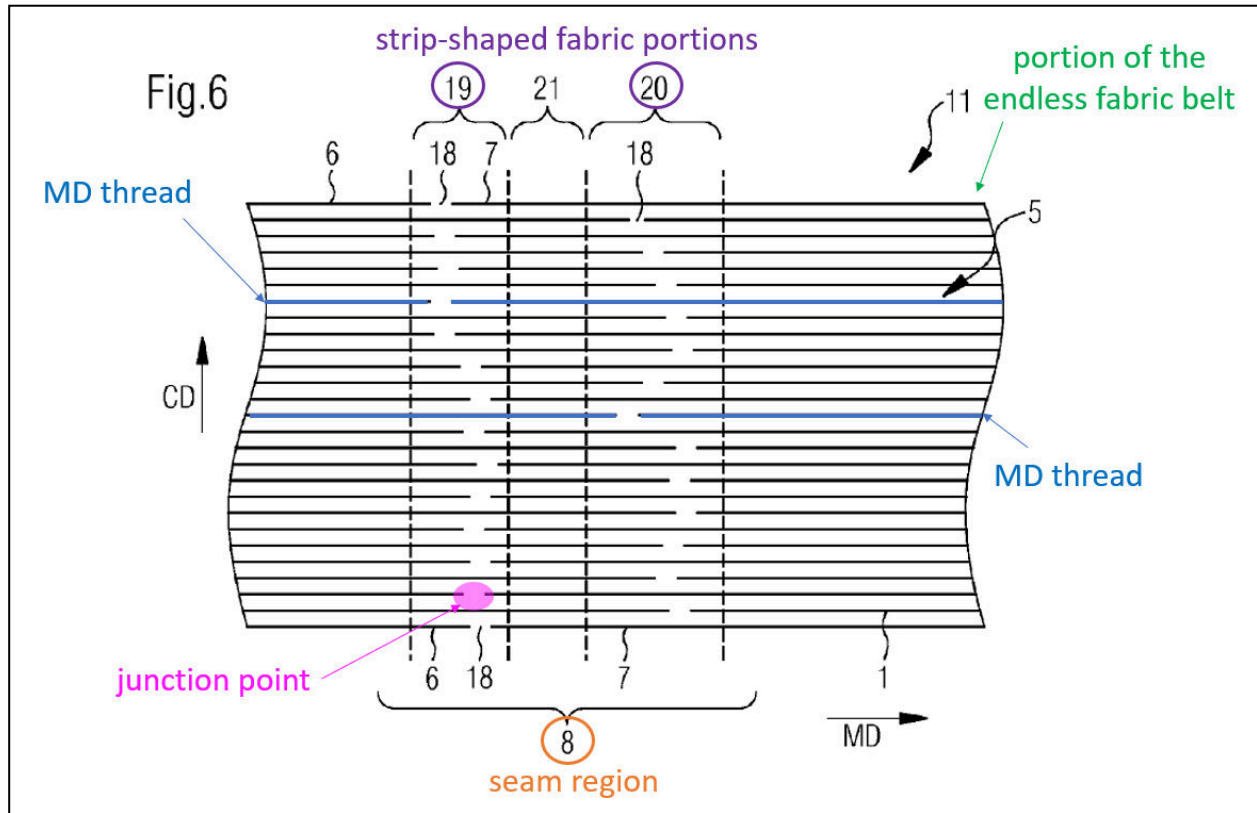
165. As was also conventional for preparing press felts, the flat-weave fabric belt is folded over and “the two fore-ends 3 and 4 of the fabric belt 10 [are] connected to one another” to “form a woven seam.” *Id.*, [0055]. The resulting “endless fabric belt 11” has a “seam region 8,” which I have indicated in orange in Fig. 2, below, where the two ends are connected. *Id.*, [0057]. It is important to be clear that this seam region 8 corresponds to, for instance, the joint where Sudre’s free ends 12, 13 are brought together (*see*, for instance, Sudre’s Fig. 2), and not to the seam that is formed by interdigitation of loops and insertion of a pintle. Straub has such a seam as well, and I will discuss this later.



Excerpt from Straub, Fig. 2 (annotated)

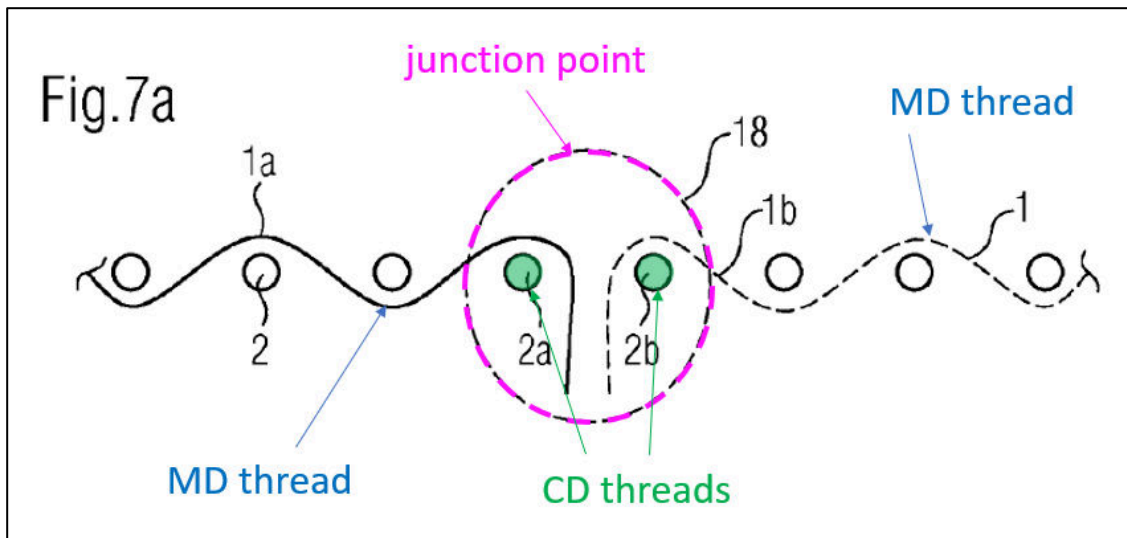
166. Fig. 6, which I have reproduced and annotated below, shows the seam region in more detail. In this seam region, “an end portion 6 of the machine direction threads 1 of one fore-end and an end portion of the machine direction threads 1 of the other fore-end of the fabric belt [] are brought together in pairs to form in each case a junction point 18,” one of which I have highlighted in pink. EX1013, [0070]. The MD threads in the seam region (two of which I have marked in dark blue) “are interwoven with machine cross-direction threads (not illustrated).” *Id.* Those CD threads would run from top to bottom of the figure, *i.e.*, generally perpendicular to the MD threads. The junction points are arranged in “two strip-shaped fabric portions 19, 20,” indicated in purple, which are spaced apart from one

another” by “a strip-shaped fabric portion 21 in which no junction points ... are formed.” *Id.*, [0071].



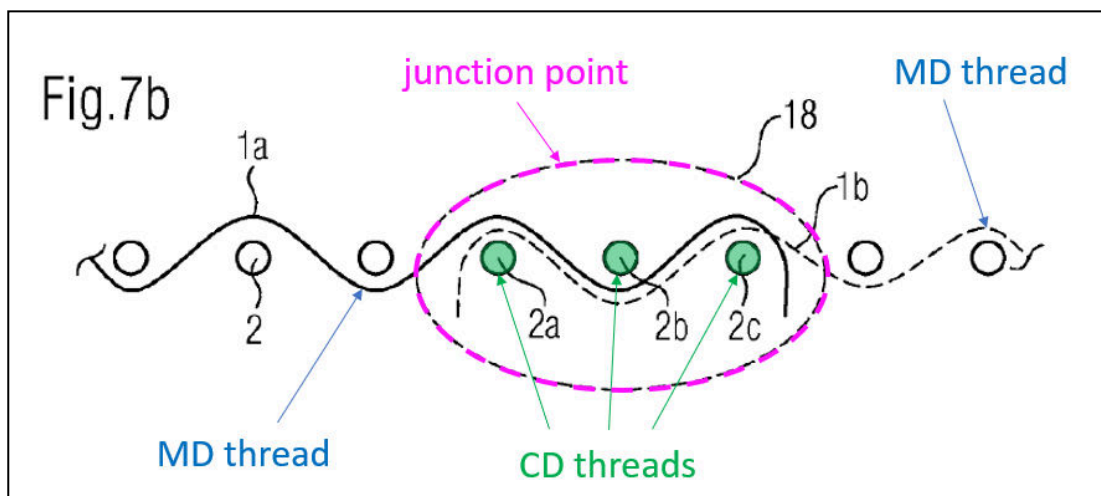
Excerpt from Straub, Fig. 6 (annotated)

167. Straub provides Figs. 7a-7d to illustrate “various possibilities for forming junction points 18.” EX1013, [0075]. For instance, in the junction point of Fig. 7a, reproduced below, “the end portions 1a and 1b” of an MD thread (indicated in navy blue) “are tied off via two directly adjacent machine cross-direction threads 2a and 2b,” shaded in green. EX1013, [0076].



Excerpt from Straub, Fig. 7a (annotated)

168. In the example junction point of Fig. 7b, reproduced below, “the end portions 1a and 1b” of an MD thread, indicated in navy blue, “are jointly interwoven with three directly adjacent machine cross-direction threads 2a, 2b and 2c,” shaded in green. EX1013, [0077].



Excerpt from Straub, Fig. 7b (annotated)

169. Straub describes that the MD and CD threads at the junction points are “connected to one another in a materially integral manner by laser light radiation at yarn contact points formed by crossing points,” for instance using “a transmission welding method.” EX1013, [0059]-[0060]. This was a conventional way to form junction points in seamable press felts. For instance, Straub describes that “one of the intersecting threads may be formed such that it absorbs the light used for welding,” or “light-absorbing material is introduced between the yarns ... at the intersection points.” *Id.*, [0065].

2. *The Sudre-Adanur-Straub Combination*

170. In the Sudre-Lee-Penven-Straub combination, “[t]he free ends 12, 13” of the flat-woven fabric of the combination “are folded over to define a two-ply structure ..., the free ends being brought into substantial abutment” and “joined.” EX1004, 1:7-8, 3:18-21, Fig. 2. I discussed this in general with respect to element [3.0], above.

171. The specific way in which the free ends of the combination flat-woven fabric are joined is based on the teachings of Straub. Specifically, the free ends “are brought together in pairs to form in each case a junction point 18,” and at each junction point, MD threads are “interwoven with machine cross-direction threads,” as taught by Straub. EX1013, [0070]-[0071]. The

MD and CD threads at each junction point are “connected to one another in a materially integral manner,” *e.g.*, by “a transmission welding method.” EX1013, [0073]. Straub’s Fig. 6 depicts the resulting arrangement, and individual junction points can be structured, *e.g.*, based on any of Straub’s Figs. 7a-7d.

172. Straub is analogous art to the ’566 Patent: it is from the same field of endeavor (*e.g.*, papermachine clothing) and is reasonably pertinent to the problem the ’566 Patent was trying to solve (*e.g.*, production of high quality papermachine clothing).

3. *Motivation for the Combination*

173. It is my opinion that a POSITA would have been motivated to join the free ends of the combination fabric flat-woven fabric based on the approach taught by Straub for at least the following reasons.

174. First, in a joint produced based on the approach described by Straub, “the strength of the seam is markedly increased.” EX1013, [0016]. A stronger seam is more mechanically robust and thus less likely to break, meaning that the press felt will have better longevity. As I have previously discussed, it is a time-consuming and complex effort to replace a press felt in a papermaking machine context, and better longevity allows this

replacement to be undertaken less often, which is economically advantageous.

175. Second, with the structure of Straub's joints, "the flexural strength of such a 'welded seam' can be markedly reduced, as compared to a seam welded along the entire length of the seam region." EX1013, [0017].

Again, this means a more mechanically robust seam and thus a better longevity for the press felt.

176. Third, with Straub's joint structure, "the stretching of the fabric belt can thereby be reduced, and also the shear strength can be increased, transverse distortion of the fabric belt thereby being prevented." EX1013, [0017]. Once again, this indicates better strength, more mechanical integrity, and better longevity.

177. Fourth, with the formation of junction points as described by Straub, "[e]mergence and separation of the thread ends [of the MD threads] is ... effectively reduced or even prevented." EX1013, [0018]. Loose MD thread ends are undesirable for various reasons. For instance, loose MD threads can get caught, or can unravel. Loose MD thread ends can also lead to artifacts in the resulting paper, thus degrading the quality of the paper products.

178. Fifth, a joint structured as taught by Straub allows “a permeability equal or similar to that in the full fabric [to be] obtained in the seam region.” EX1013, [0020]. As I discussed above, water permeability is an important characteristic of press felts. A uniform water permeability between the seam region and elsewhere means that water pooling can be avoiding equally at all points on the fabric, thus reducing artifacts in the resulting paper products.
179. Sixth, formation of junction points by welding to thereby join free ends of a flat-woven fabric into an endless structure was conventional and well-understood. For instance, this is described in EX1015 at [0011], [0017].
180. Seventh, a POSITA would have been motivated to implement the joint based on Straub because joining free ends of a flat-woven fabric by welding junction points, in the context of a press felt, was conventional and produced a predictable result: an endless structure formed by joining free ends of a flat-woven fabric at junction points.
181. It is my opinion that a POSITA would have expected success in implementing the joint of the combination fabric based on Straub at least because Straub, like Sudre and Adanur, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics. *See* EX1013, [0001].

182. It is also my opinion that a POSITA would have expected success because Straub indicates that its approach is compatible with “a fabric with only a few fabric plies,” and this is the case with the Sudre-Adanur-Straub combination fabric. *See* EX1004, 3:24-4:1; EX1013, [0039]. Likewise, Straub indicates that its approach is compatible with a fabric having “a thread density of 20 to 100 machine direction threads per inch,” which again is the case with the Sudre-Adanur combination fabric. Furthermore, a POSITA would have expected success because Straub indicates that its approach is compatible with “a fabric with only a few fabric plies,” as is the case with the Sudre-Adanur combination fabric (*see* EX1004, 3:24-4:1), and with a fabric having “a thread density of 20 to 100 machine direction threads per inch, also consistent with the Sudre-Adanur combination fabric (*see* EX1021, Fig. 3.15). EX1013, [0039].

4. *Analysis*

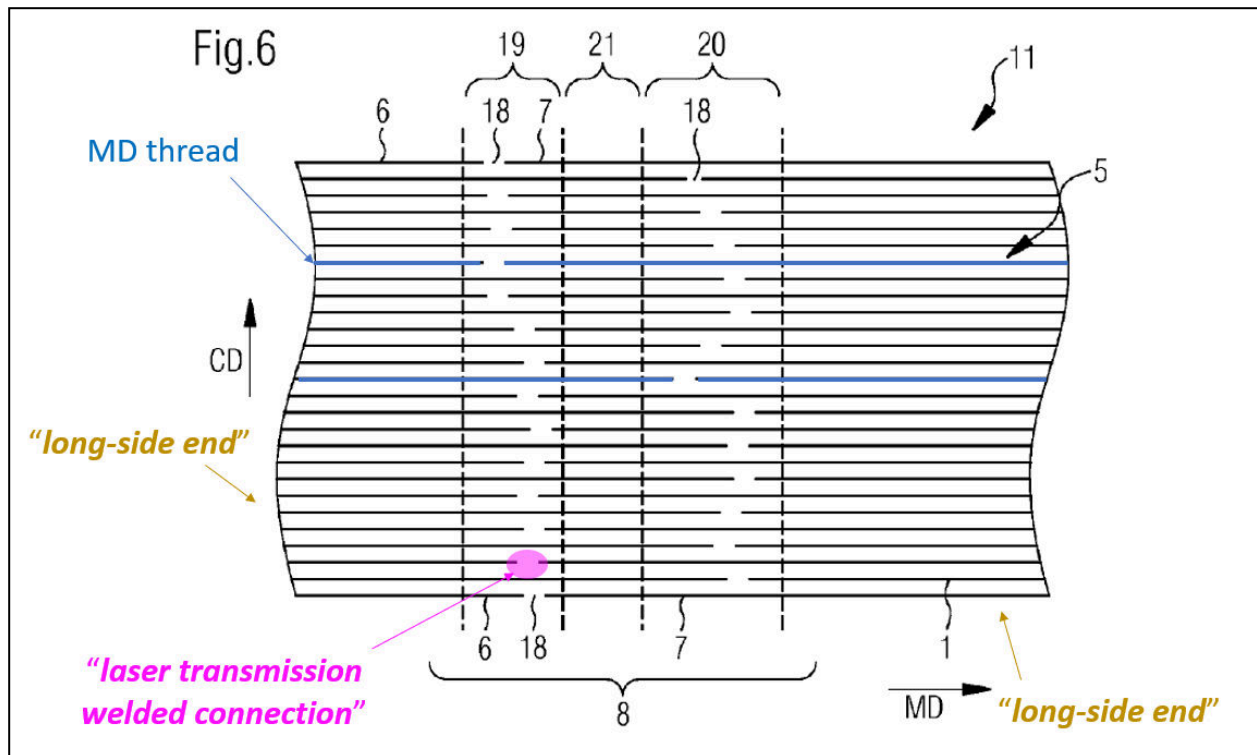
(a) Claim 4

[4.0] The clothing according to claim 3, wherein said two long-side ends are interconnected by a welded connection or a laser transmission welded connection.

183. In the Sudre-Adanur-Straub combination, ““the free ends” of the flat-woven fabric are “joined” (*said two long-side ends are interconnected*). This, in generally, I discussed above for element [3.0]. Specifically, the two long-side ends are joined using “a transmission welding method” that

involves “light [] radiated by a laser” that “is guided onto the intersections to be welded of machine direction and machine cross-direction threads” (***laser transmission welded***). EX1013, [0061]; *see* [0060] (“the stabilization of the seam region 8 by means of the materially integral connection of the yarn intersections is carried out with the aid of a transmission welding method”), [0061] (“For the welding of machine direction and machine cross-direction threads at the intersection points, a light 14 radiated by a laser 9 ... is guided onto the intersections to be welded”), [0065] (“For the welding of yarn intersections ..., the radiated light must be absorbed between the yarns touching one another at the intersections”), [0030], [0047]-[0051], [0067]-[0068], Figs. 3-5.

184. The seam region that is formed by laser transmission welding of the free ends of the combination fabric is structured as illustrated in Straub’s Fig. 6, which I have reproduced below, indicating the MD threads in dark blue and the long-side ends in yellow. *See* EX1013, [0051].



Excerpt from Straub, Fig. 6 (annotated)

185. This seam region includes “junction points” (one of which is highlighted in pink) at which “pairs” of MD threads from the two “fore-end[s]” (*long-side ends*) of the flat-woven fabric “are interwoven with machine cross-direction threads,” thus interconnecting the two long-side ends. EX1013, [0069]-[0070]. The MD and CD threads at each junction point are “connected to one another in a materially integral manner by laser radiation.” EX1013, [0059]; *see* [0061], [0065]. That is, each junction point connects MD threads from the two long-side ends of the flat-woven fabric, and is secured by laser welding, meaning that each junction point is implemented as *a laser transmission welded connection*.

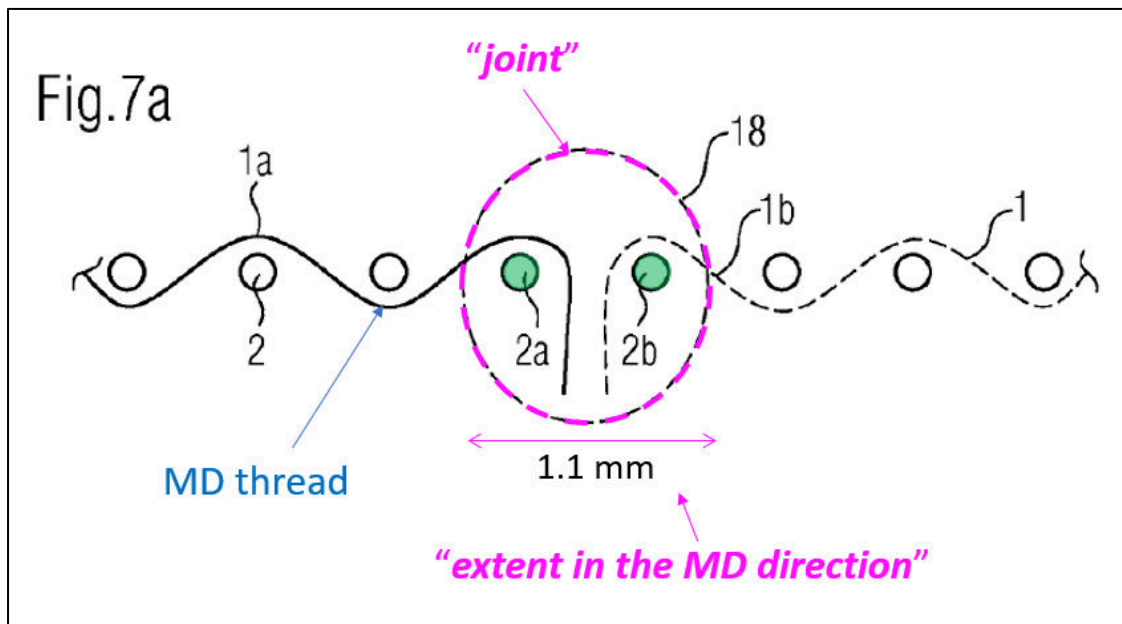
(b) Claim 5

[5.0] The clothing according to claim 3, wherein said at least one joint has an extent in a machine direction of less than 15 mm.

Each junction point in the combination endless structure is a joint

186. In the Sudre-Adanur-Straub combination, “the free ends” of the flat-woven fabric are “joined,” thus forming ***at least one joint*** and thereby forming the fabric into an endless structure, as taught by Sudre. EX1004, 1:7-8. Specifically, the joining is implemented based on the junction points described by Straub, where at each junction point, a pair of MD thread ends from the two free ends of the flat-woven fabric “are interwoven with machine cross-direction threads.” EX1013, [0001], Figs. 7a-7d. Thus, each junction point corresponds to a ***joint*** because it is a region of the fabric ***at which two of said long-side ends are interconnected*** (see my discussion of claim 3, above). See EX1013, [0056] (“the two fore-ends 3 and 4 of the flat-weave fabric belt 10 are connected to one another in that the end portions 6 of the machine direction threads 1 of one fore-end 3 and the end portions 7 of the machine direction threads 1 of the other fore-end 4 of the flat-weave fabric belt 10 are in each case brought together in pairs to form junction points”), [0001] (“end portions of the machine direction threads of the two fore-ends are brought together to form junction points”), [0008], [0015], [0026], [0070].

187. An example junction point (*joint*) is illustrated in Straub's Fig. 7a, which I have reproduced and annotated below. See EX1013, [0076]. This junction point "extends from the machine cross-direction thread 2a as far as the machine cross-direction thread 2b, as seen in the machine direction MD." *Id.* That is, as annotated in Fig. 7a, the junction point (*joint*) *extends in the machine direction* (i.e., in the direction of the MD thread (indicated blue) by a distance approximately equal to the distance occupied by two CD threads (shaded in green).



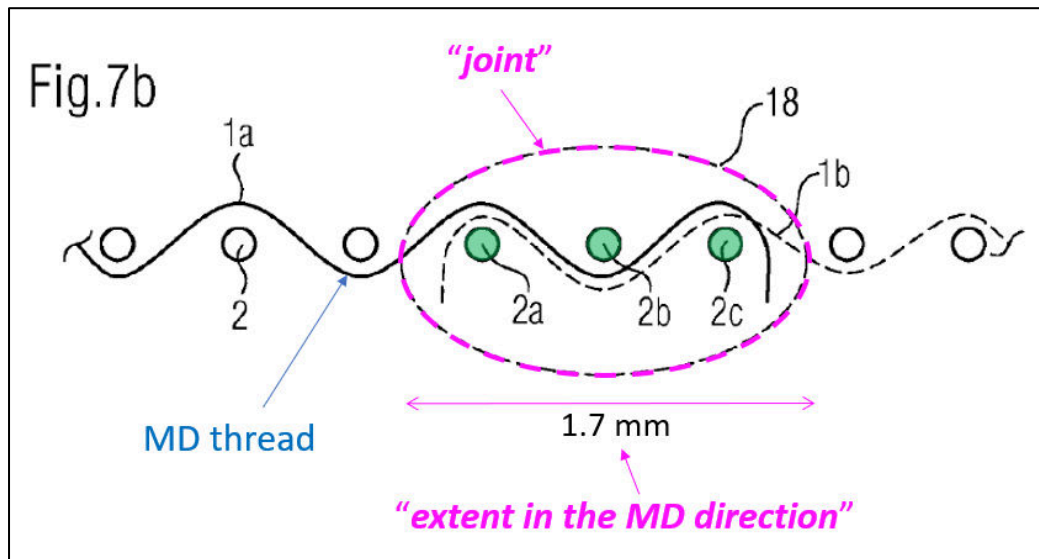
Excerpt from Straub, Fig. 7a (annotated)

188. It is my opinion that a POSITA would have found it obvious that the joints of Fig. 7a and Fig. 7b extend in the machine direction by *less than 15 mm*. For instance, as I discuss in more detail at the end of this section, a

POSITA would have provided the CD threads in the combination fabric at a density of about 17.4 threads/cm, consistent with the CD thread density of Adanur's fabric. EX1013, [0039]; *see* claim 34.

189. With a CD thread density of about 17.4 threads/cm, the two CD threads in the joint of Fig. 7a occupy a distance in the MD of about 1.1 mm (*i.e.*, 2 threads divided by a CD thread density of 17.4 threads/cm, and converted to mm)—that is, the joint extends in the MD by 1.1 mm. That is, the junction point of Straub's Fig. 7a (*said at least one joint extends in the machine direction*) by about 1.1 mm (*less than 15 mm*).

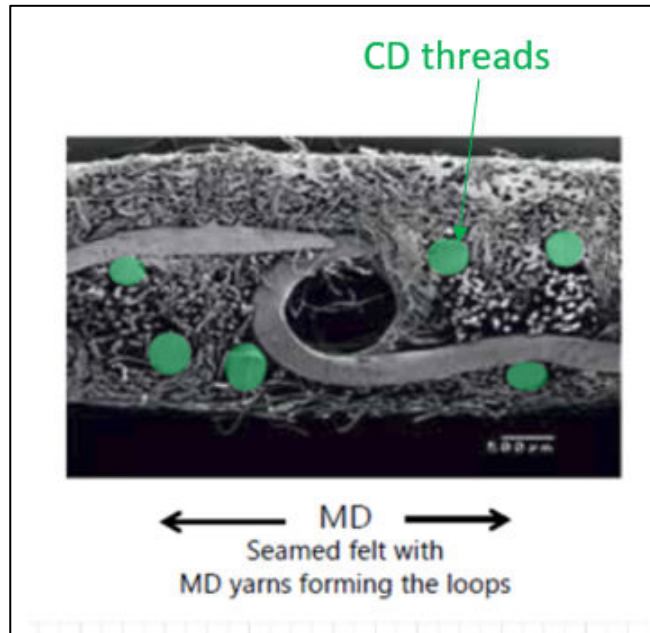
190. A similar calculation can be performed for the joint of Fig. 7b, which extends in the MD by the distance occupied by three CD threads. With a CD thread density of 17.4 threads/cm, the joint of Fig. 7b (which I have annotated below) extends in the MD by about 1.7mm (*less than 15 mm*)—that is, 3 threads divided by a CD thread density of 17.4 threads/mm. *See* EX1013, [0077].



Excerpt from Straub, Fig. 7b (annotated)

191. Similarly, Straub's Fig. 7c shows a junction point that "extends from the machine cross-direction thread 2a as far as the machine cross-direction thread 2d, *i.e.*, an MD extent of 4 CD yarns, or 2.3 mm. EX1013, [0078].
192. I obtained the CD yarn density of Adanur's fabric from Fig. 3.15, which shows cross-direction threads oriented through the plane of the image, which I have highlighted in green. These threads are near the loop, which suggests there may be some distortion to their placement due to the processes that form the loops. In this image, 6 mono-filament cross-direction threads can be seen. There are three on the left side and three on the right side. Measuring the shapes of these threads, the average diameter is 0.34 mm with a standard deviation of 0.06 mm. The threads on the left have a center to center spacing of approximately 0.60 mm and the threads on

the right have a center to center spacing of approximately 0.55 mm. The average of the two is 0.575 mm. The density of the CD threads is thus 17.4 threads/cm (*i.e.*, 2 threads * 0.34mm/thread / 0.575 mm/2 threads).



Excerpt from Adanur, Fig. 3.15 (annotated)

193. It is my opinion that a POSITA would have found it obvious to implement a CD thread density of about 17.4 threads/cm based on Adanur for at least the following reasons.

194. First, Adanur's example shown in Fig. 3.15 demonstrates that clothing having a CD thread density of about 17.4 threads/cm was present in "actual finished press fabrics" for papermachine clothing. One skilled in the art would have been motivated to use CD thread density as shown in Adanur and implement those dimensions in Sudre's fabric because Adanur's

disclosure represents “the *industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics*” and to achieve a clothing or felt seam that will “meet the *particular requirements of its intended end.*” EX1022; *see* EX1016, 6:8-23, 6:59-64; EX1005, 12 (1st paragraph).

195. Second, CD threads in press felts were conventionally provided in densities similar to that of the MD threads. The combination fabric has an MD thread density of about 13.3 threads/cm, as I discussed above, and a POSITA would thus have been motivated to provide the CD threads in a similar density range.

196. Third, using a particular CD thread density based on the teachings of Adanur is merely an application of known techniques to a known system to yield predictable results (papermaker’s fabric with a CD thread density in a known range).

197. A skilled person in the art would have expected success in applying the CD thread density dimensioned based on Adanur’s Figure 3.15 at least because, as noted above, these dimensions were being used for CD threads in “actual finished press fabrics” for papermachine clothing. This signifies that Adanur’s threads were already in the public domain. Also, it is

important to note that Sudre does not provide any reason to deviate from a usage of standard CD thread density, as described by Adanur.

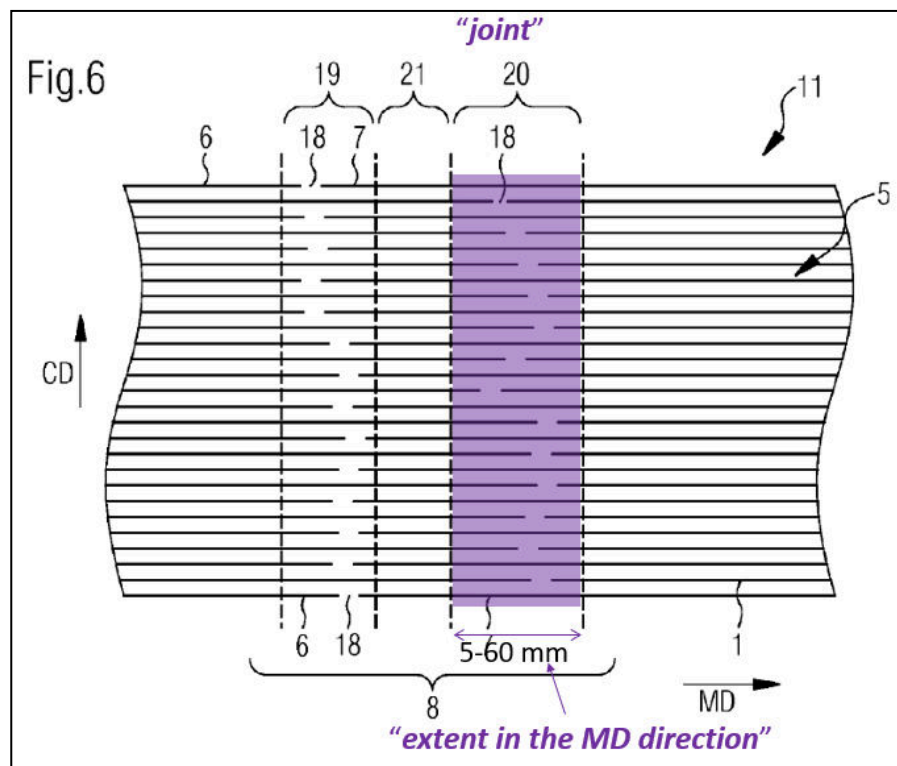
198. Additionally, I note that the junction points are staggered in each “strip-shaped fabric portion,” which has “an extent of 5 to 60 mm in the machine direction MD.” EX1013, [0074]; *see* claim 38, Fig. 6. Because the junction points are staggered, a POSITA would have recognized that multiple junction points together occupy an MD extent that is greater than the MD extent of any individual junction point. Thus, when the MD extent of the strip-shaped fabric portion is on the lower end of its 5-60mm range, a POSITA would recognize that the extent of each individual junction point is ***less than 15 mm.***

Each strip-shaped fabric portion in the combination endless structure is a joint

199. In the Sudre-Adanur-Straub combination, the junction points that join the two free ends of the flat-woven fabric are arranged in “two strip-shaped fabric portions 19, 20.” EX1013, [0071]. Each of these “strip-shaped fabric portions” corresponds to a ***joint*** because it is a region of the fabric ***at which two of said long-side ends are interconnected*** (*see* my discussion above for element [3.0]), *e.g.*, via the junction points. *See* EX1013, [0071], claim 1. *See* EX1013, [0071] (“two strip-shaped fabric portions ... in which the ... junction points 18 and the ... yarn contact points of the fabric belt which are

connected to one another in a materially integral manner are arranged”),
claim 1 (“said seam region containing a plurality of mutually spaced-apart,
strip-shaped fabric portions, in which said junction points and said yarn
contact points connected to one another in a materially integral manner are
arranged”).

200. Straub states that each “strip-shaped fabric portion[]” (*joint*) has “an
extent of 5 to 60 mm in the machine direction MD,” and I have annotated
this MD extend in Fig. 6 below. EX1013, [0074]; *see* claim 38.



Excerpt from Straub, Fig. 6 (annotated)

201. The recited MD extent of the “strip-shaped fabric portion[]” (*joint*)
(*less than 15 mm*) overlaps with the MD extent of the strip-shaped fabric

portion of the combination fabric (5-60 mm). I understand that a prior art range that overlaps with a claimed range renders that claimed range obvious unless there is something critical or unexpected associated with the claimed range. Here, the '566 Patent provides no evidence of criticality or unexpected results associated with the claimed MD extent of the joint, and indeed, I would not expect there to be any such behavior. I thus conclude that the Sudre-Adanur-Straub combination renders obvious the claimed MD extent of the joint.

202. Alternatively/additionally, it is my opinion that a POSITA would regard the MD extent of the strip-shaped fabric portion (*joint*) as merely a straightforward design choice. Generally, a press felt with a small joint is advantageous to avoid formation of distortions on paper products formed thereon, and thus would have been motivated to construct a joint with a small MD extent. *See* EX1020, [0011]. The specific “less than 15 mm” MD extent of the joint recited in claim 5 presents no unexpected results or solution, nor is there any indication that a joint of “less than 15 mm” would function differently than the joint of the Sudre-Adanur-Straub combination. Thus, a POSITA naturally would have aimed to design a relatively minimal joint, *e.g.*, a joint of less than 15 mm.

(c) Claim 6

[6.0] The clothing according to claim 5, wherein said extent of said at least one joint in the machine direction is less than 5 mm.

203. The junction points of Straub's Fig. 7a, Fig. 7b, and 7c (***said at least one joint) extend in the machine direction*** by about 1.1mm, about 1.7mm, and about 2.3mm, respectively (***less than 5 mm***), as I discussed above for claim 5.

204. Additionally, I note that the junction points are staggered in each "strip-shaped fabric portion," which has "an extent of 5 to 60 mm in the machine direction MD." EX1013, [0074]; *see* claim 38, Fig. 6. Because the junction points are staggered, a POSITA would have recognized that multiple junction points together occupy an MD extent that is greater than the MD extent of any individual junction point. Thus, when the MD extent of the strip-shaped fabric portion is 5mm range, a POSITA would recognize that the extent of each individual junction point is ***less than 5 mm***.

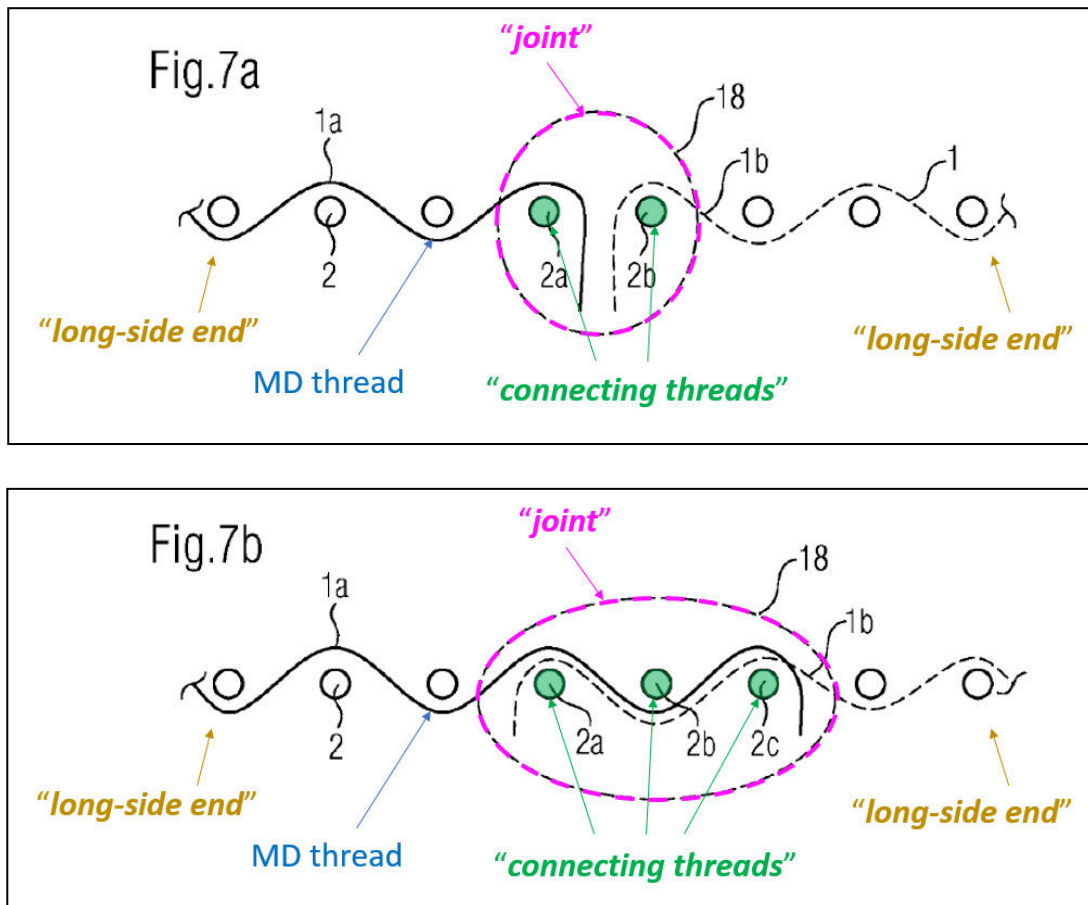
205. Alternatively/additionally, the strip-shaped fabric portion (***said at least one joint) extends in the machine direction*** by 5-60mm, as I also discussed above for claim 5. It is my opinion that a POSITA would have found implementation of the strip-shaped fabric portion with an MD extent of ***less than 5 mm*** to be a straightforward design choice. This is the case because the '566 Patent does not attribute any unexpected results or different functionality to the MD extent of the joint. Moreover, I note that there is

near overlap between the recited “less than 5 mm” range and the 5-60mm range of the combination.

(d) Claim 7

[7.0] The clothing according to claim 3, wherein said at least one joint is made by connecting elements or connecting threads being welded to at least one or both of said long-side ends.

206. In the combination, a junction point (***said at least one joint***) based on Straub’s Fig. 7a includes “two directly adjacent machine cross-direction threads 2a and 2b,” green in Fig. 7a, below (***connecting threads***). EX1013, [0076]. Alternatively/additionally, a junction point (***said at least one joint***) based on Straub’s Fig. 7b includes “three directly adjacent machine cross-direction threads 2a, 2b and 2c,” green in Fig. 7b, below (***connecting threads***). EX1013, [0077].



Excerpts from Straub, Figs. 7a-7b (annotated)

207. The CD threads (*connecting threads*) are connected to “end portions 1a and 1b of one and the same machine direction thread,” where the end portions of the MD thread are from “one fore-end and ... the other fore-end of the fabric belt” (*long-side ends*, yellow). EX1013, [0070].
208. Specifically, the “yarn intersections” between MD and CD threads are “welded,” *i.e.*, the CD threads in the junction points are welded to the MD threads from the two long-side ends (*connecting threads being welded to at least one or both of said long-side ends*). EX1013, [0067].

(e) Claim 8

[8.0] The clothing according to claim 7, wherein said connecting elements are connecting threads disposed in a CD direction of the clothing, and at most three connecting threads or at most two connecting threads are provided for a joint.

209. In the combination, a junction point based on Straub's Fig. 7a

includes "two directly adjacent machine cross-direction threads 2a and 2b,"

(at most two connecting threads disposed in a CD direction of the clothing). EX1013, [0076]; *see* my discussion above for claim 7.

Alternatively/additionally, a junction point based on Straub's Fig. 7b

includes "three directly adjacent machine cross-direction threads 2a, 2b and

2c" (at most three connecting threads disposed in a CD direction of the

clothing). EX1013, [0077]; *see* claim 33 ("the end portions brought together

in each case in pairs and forming junction points are interwoven at the

respective junction point with a maximum of no more than five common

weft threads").

(f) Claim 9

[9.0] The clothing according to claim 8, wherein one or a plurality of said connecting threads are woven with MD threads of at least one of said long-side ends.

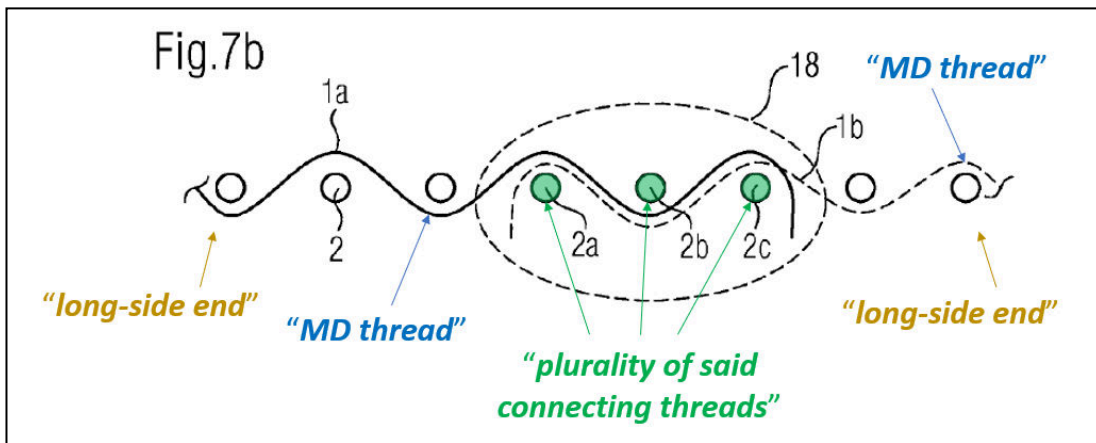
210. In the combination, a junction point based on Straub's Fig. 7b

includes "the two brought-together end portions 1a and 1b of one and the

same machine direction thread 1" (***MD threads of at least one of said long-***

side ends). EX1013, [0077]. The MD thread end portions, which I have

identified in yellow in Fig. 7b below, “are jointly interwoven with three directly adjacent machine cross-direction threads 2a, 2b and 2c,” green (*connecting threads are woven with MD threads*). *Id.*; see [0001] (“end portions of the machine direction threads of the two fore-ends are brought together to form junction points and are interwoven with machine cross-direction threads to form a seam region”).



Excerpt from Straub, Fig. 7b (annotated)

D. [GROUND 1D] – Sudre-Adanur-Lidar Renders Obvious Claims 14

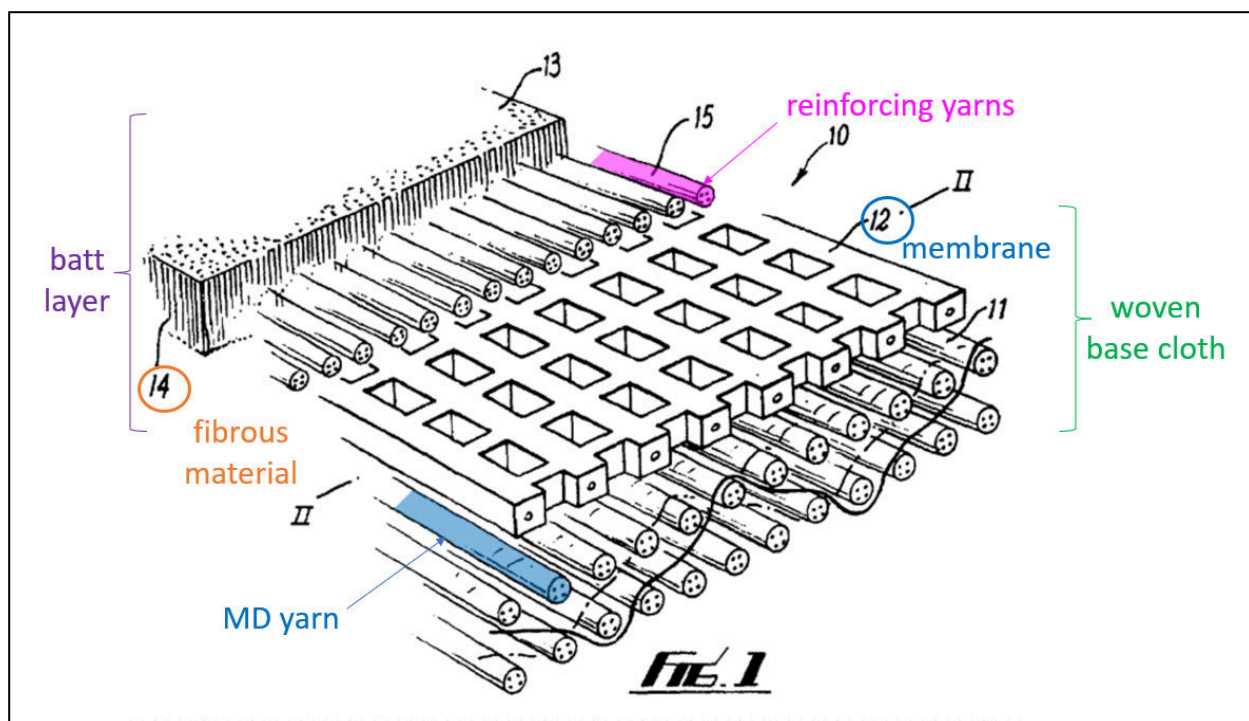
1. Lidar

211. Lidar describes “papermachine clothing ... for use as a press felt for a papermaking machine.” EX1014, 3:16-18. Lidar’s papermachine clothing, shown in Fig. 1, which I have reproduced below, includes “a woven base cloth 11 with two layers of machine direction yarns [one shaded in navy blue] bound together with a cross machine direction yarn system.” *Id.*, 3:18-

20. Optionally, the base cloth includes “a moulded mesh membrane 12.”

Id., 3:20-21; *see* 2:29-30 (“the optional thermoplastics mesh layer”).

212. Lidar’s clothing also includes a “batt layer 13,” indicated in purple, that includes “a batt of synthetic fibrous material 14 [orange] that contains a plurality of non-crimped reinforcing yarns 15” (pink) that “extend in the machine direction of the fabric.” *Id.*, 3:29-32. These reinforcing yarns 15 are “at least partially encapsulated in and/or ... at least partially impregnated with polymer,” such as “one or more of ... polyurethane (e.g. thermoplastic polyurethane), polyester or copolyester, polyamide or copolyimide, silicone or thermoplastic elastomer.” *Id.*, 2:22-27. Moreover, these reinforcing yarns “are preferably coated with an elastomeric polymer.” *Id.*, 2:27-30.



Excerpt from Lidar, Fig. 1 (annotated)

2. The Sudre-Adanur-Lidar Combination

213. In the Sudre-Adanur-Lidar combination, the “textile batt [that] is needed to at least one side of the endless base material” (*see* my discussion above of claim 13) includes “a batt of synthetic fibrous material 14 that contains a plurality of non-crimped reinforcing yarns 15” that “extend in the machine direction of the fabric,” as taught by Lidar, *e.g.*, as shown in Fig. 1. EX1014, 3:29-31. The reinforcing yarns are “at least partially encapsulated in and/or ... at least partially impregnated with ... one or more of ... polyurethane (e.g. thermoplastic polyurethane), polyester or copolyester, polyamide or copolyimide, silicone or thermoplastic elastomer.” EX1014,

2:24-27. Optionally, the combination base fabric also includes “a moulded mesh membrane 12.” EX1014, 3:20-21.

214. Like the '566 Patent, Lidar relates generally to papermachine clothing and aims to produce high quality papermachine clothing).

3. *Motivation for the Combination*

215. It is my opinion that a POSITA would have been motivated to incorporate reinforcing yarns into the batt of the combination fabric, as taught by Lidar, for at least the following reasons.

216. First, non-crimped reinforcing yarns in the batt “offer[] the advantage of providing a greater pressure contact area,” which “provid[es] enhanced dewatering with reduced marking tendency.” EX1014, 2:3-8. As I have explained previously, water management is crucial to manufacture of high-quality paper products, and a fabric structure that provides enhanced dewatering is desirable.

217. Second, the reinforcing yarns in the batt, when provided together with the mesh membrane, “offer[s] vastly improved resistance to compaction and therefore longer working life” for the fabric. EX1014, 2:13-18. Again, as I discussed above, replacement of press felts in a papermachine context is a time-consuming and elaborate operation, and a POSITA would have wanted to extend the lifetime of a press felt as much as reasonable possible.

218. Third, incorporation of reinforcing yarns into the batt of a press felt is conventional, and produces the predictable result of a press felt having reinforcing yarns in its batt layer.

219. It is my opinion that a POSITA would have expected success in pursuing this implementation at least because Lidar, like Sudre and Adanur pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics. *See* EX1014, Abstract.

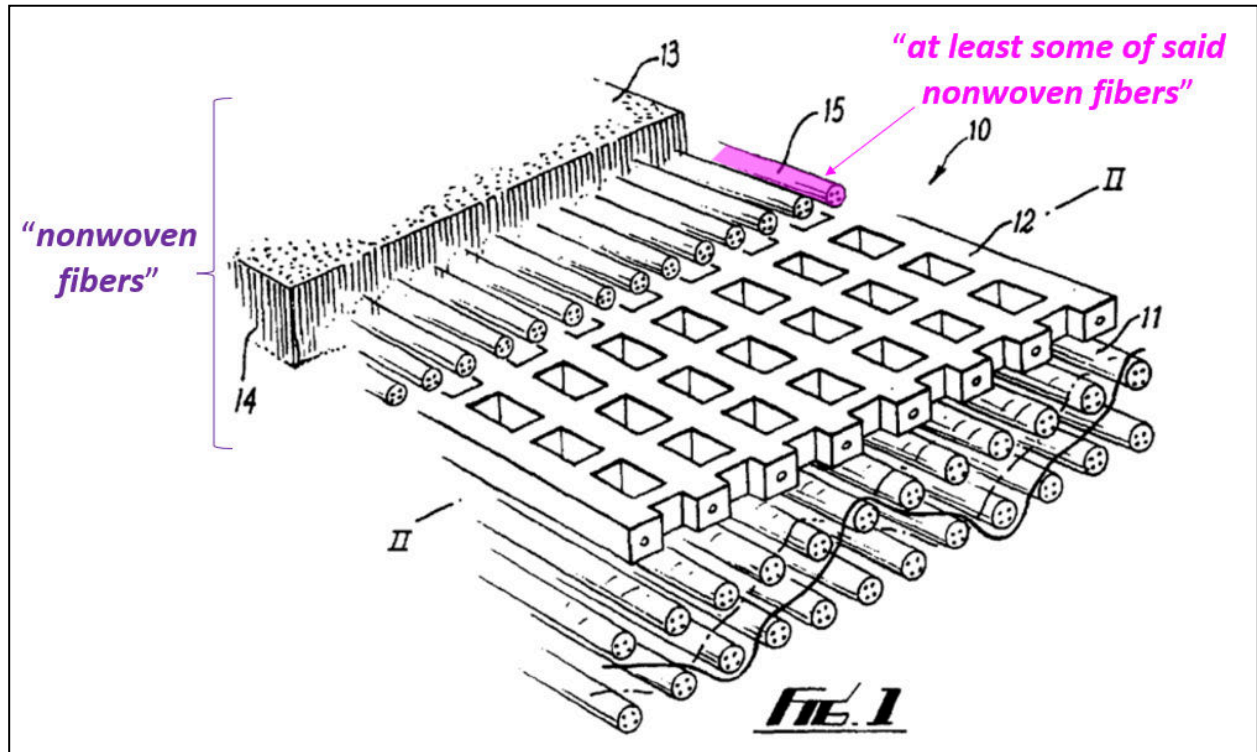
4. *Analysis*

(a) Claim 14

[14.0] The clothing according to claim 13, wherein at least some of said nonwoven fibers include or are formed of an elastomer or a polyurethane.

220. In the combination clothing, one or both of the layers of textile batt (*nonwoven fibers*; *see* my discussion above for claim 13) includes “a batt of synthetic fibrous material 14 that contains a plurality of non-crimped reinforcing yarns 15” (*at least some of said nonwoven fibers*), as taught by Lidar. EX1014, 3:29-31. These reinforcing yarns are indicated in pink in Lidar’s Fig. 1, below. *See also* EX1014, 1:38-40 (“said batt fibre layer contains a non woven array of yarns extending in the intended machine direction of the papermachine clothing”), 2:1-3 (“At least some and preferably all of the reinforcing non woven array of yarns provided in the

batt layer are preferably straight and thus non crimped”), 3:49-54, claim 1, claim 13.



Excerpt from Lidar, Fig. 1 (annotated)

221. Consistent with Lidar’s teachings, the reinforcing yarns of the batt layer (*at least some of said nonwoven fibers*) are “at least partially encapsulated in and/or ... at least partially impregnated with ... one or more of ... polyurethane (e.g., thermoplastic polyurethane) ... or thermoplastic elastomer” (*include or are formed of an elastomer or a polyurethane*).

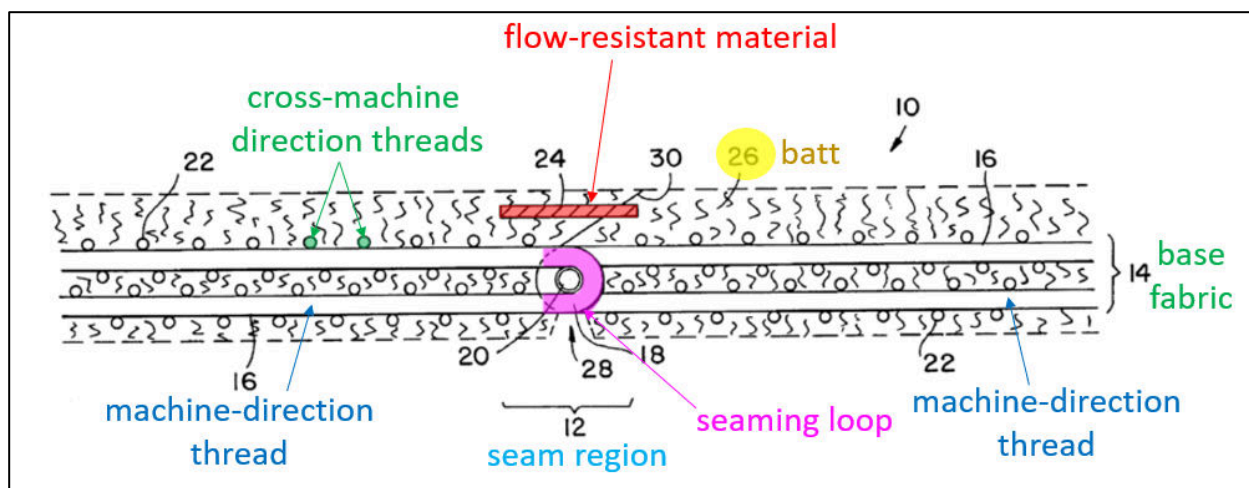
EX1014, 2:24-27; *see* 2:27-29 (“The yarns of the non-woven array are preferably coated with an elastomeric polymer”), 3:33-34 (“The reinforcing

yarns comprise multifilaments fully encapsulated in an elastomeric thermoplastic polymer material”), claim 5, claim 12.

E. [GROUND 1E] – Sudre-Adanur-Yook Renders Obvious Claim 15

1. Yook

222. Like Sudre and Adanur, Yook relates to a “papermaker’s fabric,” *e.g.*, an “on-machine-seamable press fabric for the press section of a paper machine. EX1009, 1:12-16. The seam region of Yook’s fabric is shown in Fig. 1, which I have reproduced below. *See id.*, 4:62-63. The fabric includes a woven base fabric having machine-direction threads (indicated in dark blue) woven with cross-machine direction threads (indicated in green). *See id.*, 4:64-5:5. Consistent with the structure of Sudre’s fabric, and as was conventional in press felts, the “[m]achine-direction yarns 16 ... form[ing] seaming loops 18 which are interdigitated to create a passage through which a pintle 20 is directed to join the base fabric 14 into endless form.” *Id.*, 4:64-5:3. Batt fiber (indicated in yellow) is needled “into the base fabric.” *Id.*, 5:10-13.



Excerpt from Yook, Fig. 1 (annotated)

223. The fabric also includes a “strip 24 of flow-resistant material” (red) that “is disposed over the seam region” and “attached thereto by sewing or by an adhesive.” EX1009, 5:6-10. The strip “may be a ribbon of fine woven or nonwoven material, or a ribbon of porous polymeric membrane.” *Id.*, 7:21-23. Yook describes that the “flow-resistant-material ... compensate[s] for differences between the permeabilities to air and water of the seam and of the rest of the papermaker's fabric.” EX1009, 3:66-4:2. Specifically, the strip “provides the seam with permeabilities to air and water substantially identical to that of the rest of the papermaker's fabric.” *Id.*, 4:16-18.

2. The Sudre-Adanur-Yook Combination

224. In the Sudre-Adanur-Yook combination, a “strip [] of flow-resistant material” is “is disposed over the seam region” of the Sudre-Adanur fabric,

and is “attached thereto by sewing or by an adhesive,” as taught by Yook.

EX1009, 5:6-10.

225. Like the '566 Patent, Yook relates generally to papermachine clothing, and aims to produce high quality papermachine clothing.

3. *Motivation for the Combination*

226. It is my opinion that a POSITA would have been motivated to incorporate a strip of flow-resistant material in the vicinity of the seam region of the combination fabric, based on the teachings of Yook, for at least the following reasons.

227. First, a “difference in water permeability, or flow resistance,” between the seam region and the rest of a papermaker’s fabric can “cause sheet marking” in paper products manufactured using such a fabric. EX1009, 3:37-39. A POSITA would have been motivated to incorporate a strip of flow-resistant material in the seam region of a press felt to “provide[] the seam with permeabilities to air and water substantially identical to that of the rest of the papermaker's fabric,” which, as I have discussed previously, mitigates the risk of sheet marking and thus enables manufacture of higher quality paper products. EX1009, 4:16-18.

228. Second, these permeability differences “tend[] to become more pronounced over time as more batt fiber is lost from the ‘roll’ side of the

press fabric.” EX1009, 3:39-41. A POSITA also would have been motivated to incorporate a strip of flow-resistant material to avoid exacerbation of any such remaining differences, thereby prolonging the viable lifetime of the press fabric. And again as I have discussed previously, an extended press fabric lifetime is advantageous, *e.g.*, given the complexities associated with replacing such fabrics in a papermachine context.

229. Third, integration of a strip of flow-resistant material in the seam region of a press felt was conventional, and produced the predictable result of a press felt having a strip of flow-resistant material in its seam region.

230. It is my opinion that a POSITA would have expected success in incorporating a strip of flow-resistant material in the seam region of the combination fabric at least because Yook, like Sudre and Adanur, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics. *See* EX1009, Abstract.

4. *Analysis*

(a) Claim 15

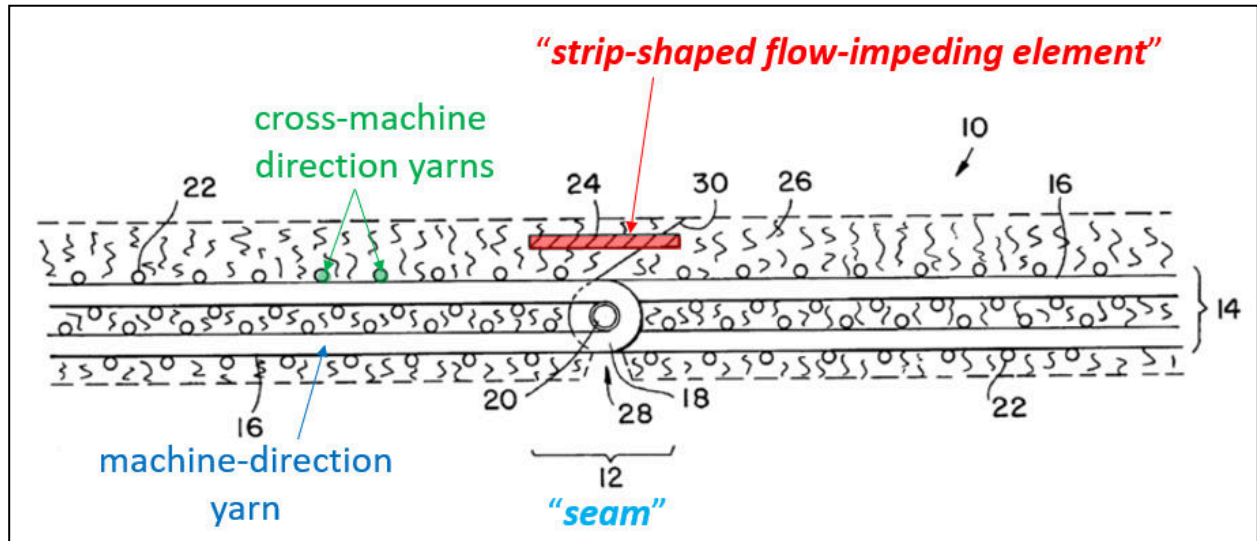
[15.0] The clothing according to claim 1, which further comprises at least one strip-shaped flow-impeding element provided in a vicinity of said seam, said at least one strip-shaped flow-impeding element being configured to cause a

permeability for at least one of air or water in said vicinity of said seam to be substantially identical to a remainder of the clothing.

231. The Sudre-Adanur-Yook combination fabric includes a “strip 24 of flow-resistant material ... disposed over the seam region” (*at least one strip-shaped flow-impeding element provided in a vicinity of said seam*), as taught by Yook and as illustrated in Yook’s Fig. 1, which I have reproduced below.³ EX1009, 5:6-8; *see* 3:65-67 (“an on-machine-seamable papermaker’s fabric having flow-resistant material applied over or adjacent to its seam”), 4:15-16 (“A strip of flow-resistant material overlies the seam and is attached thereto”), 7:21-30 (“The flow-resistant material may be a ribbon of fine woven or nonwoven material, or a ribbon of porous polymeric membrane applied to the seam area by sewing or adhesive prior to needling with batt fiber, or inserted between the layers of a laminated fabric, such as that shown in FIG. 5, on each side of the seam region and attached there by sewing or adhesion prior to needling with batt fiber. Polymeric foams or

³ Yook’s Fig. 1 is provided for illustrative purposes. The flow-impeding element in the Sudre-Adanur-Yook combination is similarly situated in the vicinity of the seam region illustrated in the Sudre-Adanur composite figure provided in [1.3].

liquid resins may alternatively be applied”), 4:22-32, 5:55-59, 7:6-9, claim 1, claims 4-9.



Excerpt from Yook, Fig. 1 (annotated)

232. This flow-impeding element “provides the seam with permeabilities to air and water substantially identical to that of the rest of the papermaker’s fabric” (*configured to cause a permeability for at least one of air or water in said vicinity of said seam to be substantially identical to a remainder of the clothing*). EX1009, 4:16-18; see 4:32-34, claim 1, claim 9, Abstract.

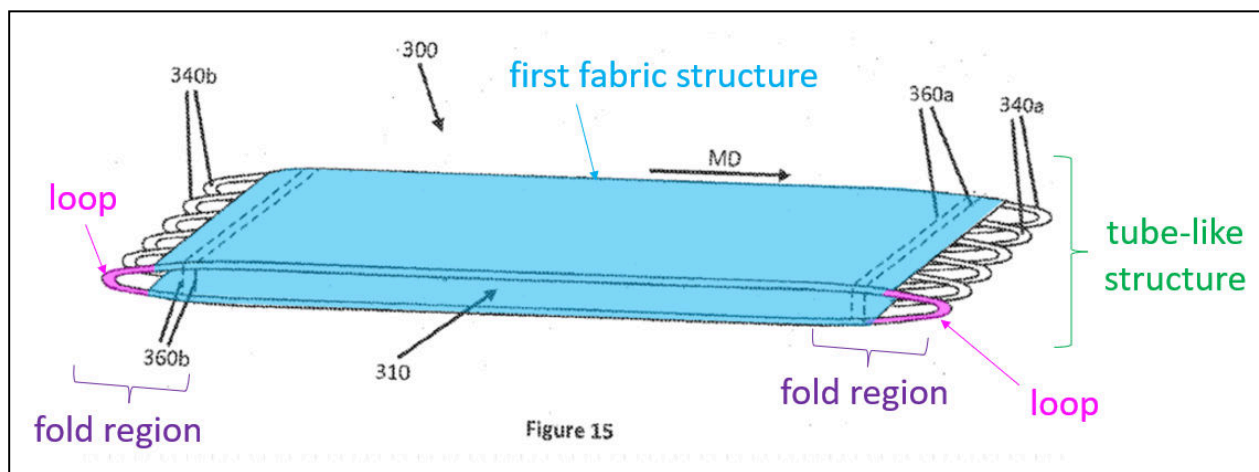
F. [GROUND 2A] – Sudre-Lee-Penven Renders Obvious Claims 1, 3, and 10-13

1. Lee

233. Like Sudre, Lee relates to “seamed press felts for use in the manufacture of paper and similar products in a papermaking or like machine.” EX1005, 1 (1st paragraph). Lee’s seamed press felt includes a

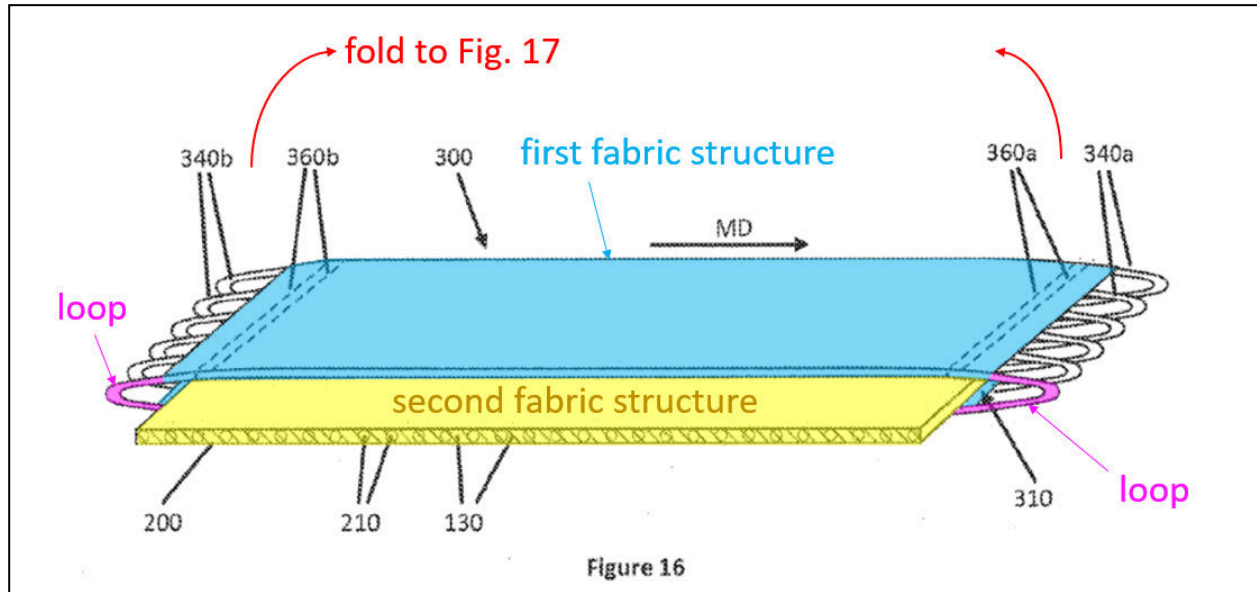
“base fabric material” formed of a “first fabric structure,” which can be a flat woven fabric. *Id.*, 8 (last paragraph), 2 (last paragraph), 11.

234. Lee’s first fabric structure is shown in Fig. 15, which I have annotated below. As was conventional for seamable press felts, and as is the case for Sudre’s press felt, Lee’s first fabric structure (shaded in blue) is “arranged in two superimposed layers joined by the MD oriented yarns at CD oriented fold regions [marked in purple] at each of two opposing ends thereof in order to form a continuous unbroken tube-like structure.” *Id.* Again as was conventional for seamed press felts—and again consistent with the structure of Sudre’s two-ply structure (see EX1004, 3:24-4:1), Lee’s first fabric structure has “MD oriented yarns” (see the arrow “MD” indicating the machine direction) that “form loops [marked in pink] at the fold regions to define a uniform channel extending the CD width of the press felt.” *Id.*



Excerpt from Lee, Fig. 15 (annotated)

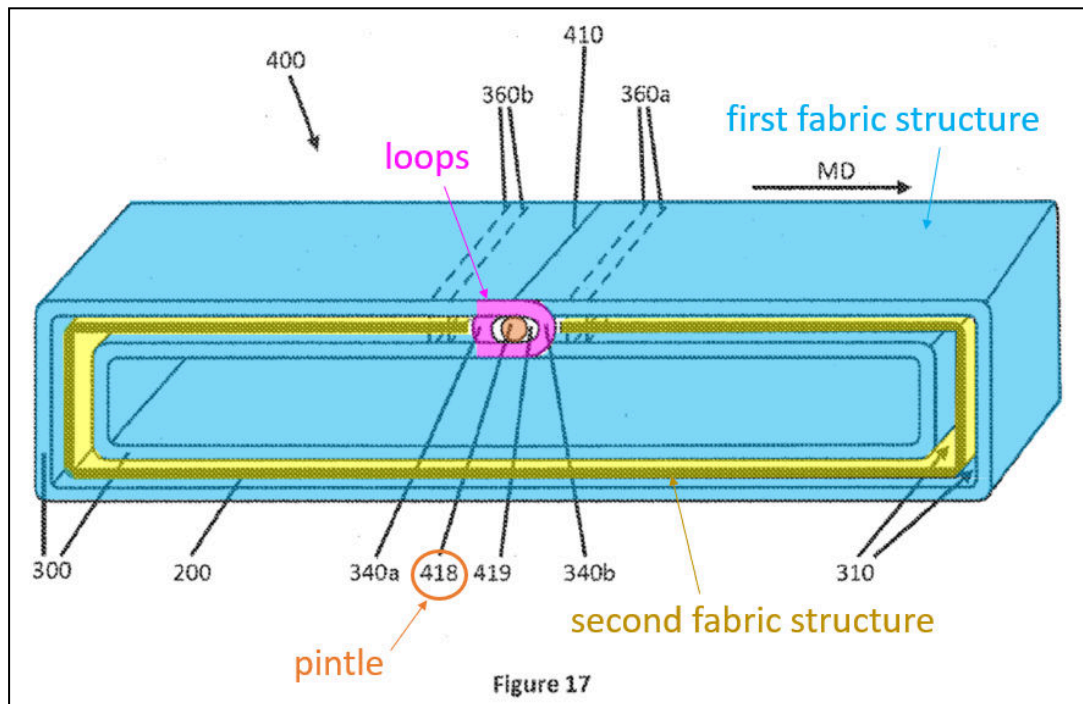
235. Lee's press felt also includes a "second fabric structure 200," which I have shaded in yellow in Fig. 16, below. Lee sometimes alternatively refers to this second fabric structure as a "generally planar yarn assembly." This second fabric structure "is inserted into the open central area 310 interior to the flattened continuous tube 300" of Fig. 15, *i.e.*, into the center of the endless tube formed by Lee's seamable first fabric structure. EX1005, 30 (last paragraph)-31 (1st paragraph).



Excerpt from Lee, Fig. 16 (annotated)

236. Fig. 17, which I have annotated below, shows a press felt that has been assembled from the structure of Fig. 16. See EX1005, 16 (3rd paragraph). Again, consistent with Sudre, and as was conventional, the fabric assembly of Fig. 16 is folded (as indicated by the red arrows I have added to Fig. 16) such that the yarn loops (pink) of the first fabric structure

are “brought together and intermeshed,” thus “provid[ing] open channel 419 through which pintle 418 may be inserted to close the opposing ends of press felt 400.” *Id.*, 32 (2nd paragraph). The result is the seamed structure of Fig. 17, with the loops (pink) interdigitated and a pintle (orange) inserted through the channel that is defined by the interdigitated loops.



Excerpt from Lee, Fig. 17 (annotated)

237. Lee generally describes that “the yarn type, size and spacing are all important features of the first fabric structure,” noting that these features affect fabric characteristics such as “water removal, permeability and void volume in the completed press felt,” impact the ability for the seam loops to be “intermeshed without any undue distortion,” and contribute to “seam

tensile strength.” EX1005, 26 (2nd paragraph). Moreover, Lee provides parameter details regarding the structure and dimension of the yarns to achieve desired performance characteristics for the fabric. For instance, Lee explains that “the yarns of the first array [*i.e.*, the yarns of the seamable endless fabric, shaded in blue] are single circular cross-sectional shaped monofilaments having a diameter of from about 0.3mm to 0.6mm.” *Id.*, 12 (1st paragraph). Additionally, Lee describes that the MD yarns in the first fabric structure (*i.e.*, the seamable endless fabric, shaded in blue) “are preferably arranged to provide a yarn density of from 15 to 40 yarns/inch (5.9 to 15.7 yarns/cm).” *Id.*

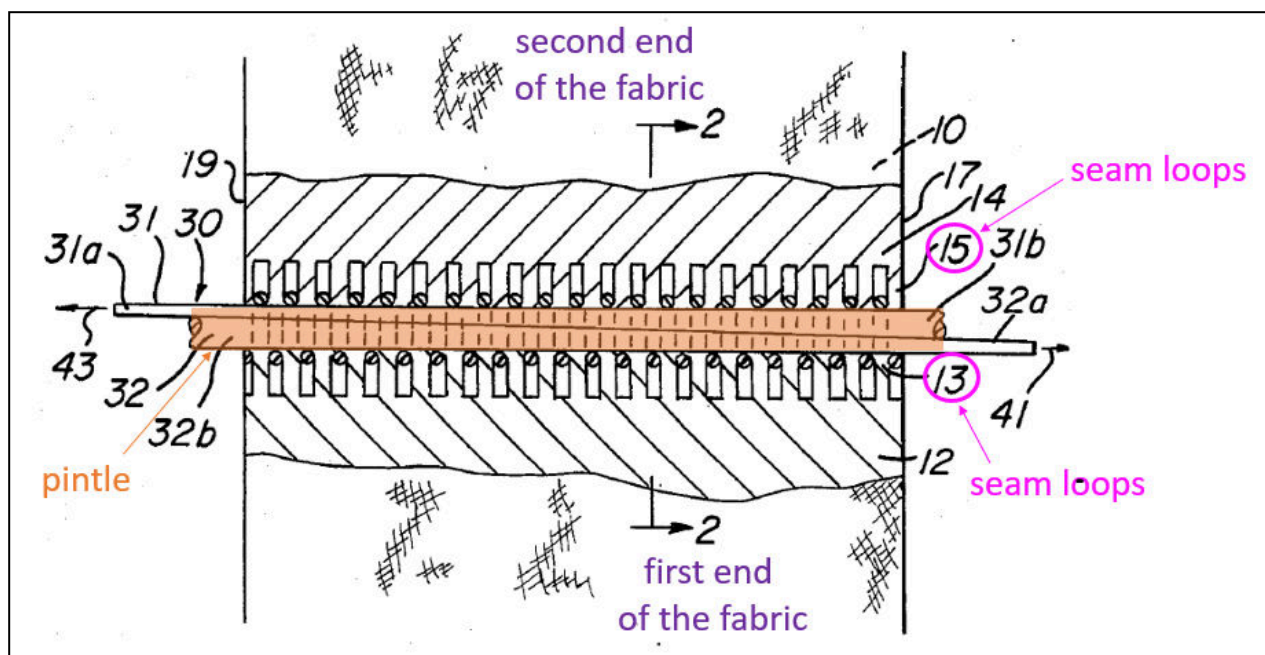
238. Lee provides similar ranges for yarn diameter and density of the second fabric structure (*i.e.*, the generally planar yarn assembly, shaded in yellow). *See* EX1005, 12 (2nd paragraph). Importantly, Lee indicates that in some cases, *e.g.*, depending on the intended application for the fabric “the yarn density and size in the second array 215 [of yarns in the second fabric structure, shaded yellow] be equal to that in the first array 115 [of yarns in the first fabric structure, shaded blue].” *Id.*, 29 (1st paragraph).

2. *Penven*

239. Like Sudre and Lee, Penven relates to “papermaking machine felts” and “methods of forming a seam in a papermakers felt.” EX1006, 1:8-10.

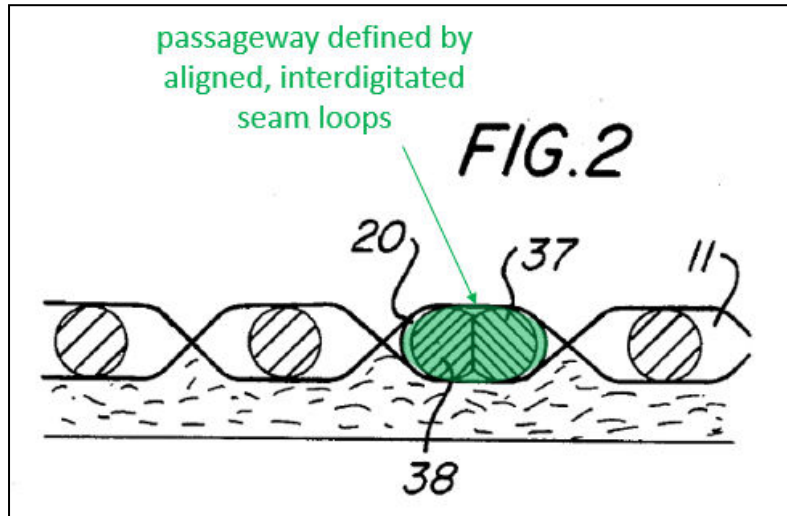
Penven's approach, which "is intended primarily for use in joining the ends of a papermaker's wet felt to form an endless felt"—*i.e.*, to conventional seaming techniques—is applicable to "various configurations of the base fabric ... [that] are well known in the art." *Id.*, 2:65-67.

240. An example of a "papermaker,s [sic] felt 10 [that] is formed in a conventional manner" is illustrated in Penven's Fig. 1, which I have reproduced and annotated below. EX1006, 3:8-9. Just like Sudre's fabrics, and as was standard for seamable press felts, this conventional felt includes "a base fabric 11 having a first end 12 and a second end 14," which I have marked in purple. "Spaced apart loops 13," shown in pink, are "formed at end 12 so as to alternately intermesh with loops 15 formed at end 14 when the ends 12 and 14 are aligned adjacent each other to form an endless felt." *Id.*, 3:8-13. And also like Sudre's fabric, and like conventional seamable press felts, the interdigitation of the loops "forms a substantially tubular passageway 20 through which a locking element or pintle [shaded in orange] may be inserted," to thereby "close[] the seam and provide[] the desired endless felt." *Id.*, 3:14-19.



Excerpt from Penven, Fig. 1 (annotated)

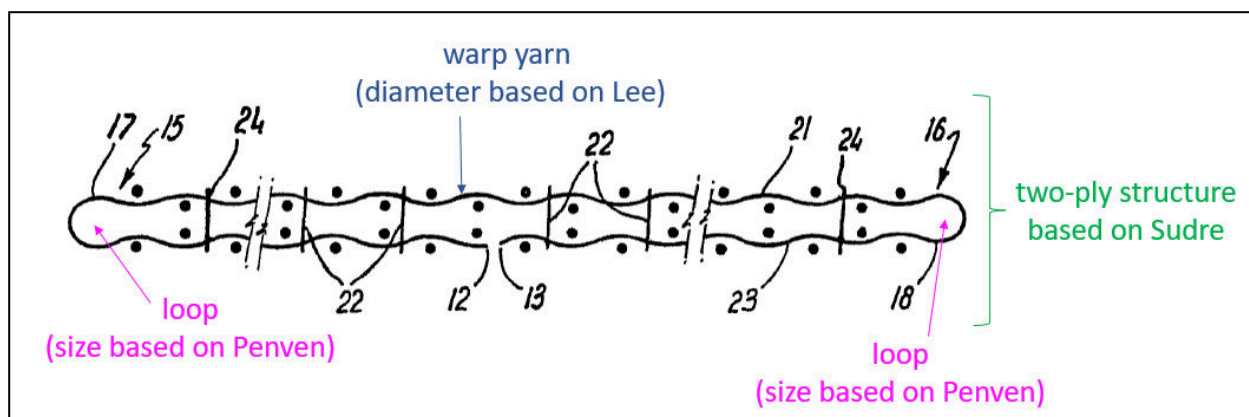
241. In the context of these conventional fabrics, Penven describes that “a *typical* seam in a papermaker’s fabric [has] an internal void diameter of about 50 mils.” EX1006, 3:64-66. This “internal void diameter” refers to the inside diameter of the seam loops. This is illustrated in Penven’s Fig. 2 (reproduced and annotated below). This figure shows “a cros [sic] section along line 2—2 of FIG. 1,” *i.e.*, a cross-section looking down the channel that is defined by the interdigitation of the loops. EX1006, 2:27.



Excerpt from Penven, Fig. 2 (annotated)

3. *The Sudre-Lee-Penven Combination*

242. I explain here how the teachings of Sudre, Lee, and Penven can be combined. This combination uses the “endless base material” described by Sudre as a starting point, *e.g.*, the base material addressed in Sudre’s Figs. 1-3. EX1004, 2:25-3:2. In this base material, the specific diameter of the machine direction (warp) threads is based on Lee’s description of warp thread diameters in papermachine clothing, and the warp thread density is also based on the teachings of Lee. The seam loops are sized according to Penven, *i.e.*, to “have an internal void diameter of about 50 mils.” EX1006, 3:64-66. I have illustrated this schematically in the combination figure below.



Sudre-Lee-Penven composite figure based on Sudre, Fig. 2

243. In more detail, the warp threads in this combination fabric generally have “a diameter of from about 0.3mm to about 0.6mm,” which is the range of warp thread diameters that is taught by Lee. EX1005, 12 (1st paragraph). Also as taught by Lee, the warp threads in the combination fabric are provided in “a yarn density of from 15 to 40 yarns/inch (5.9 to 15.7 yarns/cm).” EX1005, 12 (1st paragraph).

244. Lee provides a specific example that I would like to address as a particular implementation of this combination fabric: the warp threads have “a diameter of about 0.4mm” and are present in a “yarn density” of “24 yarns/in (9.45 yarns/cm).” EX1005, 28 (2nd paragraph).

245. It is important to note that Lee describes this specific example (0.4mm diameter warp threads, and a warp thread density of 9.45 threads/cm) in the context of the second fabric structure—that is, the planar yarn assembly (shaded yellow in my discussion of Lee above) that is inserted into the

center of Lee's seamable endless first fabric (shaded blue above). *See* EX1005, 28 (2nd paragraph). However, Lee indicates that these specific values are also applicable to the first fabric structure, *i.e.*, to the seamable endless base material (blue). For instance, Lee specifically states that "certain applications may dictate that the **yarn density and size** in the second array 215 be **equal to** that in the first array 115." EX1005, 29 (1st paragraph). That is, Lee teaches that it is appropriate to implement the same warp thread density and warp thread size for both the first and the second array. This is reinforced elsewhere in Lee: 29 (2nd paragraph) ("the yarns 210 of the second array 215 may be provided at a density equal to, but not less than, the yarn density of the first array 115, *i.e.* 15 to 40 yarns/inch (5.9 to 15.7 yarns/cm)"), 22 (2nd paragraph) ("A second array ... is prepared including an array comprising second yarns ... preferably having a second diameter or size equal to or less than that of the first yarns, and arranged at a selected yarn density which is preferably equal to or greater than the first yarn density"). Furthermore, I note that the thread diameter and density ranges that Lee provides for its first fabric structure (*i.e.*, for the seamable endless base fabric) encompass these specific example values that happen to be given in the context of Lee's second fabric structure. *See* EX1005, 12 (1st paragraph).

246. It is my opinion that a POSITA would have understood, or at least found obvious, that these specific values (0.4mm diameter warp threads, and a warp thread density of 9.45 threads/cm) are relevant to Lee's first fabric structure, *i.e.*, to a seamable endless base material, at least because (1) Lee unambiguously states that its first fabric structure (the seamable endless base material) and second fabric structure (the generally planar fabric) can have equal thread diameter and density, and (2) these specific example values (0.4mm diameter warp threads, and a warp thread density of 9.45 threads/cm) fall within the range that Lee specifies for the first fabric structure. For these reasons, I provide these specific values (0.4mm diameter warp threads, and a warp thread density of 9.45 threads/cm) as one example of the dimensions of a Sudre-Lee-Penven combination, *i.e.*, as applied to the "endless base material" based on Sudre. EX1004, 2:25-3:2.
247. I also note that like the '566 Patent, each of Sudre, Lee, and Penven relates generally to papermachine clothing, and again like the '566 Patent, each of these references generally aims to produce high quality papermachine clothing). EX1001, 2:7-10.

4. *Motivation for the Combination*

248. As I have already discussed extensively above, Sudre generally describes a method for manufacturing a papermaker's fabric. However, as I

also noted above, while Sudre explains that “a papermaker's fabric meeting the *particular requirements of its intended end use* as regards performance characteristics *can be produced from that base fabric in a simple and ready manner*,” it does not provide specific parameters for its fabric, such as warp thread size and spacing, that would allow those particular end-use requirements to be satisfied. EX1004, 6:14-17. Thus, consistent with my discussion above, it is my opinion that a POSITA would have been motivated to look to other known sources to identify the “particular requirements” of the fabric that would be suitable to obtain the desired “performance characteristics” for the base fabric. EX1004, 6:14-17. Moreover, because press felt technology was already a well-developed field as of the Critical Date of the '566 Patent, it is also my opinion that a POSITA would have understood that such design parameters can be easily identified, and indeed this is supported by Sudre itself, which indicates that these design parameters can be generally identified in “a simple and ready manner.” EX1004, 6:14-17. More specific reasons that would have motivated a POSITA to pursue particular Lee- or Penven-based parameters are discussed in greater detail below.

249. In general, it is my opinion that a POSITA would have expected success in implementing a press felt such as Sudre's using thread and loop

dimensions based on the teachings of Lee and Penven because all three of these references pertain to papermachine clothing. More specifically, all three of these references pertain to seamable press felts formed from flat woven base fabrics, and with this common context, it is my opinion that a POSITA would have understood the applicability of Lee's and Penven's teachings to the generic press felt disclosure of Sudre.

250. I have already discussed that Sudre relates to seamable press felts formed from flat woven base fabrics. Lee also relates to seamable press felts formed from flat woven base fabrics. *See* EX1005, Abstract, 2 (2nd paragraph). And similarly, Penven also relates to seamable press felts formed from flat woven base fabrics, describing, for instance, “papermaking machine felts” in which “the use of a seam to join the ends of a flat felt into an endless felt is often desirable.” EX1006, 1:1-17; *see* 1:65-2:13.

(a) Motivation for implementation of warp thread size

251. One aspect of the Sudre-Lee-Penven combination is the implementation of warp thread size based on the teachings of Lee. Generally, and consistent with my discussion above for the Sudre-Adanur ground, it is my opinion that a POSITA seeking warp thread size—a detail that is absent from Sudre—would have turned to another press felt reference, such as Lee. Based on the particular teachings of Lee, a POSITA would

have been motivated to implement, for example, warp threads with a diameter of about 0.3mm to 0.6mm, *e.g.*, 0.4mm, as taught by Lee, to obtain a press felt that “meet[s] the *particular requirements of its intended end*,” as instructed by Sudre. EX1004, 5.

252. There are multiple specific reasons to implement warp threads sized in this range, and I discussed these above for the Sudre-Adanur ground. These reasons are applicable here for the Sudre-Lee-Penven ground as well.

253. I would like to note that the warp thread diameters described by Lee are consistent with those of Adanur’s fabric, which, as I have mentioned previously, represents “the industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics.” EX1022. More generally, it is important to note that Lee’s range of warp thread diameters was conventional, as corroborated by Xu and Goetemann. *See* EX1023, 6:59-64; EX1024, 2:1-2. Given the conventional nature of this warp thread size range, it is my opinion that a POSITA would have been motivated to implement warp thread size in this range (*e.g.*, as taught by Lee) consistent with that standard practice. For instance, using warp threads of standard size allows manufacturing of the press felts to be compatible with standard weaving processes and other manufacturing techniques.

254. Additionally, as I discussed above for the Sudre-Adanur ground, warp threads in this size range are advantageous in that they are suitable to provide mechanical strength to the press felt, and this is yet another reason that would have motivated a POSITA to implement warp threads in this size range in the Sudre-Lee-Penven combination press felt. *See* EX1005, 26 (2nd paragraph).

255. In addition to the specific reasons I just discussed, as well as the reasons I discussed above for the Sudre-Adanur ground, it is my opinion that a POSITA would have been motivated to implement warp threads sized based on the teachings of Lee simply because this was a known, and predictable, design choice. Specifically, using warp threads in this size range for papermachine clothing, such as press felts, was a known and conventional technique. And using warp threads in this size range for papermachine clothing, such as press felts, would have produced a predictable result: simply a press felt with warp threads within this known, conventional size range.

256. Because warps threads in this size range were conventional, it is also my opinion that a POSITA would have expected success in incorporating such warp threads into the Sudre-Lee-Penven combination fabric. That is, for instance, usage of warp threads in this size range was standard, and thus

their implementation (*e.g.*, integration with manufacturing processes, as well as characterization of resulting fabrics) was well-developed. Moreover, as I indicated above for the Sudre-Adanur ground, Sudre is simply silent as to the size of its warp threads, and as such, it places no requirements on its warp threads that might indicate to a POSITA that conventionally sized warp threads would be somehow unwarranted.

(b) Motivation for implementation of warp thread density based on Lee's teachings

257. Another aspect of the Sudre-Lee-Penven combination is the implementation of warp thread density based on the teachings of Lee. Generally, and consistent with my discussion above for the Sudre-Adanur ground, it is my opinion that a POSITA seeking warp thread density—a detail that is absent from Sudre—would have turned to another press felt reference, such as Lee. Based on the particular teachings of Lee, a POSITA would have been motivated to implement, for example, a warp thread density as taught by Lee (*e.g.*, 5.9-15.7 threads/cm, or 9.45 threads/cm in a specific example), to obtain a press felt that “meet[s] the *particular requirements of its intended end*,” as instructed by Sudre. EX1004, 5.

258. There are multiple specific reasons to implement warp density in this range, and I discussed these above for the Sudre-Adanur ground. These reasons are applicable here for the Sudre-Lee-Penven ground as well.

259. I would like to note that the warp thread densities described by Lee are consistent with those of Adanur's fabric, which, as I have mentioned previously, represents "the industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics." EX1022.

260. In addition to the specific reasons I just discussed, as well as the reasons I discussed above for the Sudre-Adanur ground, it is my opinion that a POSITA would have been motivated to implement warp threads in a density based on the teachings of Lee simply because this was a known, and predictable, design choice. Specifically, using warp threads in this density range for papermachine clothing, such as press felts, was a known and conventional technique. And using warp threads in this density range for papermachine clothing, such as press felts, would have produced a predictable result: simply a press felt with warp threads within this known, conventional density range.

261. As I indicated above for the Sudre-Adanur ground, Sudre is simply silent as to the density of its warp threads, and as such, it places no requirements on its warp thread density that might indicate to a POSITA that conventional warp thread densities would be somehow unwarranted.

- (c) Motivation for implementation of seam loops sized based on Penven's teachings

262. Another aspect of the Sudre-Lee-Penven combination is the implementation of seam loops sized based on the teachings of Penven. Generally, and consistent with my discussion above for the Sudre-Adanur ground, it is my opinion that a POSITA seeking seam loop size—a detail that is absent from Sudre—would have turned to another press felt reference, such as Penven. Based on the particular teachings of Penven, a POSITA would have been motivated to implement, for example, the seam loops of the combination fabric to have a size of about 50 mils.
263. There are multiple specific reasons to implement loop sizes as taught by Penven, and I discussed these above for the Sudre-Adanur ground. These reasons are applicable here for the Sudre-Lee-Penven ground as well.
264. I would like to note that the loop sizes described by Penven are consistent with those of Adanur’s fabric, which, as I have mentioned previously, represents “the industry standard for papermakers, as well as for manufacturing of forming, pressing and drying fabrics.” EX1022. Penven, too, indicates that its loop size is conventional, describing that EX1006, 3:64-66 (“a typical seam in a papermaker’s fabric having an internal void diameter of about 50 mils.”) These seam loop sizes are compatible with conventionally sized pintles, and a POSITA would have been motivated to

implement such seam loops such that the resulting fabric would be usable with those conventional pintles.

265. In addition to the specific reasons I just discussed, as well as the reasons I discussed above for the Sudre-Adanur ground, it is my opinion that a POSITA would have been motivated to implement seam loops sized based on the teachings of Penven simply because this was a known, and predictable, design choice. Specifically, using this size of seam loops for papermachine clothing, such as press felts, was a known and conventional technique. And using seam loops of this size for papermachine clothing, such as press felts, would have produced a predictable result: simply a press felt with seam loops having a known, conventional size.

266. As I indicated above for the Sudre-Adanur ground, Sudre is simply silent as to the size of its seam loops, and as such, it places no requirements on its seam loops that might indicate to a POSITA that conventionally sized seam loops would be somehow unwarranted.

(d) Motivation for incorporation of warp threads with a circular cross-section

267. Another aspect of the Sudre-Lee-Penven combination is the implementation of round warp threads based on the teachings of Lee. Generally, and consistent with my discussion above for the Sudre-Adanur ground, it is my opinion that a POSITA seeking information about warp

thread shape—a detail that is absent from Sudre—would have turned to another press felt reference, such as Lee. Based on the particular teachings of Lee, a POSITA would have been motivated to implement, for example, round warp threads.

268. There are multiple specific reasons to implement round warp threads, and I discussed these above for the Sudre-Adanur ground. These reasons are applicable here for the Sudre-Lee-Penven ground as well.

269. In addition to those specific reasons, it is my opinion that a POSITA would have been motivated to implement round warp threads simply because this was a known, and predictable, design choice. Specifically, using round warp threads for papermachine clothing, such as press felts, was a known and conventional technique. And using round warp threads for papermachine clothing, such as press felts, would have produced a predictable result: simply a press felt with round warp threads.

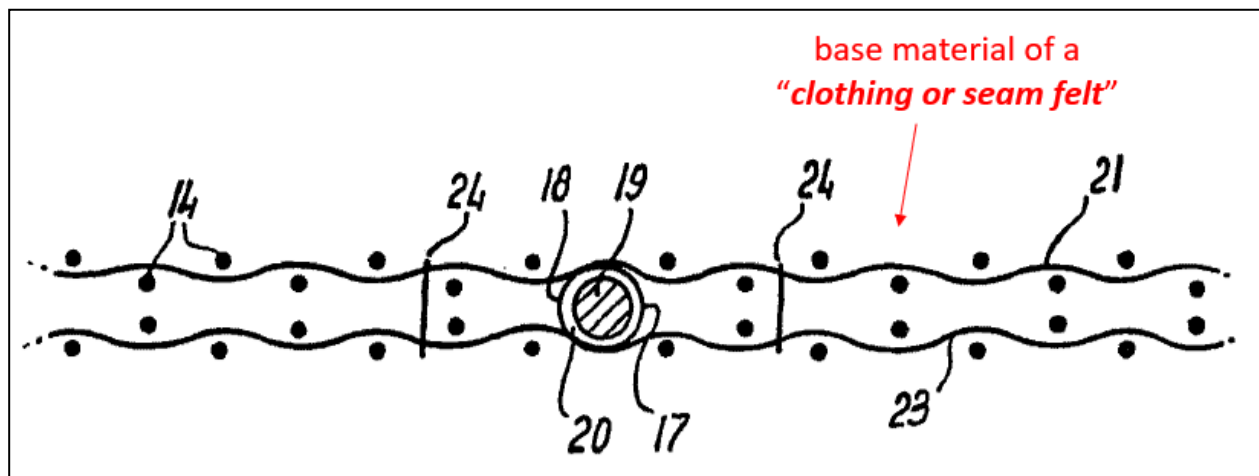
270. As I indicated above for the Sudre-Adanur ground, a POSITA would have expected success because use of round warp threads was conventional, predictable, and well-developed. Additionally, Sudre is simply silent as to the shape of its warp threads, and as such, it places no requirements on its warp thread shape that might indicate to a POSITA that round warp threads would be somehow unwarranted.

5. Analysis

(a) Claim 1

[1.0] A clothing or a seam felt for a machine for producing a fibrous material, paper, board, tissue or pulp web, comprising:

271. If the preamble is determined to be limiting, it is my opinion that the Sudre-Lee-Penven combination renders it obvious, for at least similar reasons as those I discussed above in the context of the Sudre-Adanur combination. Specifically, in the Sudre-Lee-Penven combination, just as in the Sudre-Adanur combination, Sudre describes “a papermaker’s wet felt,” *i.e.*, “papermachine clothing” (*a clothing or seam felt*). EX1004, 3:13-18; *see* Figs. 1-3, 1:2-5, 1:22-24, 2:18-3:2, 5:8, Abstract, claim 1. I have marked this *clothing* in Fig. 3, reproduced and annotated below.



Excerpt from Sudre, Fig. 3 (annotated)

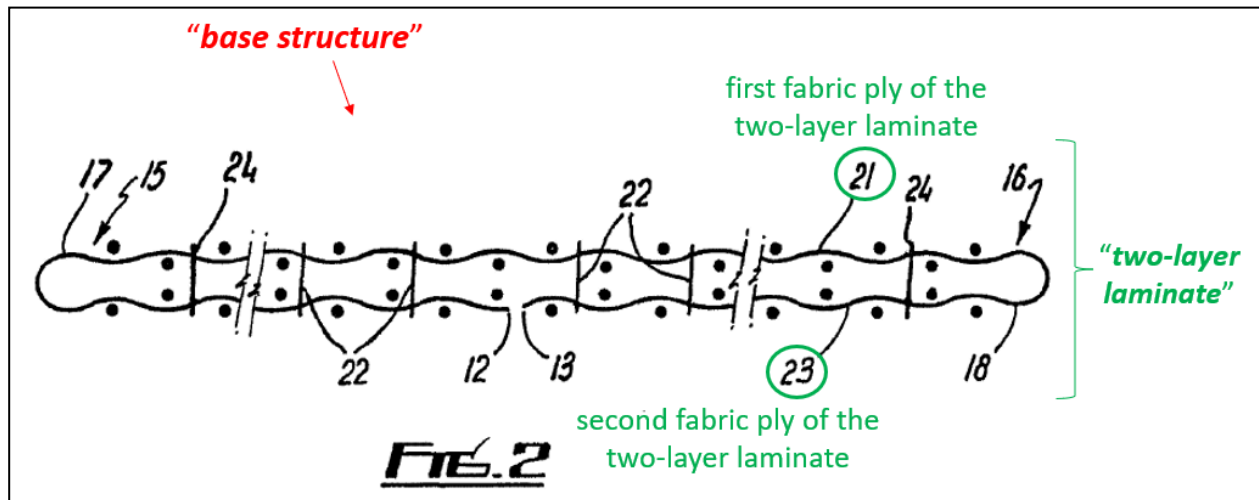
272. Papermaker’s fabrics are used in papermaking machines for manufacture of paper products (*for a machine for producing a fibrous*

material, paper, board, tissue or pulp web), as I discussed above for element [1.0] of Ground 1A, and as I discussed in general earlier in this document. See EX1021, 103; EX1013, 1:10-16.

[1.1] a base structure including a two-layer laminate structure formed of one or a plurality of flat-woven fabrics, said base structure having two end sides;

273. In the Sudre-Lee-Penven combination, this element is satisfied based on the teachings of Sudre for at least similar reasons as those I discussed above in the context of the Sudre-Adanur combination. Specifically, in the Sudre-Lee-Penven combination, the clothing includes “a base material for use in the manufacture of a papermaker’s wet felt” (*a base structure*).

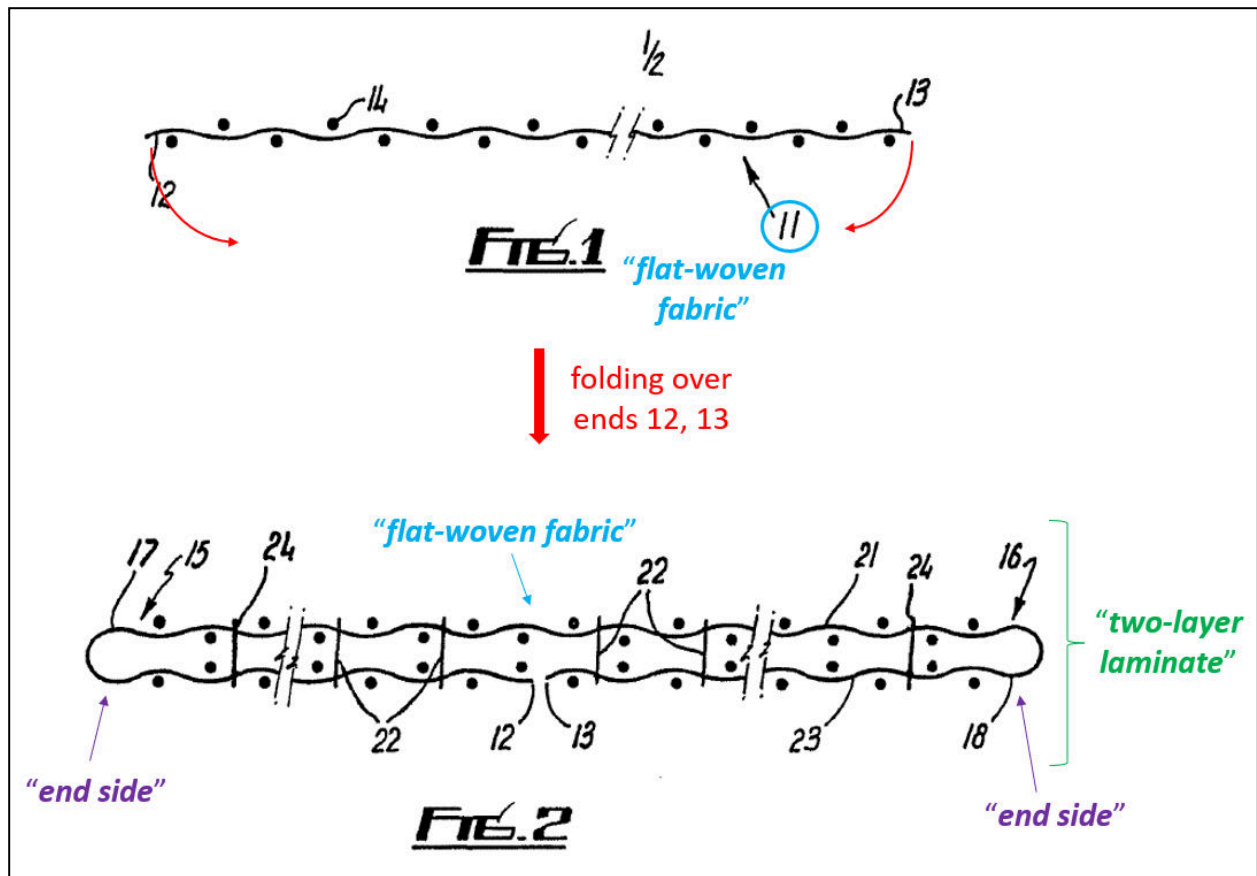
EX1004, 3:13-15; see 1:22-26, 2:25-3:2, 3:9-11, 5:20-21, 5:23-25, 6:11-17, Abstract, claim 1. I have marked this base structure in red in Sudre’s Fig. 2, reproduced and annotated below.



Excerpt from Sudre, Fig. 2 (annotated)

274. Like in the Sudre-Adanur combination, in the Sudre-Lee-Penven combination, the “base material ... comprises a flat-woven fabric 11,” the ends of which “are folded over to define a two-ply structure” (*base structure including a two-layer laminate structure*). EX1004, 3:18-19; *see* 1:25-2:1, 2:5-6, 4:4, Abstract, claim 1, claim 3. I have identified this two-layer laminate structure in green in Sudre’s Fig. 2, annotated above.

275. The generation of this two-layer laminate structure is illustrated in Sudre’s Figs. 1 and 2, which are reproduced and annotated below. Specifically, the “two-ply structure” (green) is formed by “fold[ing] over” the “free ends 12, 13” of “a flat-woven fabric 11 [marked in blue] of open weave construction” such that “the free ends [are] brought into substantial abutment” (*two-layer laminate structure formed of one ... flat-woven fabric*). EX1004, 3:14-19; *see* 2:25-3:2, claim 5, 4:2-3.



Excerpt from Sudre, Figs. 1-2 (annotated)

276. The resulting "two-ply structure [has] fold regions 15, 16" (*end sides*) at its two opposing ends (*said base structure having two end sides*).

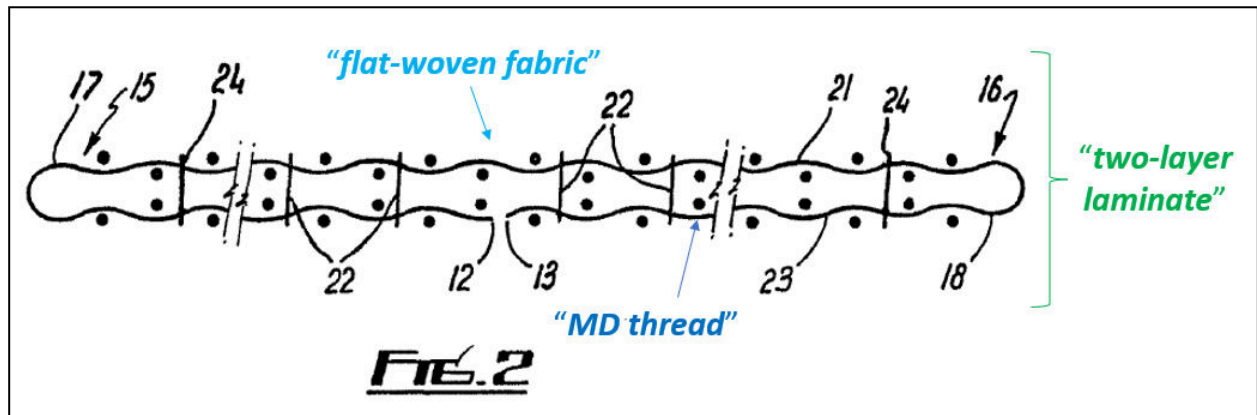
EX1004, 3:18-19; *see* 1:25-2:2, claim 5, claim 1. I have marked these end sides in purple in Fig. 2 above.

[1.2] said laminate structure having MD threads being monofilaments with a round cross section forming seam loops at said two end sides of said base structure, said seam loops interconnecting said two layers of said laminate

structure, said seam loops having a diameter LD and said associated MD threads having a diameter MDYD;

MD threads in the combination

277. Consistent with my discussion above for the Sudre-Adanur ground, the flat-woven fabric of the Sudre-Lee-Penven laminate structure includes “warp yarns” (*MD threads*) that “extend in the machine direction of the eventual papermaker’s fabric.” EX1004, 1:10-12. These MD threads are marked in dark blue in Fig. 2, reproduced and annotated below.



Excerpt from Sudre, Fig. 2 (annotated)

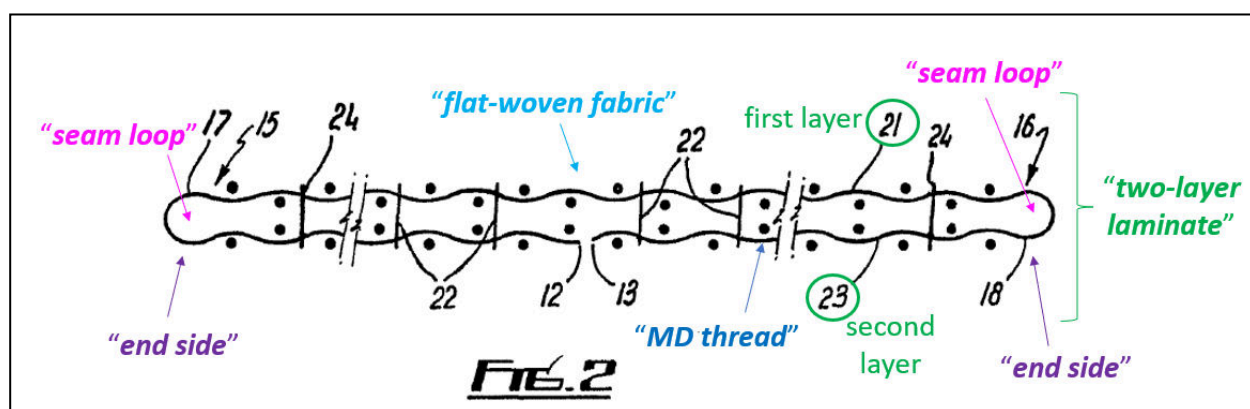
278. As I discussed above for the Sudre-Adanur ground, Sudre describes that “such machine direction yarns will ordinarily comprise monofilament yarns” (*MD threads being monofilaments*). EX1004, 4:23-25.

279. In the Sudre-Lee-Penven combination, the monofilament machine direction threads are “circular cross-sectional shaped monofilaments” (*MD threads being monofilaments with a round cross section*), based on the teachings of Lee. EX1005, 12 1st paragraph; see 26 last paragraph (“the

yarns 110 of the first fabric structure 100 are ... monofilaments having a preferably circular cross-sectional shape”), 27 1st paragraph (“circular cross-section monofilaments”), claim 27 (“the yarns of the first array are circular in cross-section”), claim 28 (“the yarns of the first array are single circular cross-sectional shaped monofilaments”), claim 32. I discussed above the reasons that would have motivated a POSITA to use round MD threads.

Seam loops in the combination

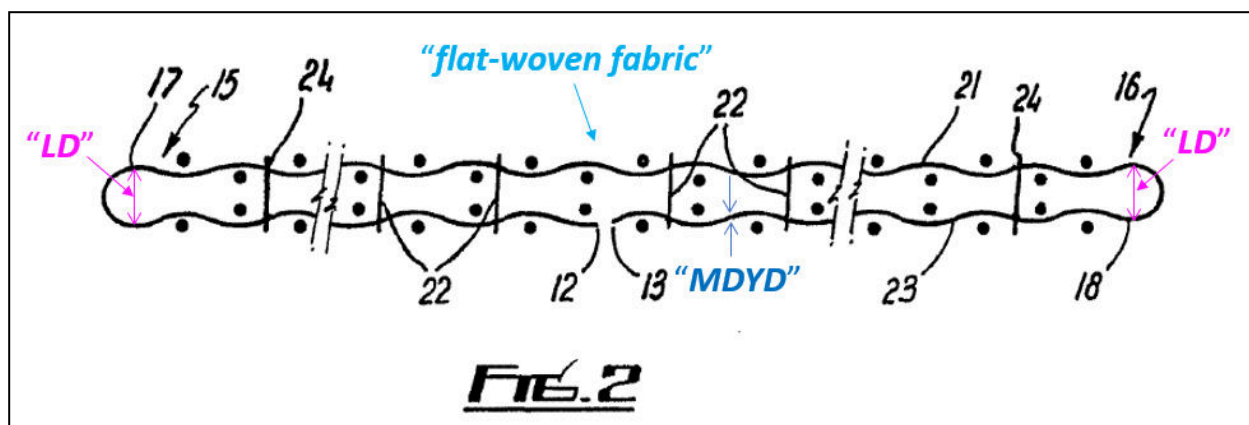
280. Consistent with my discussion for the Sudre-Adanur combination, in the Sudre-Lee-Penven combination, Sudre describes that “[w]eft threads 14 are removed from the fold regions 15, 16 ... to give loops 17, 18 extending outwardly therefrom” (*seam loops at said two end sides of said base structure*). EX1004, 3:22-24; *see* Abstract. I have marked these seam loops in pink in Fig. 2, reproduced and annotated below.



Excerpt from Sudre, Fig. 2 (annotated)

281. As I discussed above, and as was conventional for seamable press felts, the seam loops are formed by the MD threads: “In the event that the machine direction threads are to form loops at the respective fabric ends for interdigitation and receipt of a pintle wire” (***MD threads ... forming seam loops***). *Id.*, 4:21-23; *see* 2:2-4, claim 1, claim 5. Also as discussed above, and as was conventional, ***said seam loops interconnect said two layers of said laminate structure***. That is, the seam loops are formed of MD yarns that extend from the first layer to the second layer of the laminate structure, thus interconnecting the two layers. *See* EX1004, Fig. 2.

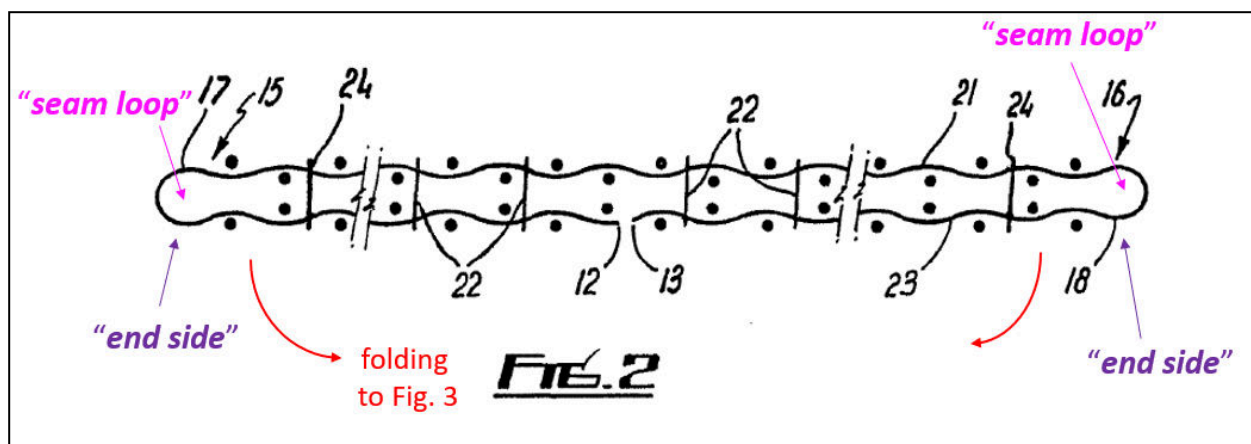
282. The inside diameter of the seam loops (***said seam loops having a diameter LD***), which I have indicated in Sudre’s Fig. 2, reproduced below, is based on the teachings of Penven. I discuss this further in element [1.5] below. *See* EX1006, 3:64-66. The MD threads that form the seam loops have a diameter (***associated MD threads having a diameter MDYD***), which I have also indicated in Fig. 2, that is based on the teachings of Lee. I discuss this further in element [1.4] below. *See* EX1005, 12 (1st paragraph), 28 (2nd paragraph).



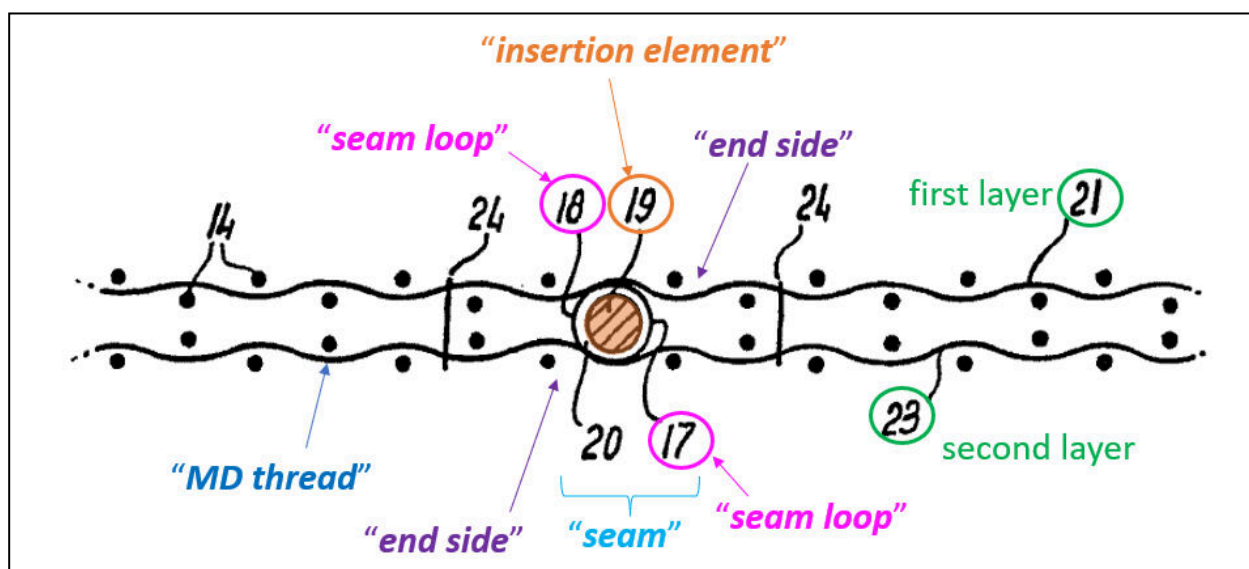
Excerpt from Sudre, Fig. 2 (annotated)

[1.3] a seam interconnecting said end sides to make the clothing endless, said seam being formed by interengaging said seam loops of said two end sides and an insertion of an insertion element;

283. As I discussed above for the Sudre-Adanur combination, and again as was conventional for seamable press felts, in the Sudre-Lee-Penven combination, “the two-ply structure” of Sudre’s Fig. 2 is “brought into endless form by the interdigitation of such loops” (***interengaging said seam loops of said two end sides***). EX1004, 3:24-26; *see* Abstract, 1:14-18, 2:13-17, 3:9-10. This is illustrated in Sudre’s Figs. 2-3, which I have reproduced and annotated below.



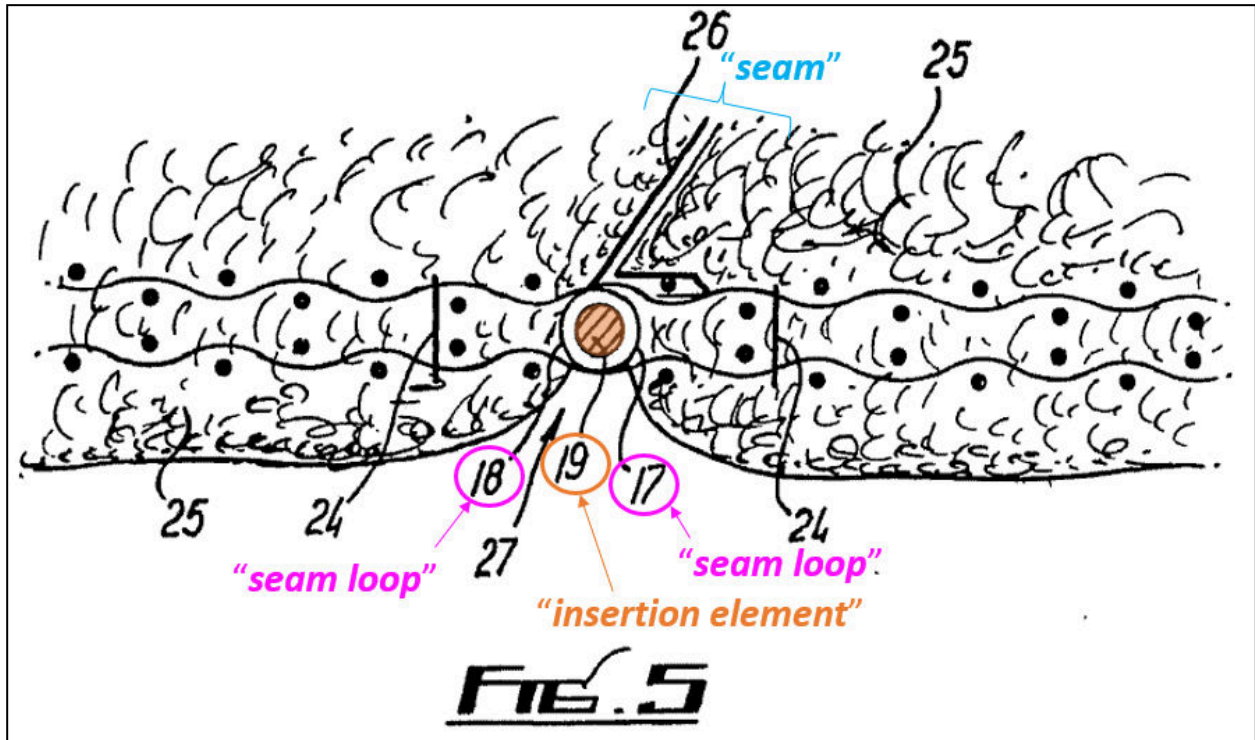
Excerpt from Sudre, Fig. 2 (annotated)



Excerpt from Sudre, Fig. 3 (annotated)

284. As I discussed above, and again as was conventional, Sudre describes “the introduction of a pintle wire 19 into the tunnel 20 formed thereby” (*insertion of an insertion element*). EX1004, 3:26-4:1; see 4:21-24, 1:14-18, Abstract. I have shaded the pintle in orange in Sudre’s Fig. 3, above.

285. Once again as was conventional, the interdigitation of the loops and insertion of the pintle wire form a seam, as described by Sudre: “The loops (17, 18) may be interdigitated directly to receive a pintle wire into engagement and thus form a seam” (*said seam being formed by interengaging said seam loops ... and an insertion of an insertion element*). EX1004, Abstract; see 2:13-17, 3:9-10, 1:14-18. I have marked the seam in blue in Fig. 3 (above) and Fig. 5 (below).



Excerpt from Sudre, Fig. 5 (annotated)

286. The seam can be considered to *interconnect said end sides* because the loops of the two end sides are interdigitated at the seam, as I discussed above and as was conventional for seamed press felts. See EX1004,

Abstract, 2:13-17. Alternatively/additionally, the seam can be considered to *interconnect said end sides* in that the presence of the pintle wire through the channel defined by the interdigitated loops holds together the loops and thus also holds together the two end sides. *See* EX1004, Abstract, 2:13-17.

287. The resulting seamed fabric is *endless*, *e.g.*, in that the connection of one end side to the other at the seam forms the clothing into a continuous loop. *See* EX1004, 2:26-3:1, 1:3-4, 2:12, 5:9-10. Indeed, this is the conventional way to produce an endless seamed press felt. Specifically, Sudre describes that the seam interconnecting the end sides *makes the clothing endless*: “the two-ply structure being brought into endless form by the interdigitation of such loops and the introduction of a pintle wire,” *i.e.*, by formation of the seam. EX1004, 3:24-26.

[1.4] said seam having a loop density of between 64% and 90%; and

288. In the Sudre-Lee-Penven combination, both the MD thread density and the diameter of the MD threads of the combination fabric, which together dictate the loop density (*see* EX1001, 6:11-18), are implemented based on Lee, as I discussed further here. I discussed above some reasons that would have motivated a POSITA to implement these dimensions in the combination fabric.

The loop density of Lee's specific example falls within the claimed loop density range

289. First, in one example implementation of the combination, the thread density and MD thread diameter is implemented in the combination fabric based on the teachings of the specific example of Lee in which “the yarn density” of the MD threads “is 24 yarns/in (9.45 yarns/cm),” and the MD threads have “a diameter of about 0.4mm.” EX1005, 28 (2nd paragraph).

290. The '566 Patent explains that loop density is calculated by multiplying twice the thread density by the MD thread diameter. *See* EX1001, 6:11-18;. For this specific example (9.45 threads/cm and 0.4mm diameter MD threads), the loop density is thus 75.6% (*i.e.*, $2*(9.45 \text{ threads/cm})*(0.4\text{mm})*(1\text{cm}/10\text{mm}))$).

291. This loop density (75.6%) falls within the claimed loop density range (***said seam having a loop density of between 64% and 90%***).

292. I also note that the '566 Patent states that “the seam loop density of a clothing can change during the production process,” and “thermal method steps can lead to shrinkage of the clothing in the transverse direction.” EX1001, 6:27-30. The '566 Patent also states that “[t]he values of the seam loop density indicated in this application relate to the finished clothing, if not otherwise specified.” *Id.*, 6:33-35.

293. Lee does not specifically state whether its loop density (75.6%) is prior to thermal method steps or after thermal processing. However, even if it is prior to a thermal method step, it is my opinion that a POSITA nevertheless would have understood, or at least found obvious, that thermal treatment of the Sudre-Lee-Penven combination fabric would result in a clothing having a loop density that would still fall within the claimed range. This is because the '566 Patent indicates that pre-treatment loop densities of "between 55% and 80%" correspond to loop densities in the finished clothing of "between 64% and 90%," *i.e.*, the claimed loop density range. EX1001, 6:30-40. Because the Sudre-Lee-Penven loop density value falls within the 55%-80% range of suitable pre-treatment values, and because the thread composition and fabric structure of the Sudre-Lee-Penven clothing is similar to that of the '566 Patent's clothing, a POSITA would have expected the post-treatment loop density of the Sudre-Lee-Penven fabric likewise to fall within the claimed 64%-90% range. That is, for instance, Sudre is generic as to the composition of the threads, as is the '566 Patent. And as discussed above, the weave, and the endless nature of the fabric, are consistent between the Sudre-Lee-Penven combination and the '566 Patent.

Lee's ranges of thread density and MD thread diameter renders obvious the claimed range

294. In a second example implementation, the thread density and MD thread diameter in the combination fabric are based on Lee's teachings of ranges of values for these two parameters, *i.e.*, Lee's teachings that the MD threads are "arranged to provide a yarn density of from 15 to 40 yarns/inch (5.9 to 15.7 yarns/cm)" and that the MD threads have "a diameter of from about 0.3mm to about 0.6mm," *e.g.*, "about 0.5mm." EX1005, 12 (1st paragraph); *see* 26 (2nd paragraph), claim 28; *see* 27 (1st paragraph).
295. Lee's disclosed thread density range (5.9 to 15.7 threads/cm) and MD thread diameter range (0.3mm to 0.6mm) together correspond to a loop density range of 35% to 188%. A POSITA would have understood that a loop density of greater than 100% can be regarded as non-physical, indicating that certain combinations of MD thread diameter and thread diameter within the disclosed ranges are not viable combinations. For instance, a POSITA would have understood that the combination of the largest MD thread diameter (0.6mm) and largest thread density (15.7 threads/cm), which would correspond to a loop density value of 188%, is an unrealistic choice because such large-diameter threads simply cannot be fit into such a high density arrangement of loops. That is, a POSITA would have recognized that within the context of Lee's disclosed thread density and

MD thread diameter ranges, the maximum loop density is generally no more than 100%—for instance, as can be achieved by combinations of, *e.g.*, large diameters and low thread counts or vice versa.

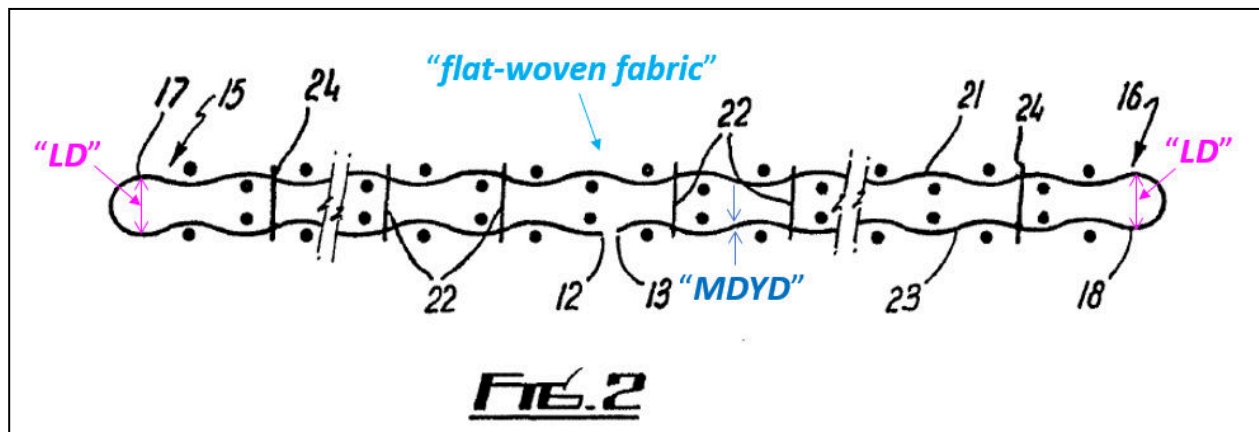
296. The claimed loop density range (*said seam having a loop density of between 64% and 90%*) falls within the loop density range of the combination (greater than 35%, *e.g.*, 35%-100%). I understand that a prior art range that overlaps with a claimed range renders that claimed range obvious unless there is something critical or unexpected associated with the claimed range. Here, the '566 Patent provides no evidence of criticality or unexpected results associated with the claimed loop density range, and indeed, I would not expect there to be any such behavior. I thus conclude that the Sudre-Lee-Penven combination renders obvious the claimed loop density range based on Lee's teachings of ranges of warp thread diameter and warp thread density.

297. Moreover, as I discussed above, even if the Sudre-Lee-Penven loop density range (greater than 35%, *e.g.*, 35%-100%) refers to the fabric before any heat treatments, this Sudre-Lee-Penven range overlaps with the '566 Patent's pre-treatment loop density range (55%-80%), and thus it is my opinion that a POSITA would have expected the corresponding post-treatment loop density range of the Sudre-Lee-Penven fabric likewise to

overlap with the claimed 64%-90% range, for the same reasons I discussed earlier with respect to Lee's specific example.

[1.5] said diameter LD of said seam loops and said diameter MDYD of said associated MD threads having a ratio LD/MDYD of between 2.7 and 3.6.

298. As I have discussed previously, the inside diameter of the seam loops (*said diameter LD of said seam loops*) are indicated in pink in Sudre's Fig. 2, below, and the diameter of the MD threads that form the seam loops (*said diameter MDYD of said associated MD threads*) are indicated in in dark blue.



Excerpt from Sudre, Fig. 2 (annotated)

299. The diameter MDYD is based on the teachings of Lee, as I discussed above for element [1.4].

300. The diameter LD of the seam loops is based on the teachings of Penven. Specifically, the combination fabric, which as I have previously mentioned, is simply structured as a conventional seamable press felt, is

implemented as was conventional, *i.e.*, such that the “seam ... [has] an internal void diameter of about 50 mils,” as taught by Penven. EX1006, 3:64-66. 50 mils corresponds to 1.27 mm, meaning that the diameter MDYD of the seam loops is about 1.27 mm.

The loop density of Lee’s specific example falls within the claimed loop density range

301. In a first example implementation, when the combination fabric is implemented according to Lee’s specific example, the MD thread diameter (**MDYD**) is “about 0.4mm.” EX1005, 28 (2nd paragraph), as I discussed above for element [1.4]. With 0.4mm MD thread diameter, and 1.27mm diameter seam loops, the combination fabric has a *ratio LD/MDYD* of 1.27mm/0.4mm, *i.e.*, 3.175.

302. This ratio (3.175) falls within the recited range of ratios (*a ratio LD/MDYD of between 2.7 and 3.6*).

Lee’s ranges of thread density and MD thread diameter renders obvious the claimed range

303. In a second example implementation, when the combination fabric is implemented according to Lee’s disclosed range of MD thread diameters, the MD thread diameter (**MDYD**) is “from about 0.3mm to about 0.6mm,” based on Lee’s teachings of suitable ranges for its first fabric structure, as I

discussed above for element [1.4]. EX1005, 12 (1st paragraph); *see* 27 (1st paragraph), claim 28.

304. The seam loops again have a diameter of 1.27mm based on Penven's teaching that this size was conventional, *e.g.*, for use with conventional pintles.

305. The combination fabric thus has a *ratio LD/MDYD* that ranges from 2.1 (1.27mm/0.6mm) to 4.2 (1.27mm/0.3mm).

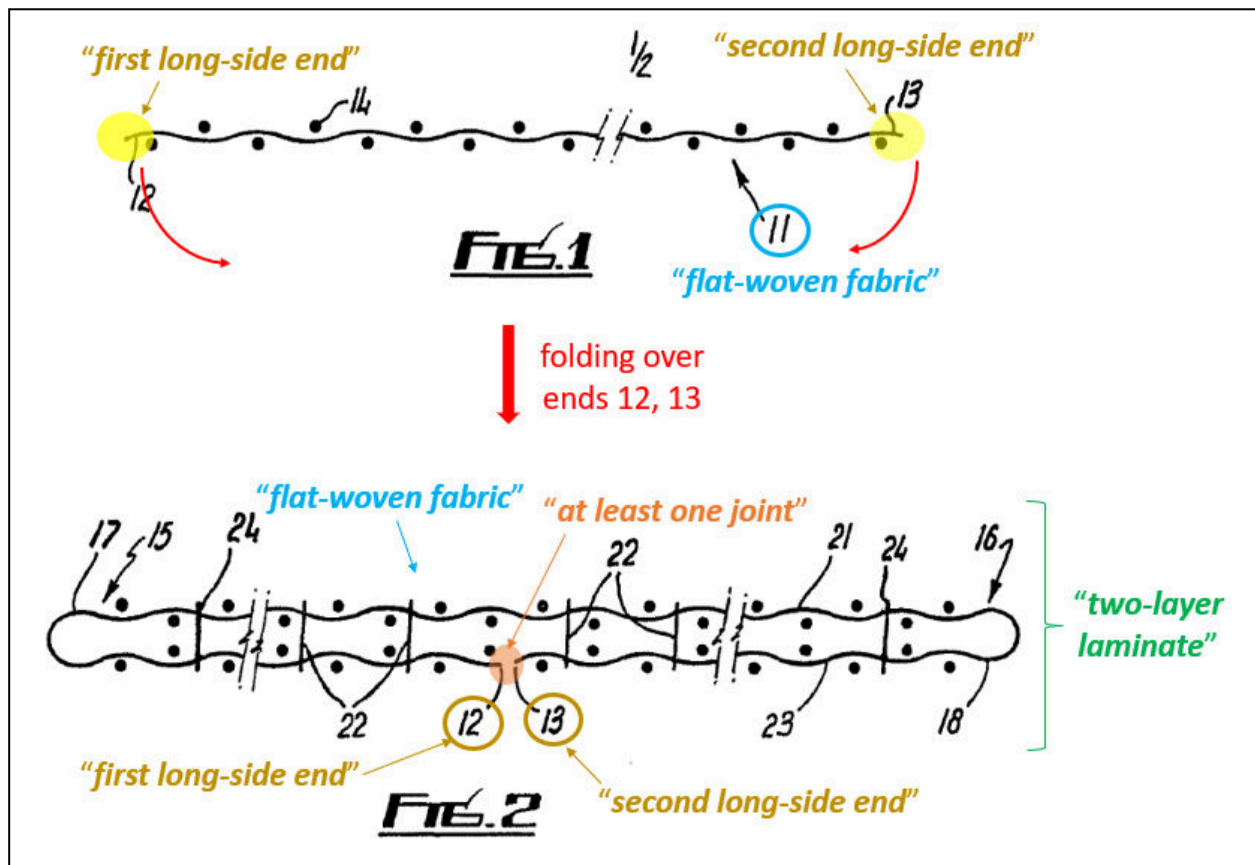
306. The recited range of ratios (*a ratio LD/MDYD of between 2.7 and 3.6*) overlaps with the range of ratios of the combination fabric (between 2.1 and 4.2). I understand that a prior art range that overlaps with the claimed range renders that claimed range obvious, unless there is evidence of something critical or unexpected associated with the claimed range.

Although the '566 Patent states that "given the LD/MDYD ratios according to the invention, the seam produced is optimal," it provides no evidence or even qualitative explanation of why this is the case. EX1001, 3:1-3. I thus conclude that the range of LD/MDYD ratios in the Sudre-Lee-Penven combination, based on Lee's disclosed range of MD thread diameters and Penven's disclosure of conventional seam loop sizes, renders obvious the claimed range of ratios.

(b) Claim 3

[3.0] The clothing according to claim 1, wherein each of said flat-woven fabrics has a first and a second long-side end, said two-layer laminate structure has at least one joint at which two of said long-side ends are interconnected, and said interconnected long-side ends belong to an identical flat-woven fabric or to different flat-woven fabrics.

307. As I discussed above for the Sudre-Adanur ground, in the Sudre-Lee-Penven combination, Sudre's "flat-woven fabric 11" (*said flat-woven fabric*) has "free ends 12, 13" (*a first and a second long-side end*), marked yellow in Fig. 1, reproduced below. EX1004, 3:14-18.



Excerpt from Sudre, Figs. 1 and 2 (annotated)

308. Again as I discussed above, and as was conventional, Sudre describes that "[t]he free ends are folded over to define a two-ply structure" (*said two-*

layer laminate structure) such that “the free ends [are] brought into substantial abutment.” EX1004, 3:18-20, as shown in Figs. 1-2, reproduced above. Sudre also describes that “the free ends [are] joined,” thus forming *at least one joint* (marked in orange) *at which [the two] long-side ends are interconnected*. EX1004, 1:7-8; *see* 7:2-5, 5:26-6:1. The joined free ends 12, 13 belong to the same flat-woven fabric 11 (*said interconnected long-side ends belong to an identical flat-woven fabric*). *See* EX1004, 1:7-8, 3:18-20, 5:26-6:1, 7:2-5, Figs. 1-2.

(c) Claim 10

[10.0] The clothing according to claim 1, wherein said diameter of said MD threads is between 0.15 mm and 0.7 mm.

309. In the Sudre-Lee-Penven combination fabric, both the specific example MD thread diameter (0.4mm) and the range of MD thread diameters (0.3mm to 0.6mm), which are based on Lee, fall within the claimed diameter range (*said diameter of said MD threads is between 0.15 mm and 0.7 mm*). *See* EX1005, 28 (2nd paragraph), 12 (1st paragraph); *see* 27 (1st paragraph), claim 28; [1.4], *supra*.

(d) Claim 11

[11.0] The clothing according to claim 10, wherein said diameter of said MD threads is between 0.3 mm and 0.5 mm.

310. When the combination fabric is implemented according to Lee’s specific example, the MD thread diameter is “about 0.4mm.” EX1005, 28

(2nd paragraph); *see* my discussion above for element [1.4]. This diameter (0.4mm) falls within the claimed diameter range (***said diameter of said MD threads is between 0.3 mm and 0.5 mm***).

311. When the combination fabric is implemented according to Lee's disclosed range of MD thread diameters, the MD thread diameter (***MDYD***) is "from about 0.3mm to about 0.6mm." EX1005, 12 (1st paragraph); *see* 27 (1st paragraph), claim 28; *see* my discussion above for element [1.4]. The recited diameter range (***said diameter of said MD threads is between 0.3 mm and 0.5 mm***) overlaps with the MD thread diameter range of the combination fabric (0.3mm to 0.6mm). The '566 Patent does not indicate—either by evidence or by any qualitative explanation—that the claimed MD thread diameter range is in any way critical or associated with unexpected results. I thus conclude that the 0.3-0.6mm diameter range of the combination, based on Lee, renders the claimed MD thread diameter range obvious.

(e) Claim 12

[12.0] The clothing according to claim 1, wherein said loop density of said seam is between 72% and 86%.

312. When the combination fabric is implemented according to Lee's specific example, the loop density is 75.6%. *See* EX1005, 28 (2nd paragraph); *see* my discussion above for element [1.4]. This loop density

value (75.6%) falls within the claimed loop density range (***said loop density of said seam is between 72% and 86%***).

313. When the combination fabric is implemented according to Lee's disclosed ranges of MD thread diameter and thread density, the loop density is 35% to 188%. See EX1005, 12 (1st paragraph); see my discussion above for element [1.4]. The claimed loop density range (***said loop density of said seam is between 72% and 86%***) falls within the loop density range of the combination (35%-188%). As I discussed above, the '566 Patent provides no evidence or even qualitative explanation of anything critical or unexpected associated with the claimed loop density range, and I thus conclude that the Sudre-Lee-Penven combination, based on the teachings of Lee, renders the claimed range obvious.

314. As I also discussed above, even if the Sudre-Lee-Penven loop density value (75.6%) or loop density range (greater than 35%, e.g., 35%-100%) refers to the pre-treatment fabric, it is my opinion that a POSITA would have expected the corresponding post-treatment loop density value or range of values of the Sudre-Lee-Penven fabric likewise to fall within or overlap with the claimed 72%-86% range, at least because the Sudre-Lee-Penven values fall within the pre-treatment values that the '566 Patent indicates are

appropriate for achieving post-treatment loop densities within the claimed range.

(f) Claim 13

[13.0] The clothing according to claim 1, which further comprises one or a plurality of layers of nonwoven fibers disposed at least on an upper side of the clothing for contacting the web.

315. As I discussed above for the Sudre-Adanur ground, and as was conventional for seamed press felts, in the Sudre-Lee-Penven combination, Sudre describes that “a textile batt 25 is needled to each face of the endless structure.” EX1004, 5:8-9. The textile batt, which I have marked in purple in Fig. 5, below, corresponds to ***a plurality of layers of nonwoven fibers***, as I discussed above for claim 13 in the Sudre-Adanur ground. *See* EX1004, 5:19-20, claim 7, 2:10-12 3:9-11.

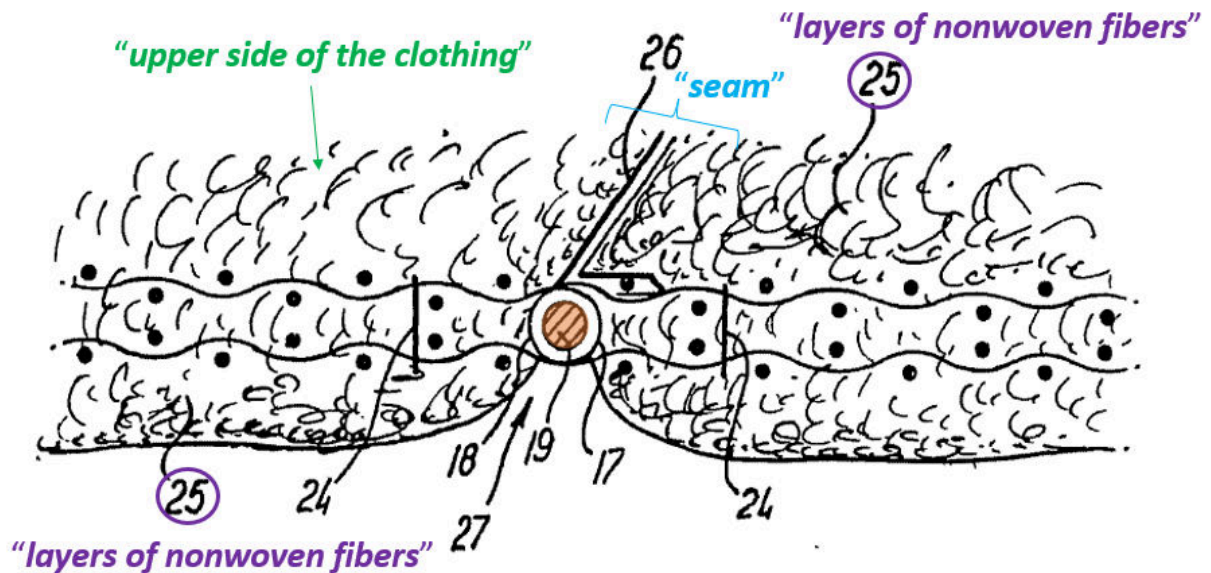


FIG. 5

Excerpt from Sudre, Fig. 5 (annotated)

316. The textile batt (*nonwoven fibers*) is “needed to each face of the endless structure,” *i.e.*, *disposed at least on an upper side of the clothing*. EX1004, 3:9-11, Fig. 5; *see* 3:9-11, 6:14-16, claim 7, 2:10-12. One side of the combination fabric is “the machine side ... 27” that faces the papermaking machine, and the other side is “the paper side ... 26” (*an upper side of the clothing*) that faces and contacts the paper (*the web*). EX1004, 5:12-14. I have indicated the paper side in green in Fig. 5, above. Both sides of the combination fabric include the textile batt and thus the batt on the paper side contacts the paper (*for contacting the web*).

**G. [GROUND 2B] – Sudre-Lee-Penven-Shipley Renders
Obvious Claim 2**

1. *The Sudre-Lee-Penven-Shipley Combination*

317. The Sudre-Lee-Penven-Shipley combination is similar to the Sudre-Adanur-Shipley combination I discussed above. Specifically, the “flat-woven fabric” of the combination (which is based on Sudre, as I discussed above for element [1.1]) is woven as taught by Shipley. EX1004, 3:13-18. The combination flat-woven fabric includes a “weave pattern ... [that] repeats with respect to eight stacked pairs of MD yarns ... and eight CMD yarns,” as taught by Shipley. In this pattern, “[e]ach of the CMD yarns in the repeat floats over five upper layer MD yarns, between one pair of stacked upper and lower MD yarns, under the next lower layer MD yarn, between the next pair of upper and lower MD yarns and then continues to float over the next five upper layer MD yarns in its repeat.” EX1010, 3:6-13. This is illustrated, *e.g.*, in Shipley’s Figs. 1-3.

2. *Motivation for the Combination*

318. It is my opinion that a POSITA would have been motivated to structure the combination fabric such that each CMD thread is woven over multiple MD threads, as taught by Shipley, and would have expected success in doing so, for at least the same reasons that I discussed above for the

Sudre-Adanur-Shipley combination. *See* EX1010, 2:26-34; EX1011, Figs. 2-3; EX1012, 2:14-19.

319. In addition to the specific reasons discussed above for the Sudre-Adanur-Shipley ground, it is my opinion that a POSITA would have been motivated to implement a weave pattern based on the teachings of Shipley simply because a weave patterns including floats, as taught by Shipley, in the context of papermachine clothing, such as press felts, was a known and conventional technique. And using such a weave pattern for papermachine clothing, such as press felts, would have produced a predictable result: simply a press felt with a weave pattern that incorporates floats.

320. It is my opinion that a POSITA would have expected success in incorporating a weave pattern like Shipley's, in which each CMD thread is woven over multiple MD threads, because weave patterns including floats were conventional, and because Shipley, like Sudre, Lee, and Penven, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics, as I discussed above for the Sudre-Adanur-Shipley ground.

321. Additionally, it is my opinion that a POSITA would have expected success in integrating the teachings of Shipley into the combination fabric because the MD thread diameter and MD thread density of Shipley's fabric

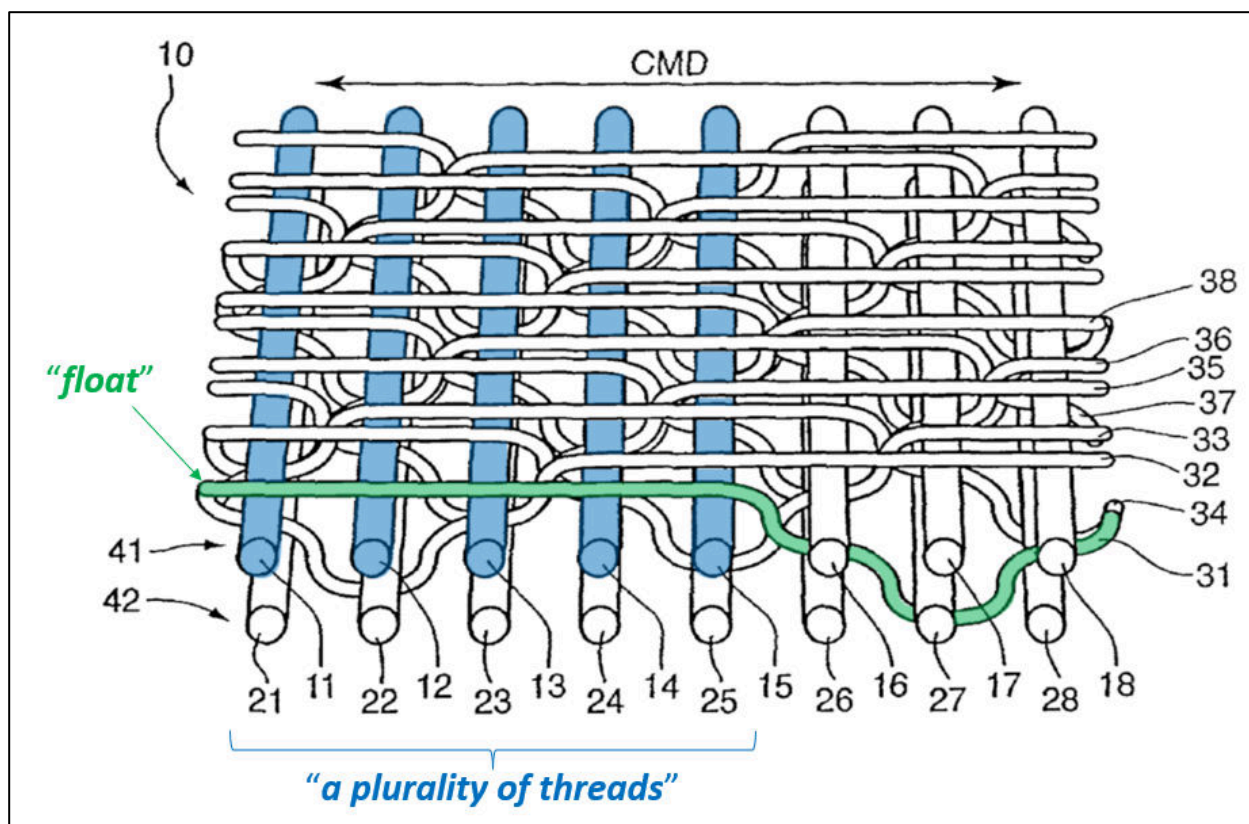
overlaps with these parameters in the combination fabric—that is, with the MD thread diameter and MD thread density as taught by Lee, which I discussed for element [1.4]. Specifically, Shipley describes that for “a base fabric for a press felt,” the MD threads are “single monofilament nylon yarns having a diameter of 0.010”-0.020” (about 0.25-0.5mm), which overlaps with the 0.3-0.6mm MD thread diameter range of the combination fabric. EX1010, 3:48-52; *see* EX1005, 12 (1st paragraph), 28 (2nd paragraph). Similarly, Shipley describes an MD thread density of “20-40 yarns per inch,” again overlapping with the 15 to 40 threads/inch MD thread density of the combination fabric. EX1010, 3:48-52; *see* EX1005, 12 (1st paragraph), 28 (2nd paragraph). Indeed, Shipley expressly indicates the suitability of its weave configuration for this thread density range, stating that “[t]he weave enhances the stability of the felt by allowing more machine direction yarns per inch.” EX1010, 2:24-26. This similarity in dimensions indicates that the teachings of Shipley would be compatible with the Sudre-Lee-Penven combination fabric.

3. *Analysis*

(g) Claim 2

[2.0] The clothing according to claim 1, wherein at least one of said flat-woven fabrics have floats extending over two or a plurality of threads.

322. Consistent with my discussion above for the Sudre-Adanur-Shipley combination, the Sudre-Lee-Penven-Shipley combination flat-woven fabric is woven based on the weave pattern described by Shipley, which is shown in Fig. 1, reproduced and annotated below. In Fig. 1, I have shaded some of the MD threads in dark blue, and one example CMD thread in green. Specifically, in the combination flat-woven fabric, “[e]ach of the CMD yarns in the repeat floats over five upper layer MD yarns” (***floats extending over two or a plurality of threads***), as can be seen by the green CMD thread extending over the blue-shaded MD threads 11-15. EX1010, 3:8-12; *see* 2:9-11, 3:12-28, Abstract, claim 1.



Excerpt from Shipley, Fig. 1 (annotated)

H. [GROUND 2C] – Sudre-Lee-Penven-Straub Renders Obvious Claims 4-9

1. *The Sudre-Lee-Penven-Straub Combination*

323. The Sudre-Lee-Penven-Straub combination is structured similarly to the Sudre-Adanur-Straub combination, which I discussed above.

Specifically, in the Sudre-Lee-Penven-Straub combination, “[t]he free ends 12, 13” of the flat-woven fabric of the combination “are folded over to define a two-ply structure ..., the free ends being brought into substantial abutment” and “joined.” EX1004, 1:7-8, 3:18-21, Fig. 2. I discussed this in general with respect to element [3.0], above.

324. The specific way in which the free ends of the combination flat-woven fabric are joined is based on the teachings of Straub. Specifically, the free ends “are brought together in pairs to form in each case a junction point 18,” and at each junction point, MD threads are “interwoven with machine cross-direction threads,” as taught by Straub. EX1013, [0070]-[0071]. The MD and CD threads at each junction point are “connected to one another in a materially integral manner,” *e.g.*, by “a transmission welding method.” EX1013, [0073]. Straub’s Fig. 6 depicts the resulting arrangement, and individual junction points can be structured, *e.g.*, based on any of Straub’s Figs. 7a-7d.

2. *Motivation for the Combination*

325. It is my opinion that a POSITA would have been motivated to join the free ends of the combination fabric flat-woven fabric based on the approach taught by Straub, and would have expected success in doing so, for at least the same reasons that I discussed above for the Sudre-Adanar-Straub combination. *See* EX1013, [0016]-[0020]; EX1015, [0011], [0017].

326. In addition to these specific reasons discussed above for the Sudre-Adanur-Straub combination, it is my opinion that a POSITA would have been motivated to implement joints based on Straub simply because joining free ends of a flat-woven fabric by welding junction points, in the context of

papermachine clothing, such as press felts, was a known and conventional technique. And using this approach to joining would have produced a predictable result: an endless press felt structure formed by joining free ends of a flat-woven fabric at junction points).

327. It is my opinion that a POSITA would have expected success because Straub, like Sudre, Lee, and Penven, pertains to papermachine clothing, and specifically to seamable press felts formed from flat woven base fabrics, as I discussed above for the Sudre-Adanur-Straub ground. Moreover, Sudre indicates that the free ends “may be joined together ... in any other manner,” which indicates compatibility with Straub’s particular approach to joining the free ends. EX1004, 7:3-5.

328. It is also my opinion that a POSITA would have expected success because Straub indicates that its approach is compatible with “a fabric with only a few fabric plies,” and this is the case with the Sudre-Lee-Penven combination fabric. *See* EX1004, 3:24-4:1; EX1013, [0039]. Likewise, Straub indicates that its approach is compatible with a fabric having “a thread density of 20 to 100 machine direction threads per inch,” which again is the case with the Sudre-Lee-Penven combination fabric. *See* EX1005, 12 (1st paragraph); EX1013, [0039].

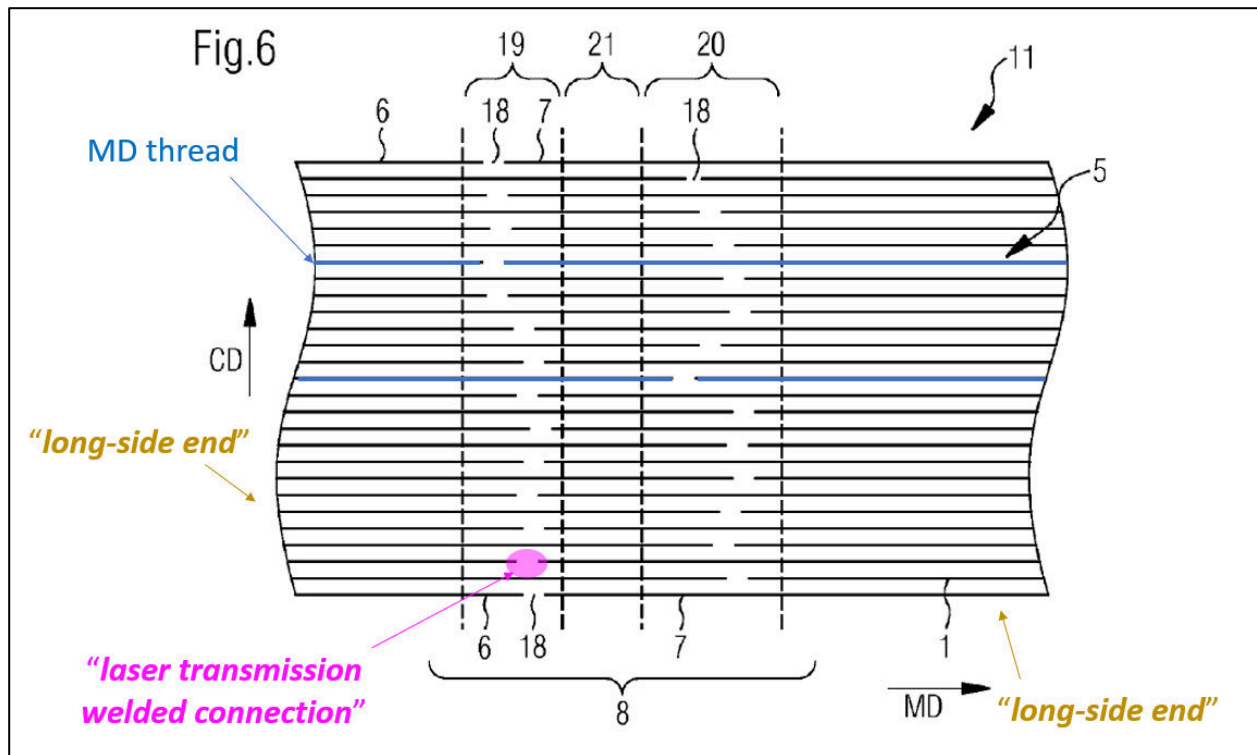
3. Analysis

(a) Claim 4

[4.0] The clothing according to claim 3, wherein said two long-side ends are interconnected by a welded connection or a laser transmission welded connection.

329. In the Sudre-Lee-Penven-Straub combination, as in the Sudre-Adanur-Straub combination I discussed above, “the free ends” of the flat-woven fabric are “joined” (***said two long-side ends are interconnected***). This, in generally, I discussed above for element [3.0]. Specifically, the two long-side ends are joined using “a transmission welding method” that involves “light [] radiated by a laser” (***laser transmission welded***), as taught by Straub. EX1004, 1:7-8; EX1013, [0060]-[0061]; *see* [0060], [0061], [0065], [0030], [0047]-[0051], [0067]-[0068], Figs. 3-5.

330. The seam region that is formed by laser transmission welding of the free ends of the combination fabric is structured as illustrated in Straub’s Fig. 6, which I have reproduced below, indicating the MD threads in dark blue and the long-side ends in yellow. *See* EX1013, [0051].



Excerpt from Straub, Fig. 6 (annotated)

331. This seam region includes “junction points” (one of which is highlighted in pink) at which “pairs” of MD threads from the two “fore-end[s]” (*long-side ends*) of the flat-woven fabric “are interwoven with machine cross-direction threads,” thus interconnecting the two long-side ends. EX1013, [0069]-[0070]. The MD and CD threads at each junction point are “connected to one another in a materially integral manner by laser radiation.” EX1013, [0059]; *see* [0061], [0065]. That is, each junction point connects MD threads from the two long-side ends of the flat-woven fabric, and is secured by laser welding, meaning that each junction point is implemented as *a laser transmission welded connection*.

(b) Claim 5

[5.0] The clothing according to claim 3, wherein said at least one joint has an extent in a machine direction of less than 15 mm.

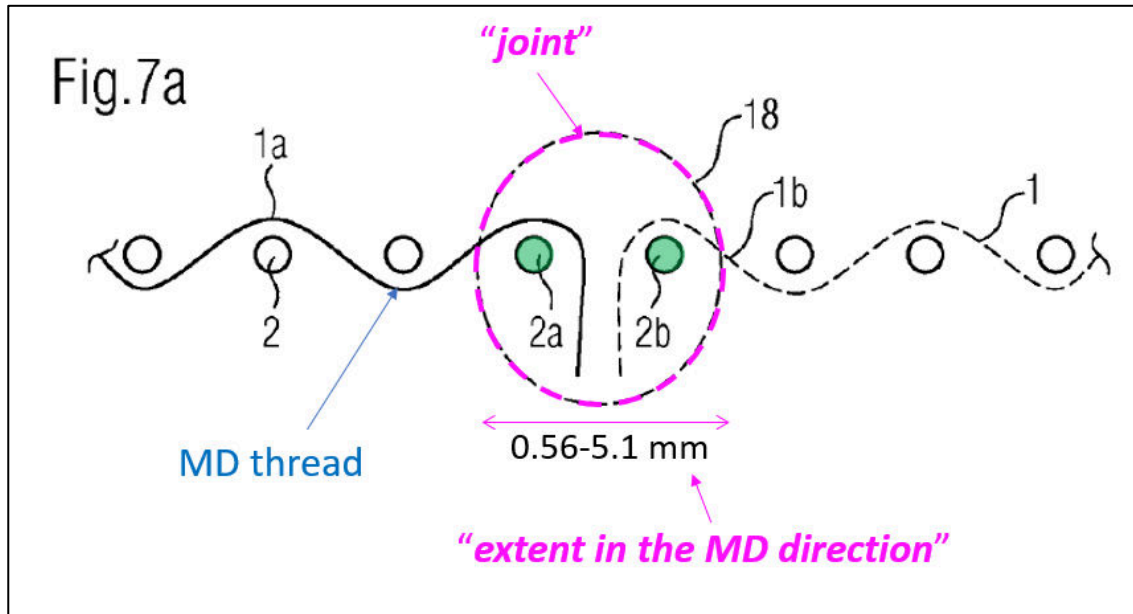
Each junction point in the combination endless structure is a joint

332. Consistent with my discussion above for the Sudre-Adanur-Straub ground, in the Sudre-Lee-Penven-Straub combination, “the free ends” of the flat-woven fabric are “joined” to form ***at least one joint***, which forms the fabric into an endless structure, as taught by Sudre—and as was conventional for seamable press felts. EX1004, 1:7-8. Specifically, the joining is implemented based on the junction points described by Straub: at each junction point, a pair of MD thread ends from the two free ends of the flat-woven fabric “are interwoven with machine cross-direction threads.” EX1013, Abstract, Figs. 7a-7d. That is, each junction point in the combination corresponds to a ***joint***, as claimed, because it is a region of the fabric ***at which two of said long-side ends are interconnected*** (see my discussion above for element [3.0]). See EX1013, [0056], [0001], [0008], [0015], [0026], [0070].

333. One example junction point (***joint***) is illustrated in Straub’s Fig. 7a, which I have reproduced and annotated below. See EX1013, [0076]. As explained by Straub, this junction point “extends from the machine cross-direction thread 2a as far as the machine cross-direction thread 2b, as seen in

the machine direction MD” (*joint extends in the machine direction*). *Id.*

That is, the joint extends in the machine direction by the distance occupied by two CD threads (shaded in green).



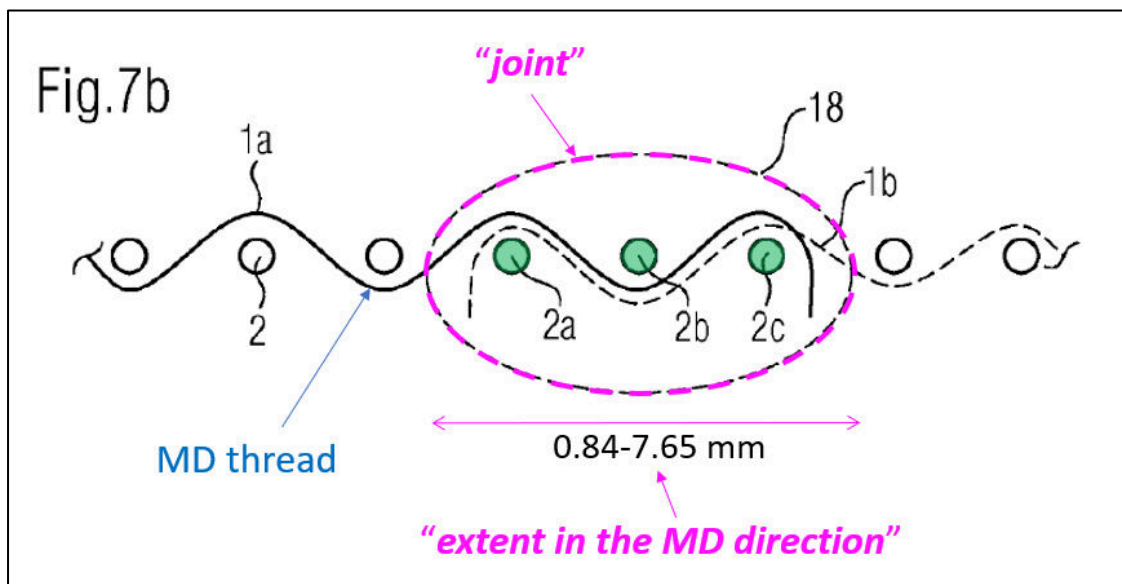
Excerpt from Straub, Fig. 7a (annotated)

334. It is my opinion that a POSITA would have found it obvious that the joint of Fig. 7a extends in the machine direction by ***less than 15 mm***. For instance, as I discuss in more detail at the end of this section, a POSITA would have provided the CD threads in the combination fabric at a density of “10 to 90 machine cross-direction threads per inch,” consistent with the teachings of Straub. EX1013, [0039]; *see* claim 34.

335. With a CD thread density of 10 threads per inch, the two CD threads in the joint of Fig. 7a occupy a distance in the MD of 5.1mm (*i.e.*, 2 threads

divided by a CD thread density of 10 threads/inch, and converted to mm)—that is, the joint extends in the MD by 5.1mm. And with a CD thread density of 90 threads per inch, the two CD threads in the joint of Fig. 7a occupy a distance in the MD of 0.56mm (again, 2 threads divided by a CD thread density of 90 threads/inch, and converted to mm)—that is, the joint extends in the MD by 0.56mm.

336. A similar calculation can be performed for the joint of Fig. 7b, which extends in the MD by the distance occupied by three CD threads. When the CD thread density is 10 threads/inch, the joint of Fig. 7b (annotated below) thus extends in the MD by 7.65mm, and when the CD thread density is 90 threads/inch, the joint of Fig. 7b extends in the MD by 0.84mm.



Excerpt from Straub, Fig. 7b (annotated)

337. Similarly, Straub's Fig. 7c shows a junction point that "extends from the machine cross-direction thread 2a as far as the machine cross-direction thread 2d, *i.e.*, an MD extent of 4 CD yarns, or 1.12-10.2 mm. EX1013, [0078].

338. Thus, based on Straub's teachings of CD thread density, the junction point of Straub's Fig. 7a (*said at least one joint extends in the machine direction* by 0.56-5.1mm (*less than 15 mm*). Similarly, the joint of Fig. 7b, which encompasses three CD threads, extends in the machine direction by 0.84-7.65mm (*less than 15 mm*). See EX1013, [0077]. The joint of Fig. 7c also extends in the machine direction by less than 15 mm.

339. It is my opinion that a POSITA would have found it obvious to implement a CD thread density of 10-90 threads per inch for at least the following reasons.

340. First, CD threads in press felts were typically provided in densities generally similar to the density of the MD threads. The combination fabric has an MD thread density of 15-40 threads/inch, based on the teachings of Lee (*see* EX1005, 12 (1st paragraph)). Straub's disclosure of a CD thread density of 10-90 threads/inch is consistent with that MD thread density, and a POSITA would thus have been motivated to provide the CD threads in a

density range based on Straub for consistency with the MD thread density based on Lee.

341. Second, a CD thread density range of 10-90 threads per inch was commonly used in press felts. Just as a POSITA would have been motivated to implement a standard MD thread density based on Lee, as I discussed above, a POSITA similarly would have been motivated to implement a standard CD thread density for compatibility with standard practice.

342. Third, Straub's CD thread density, in the context of papermachine clothing, was conventional, and its combination with the Sudre-Lee-Penven press felt would have produced straightforward and predictable results: *i.e.*, a press felt with a CD thread density in the range of 10-90 threads/cm.

343. It is my opinion that a POSITA would have expected success at least because Sudre is generic with respect to its weave configuration and CD thread density, and provides no indication that it would be incompatible with the thread density teachings of Straub.

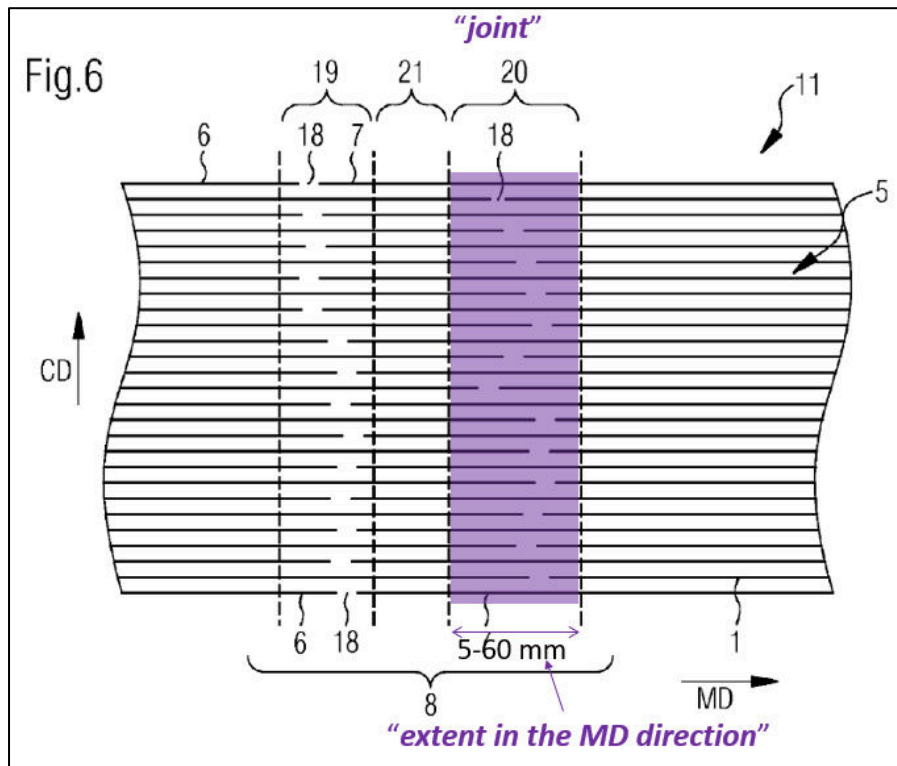
344. Additionally, I note that the junction points are staggered in each "strip-shaped fabric portion," which has "an extent of 5 to 60 mm in the machine direction MD." EX1013, [0074]; *see* claim 38, Fig. 6. Because the junction points are staggered, a POSITA would have recognized that multiple junction points together occupy an MD extent that is greater than

the MD extent of any individual junction point. Thus, when the MD extent of the strip-shaped fabric portion is on the lower end of its 5-60mm range, a POSITA would recognize that the extent of each individual junction point is *less than 15 mm*.

Each strip-shaped fabric portion in the combination endless structure is a joint

345. Also as I discussed above for the Sudre-Adanur-Straub combination, in the Sudre-Lee-Penven-Straub combination, the junction points that join the two free ends of the flat-woven fabric are arranged in “two strip-shaped fabric portions 19, 20.” EX1013, [0071]. Each of these “strip-shaped fabric portions” corresponds to a *joint* because it is a region of the fabric *at which two of said long-side ends are interconnected* (see my discussion above for element [3.0]), e.g., via the junction points. See EX1013, [0071], claim 1.

346. Straub states that each “strip-shaped fabric portion[]” (*joint*) has “an extent of 5 to 60 mm in the machine direction MD,” and I have annotated this MD extent in Fig. 6 below. EX1013, [0074]; see claim 38. This MD extent of the joint overlaps with the recited range, and as I discussed above for the Sudre-Adanur-Straub ground, thus renders the recited range obvious.



Excerpt from Straub, Fig. 6 (annotated)

347. I also note, as I did above for the Sudre-Adanur-Straub ground, that the MD extent of the strip-shaped fabric portion (*joint*) is simply a straightforward design choice that a POSITA would have pursued.

(c) Claim 6

[6.0] The clothing according to claim 5, wherein said extent of said at least one joint in the machine direction is less than 5 mm.

348. The junction point of Straub's Fig. 7a (*said at least one joint*) extends *in the machine direction* by 0.56-5.1mm, as I discussed above for claim 5. This overlaps with the recited range (*less than 5 mm*) and thus renders the claim obvious, as I discussed above for the Sudre-Adanur-Straub ground.

349. Additionally, I note that the junction points are staggered in each “strip-shaped fabric portion,” which has “an extent of 5 to 60 mm in the machine direction MD.” EX1013, [0074]; *see* claim 38, Fig. 6. Because the junction points are staggered, a POSITA would have recognized that multiple junction points together occupy an MD extent that is greater than the MD extent of any individual junction point. Thus, when the MD extent of the strip-shaped fabric portion is 5mm range, a POSITA would recognize that the extent of each individual junction point is *less than 5 mm*.

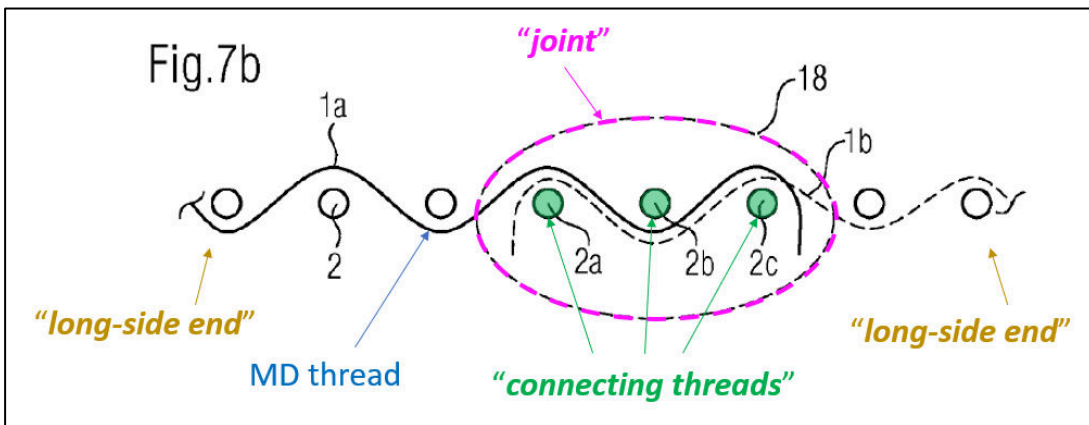
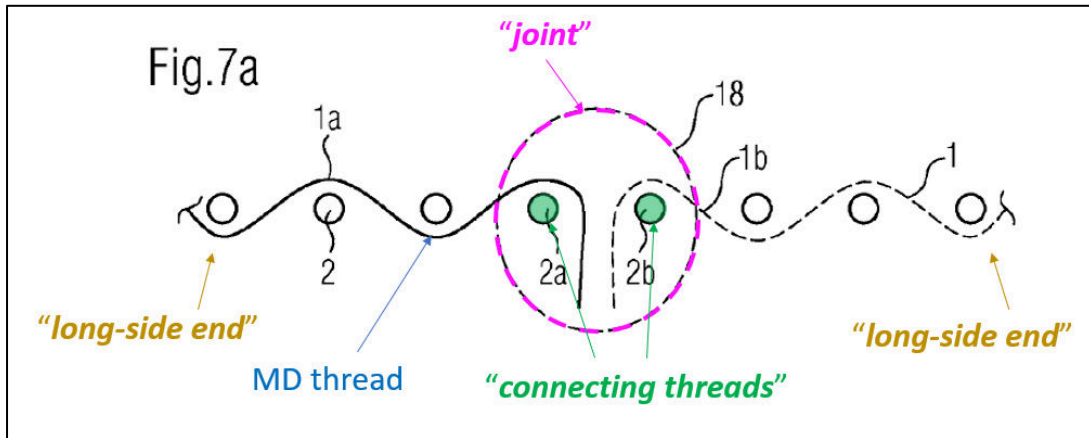
350. As I also discussed above for the Sudre-Adanur-Straub ground, the strip-shaped fabric portion (*said at least one joint extends in the machine direction* by 5-60mm, and it is my opinion that it would have been a straightforward design choice for a POSITA to instead implement that strip-shaped fabric portion with an MD extent of *less than 5 mm*.

(d) Claim 7

[7.0] The clothing according to claim 3, wherein said at least one joint is made by connecting elements or connecting threads being welded to at least one or both of said long-side ends.

351. As I discussed above for the Sudre-Adanur-Straub combination, in the Sudre-Lee-Penven-Straub combination, a junction point (*said at least one joint*) includes “two directly adjacent machine cross-direction threads 2a and 2b” (annotated in green in Fig. 7a, reproduced below) or “three directly

adjacent machine cross-direction threads 2a, 2b and 2c” (annotated in green in Fig. 7b, also reproduced below) (**connecting threads**). EX1013, [0076]-[0077].



Excerpts from Straub, Figs. 7a-7b (annotated)

352. These “yarn intersections” between MD and CD threads are “welded,” *i.e.*, the CD threads in the junction points are welded to the MD threads from the two long-side ends (**connecting threads being welded to at least one or both of said long-side ends**). EX1013, [0067]; *see* [0070].

(e) Claim 8

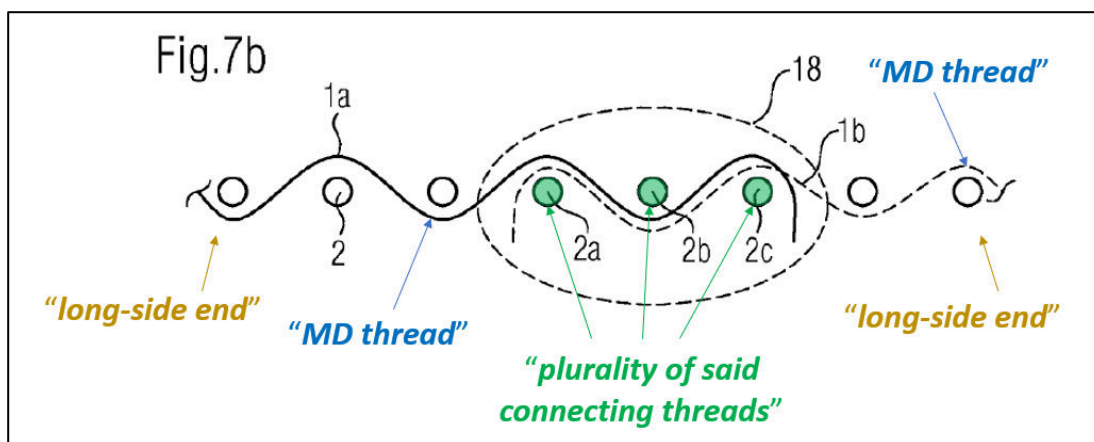
[8.0] The clothing according to claim 7, wherein said connecting elements are connecting threads disposed in a CD direction of the clothing, and at most three connecting threads or at most two connecting threads are provided for a joint.

353. As I discussed above for the Sudre-Adanur-Straub combination, in the Sudre-Lee-Penven-Straub combination, a junction point includes “two directly adjacent machine cross-direction threads 2a and 2b,” as is the case for Fig. 7a, below (***at most two connecting threads disposed in a CD direction of the clothing***) or “three directly adjacent machine cross-direction threads 2a, 2b and 2c,” as is the case for Fig. 7b, also below (***at most three connecting threads disposed in a CD direction of the clothing***). EX1013, [0076]-[0077]; *see* claim 33.

(f) Claim 9

[9.0] The clothing according to claim 8, wherein one or a plurality of said connecting threads are woven with MD threads of at least one of said long-side ends.

354. As I discussed above for the Sudre-Adanur-Straub combination, in the Sudre-Lee-Penven-Straub combination, a junction point based on Straub’s Fig. 7b includes “the two brought-together end portions 1a and 1b of one and the same machine direction thread 1” (***MD threads of at least one of said long-side ends***). EX1013, [0077]. The MD thread end portions, which I have identified in yellow in Fig. 7b below, “are jointly interwoven with three directly adjacent machine cross-direction threads 2a, 2b and 2c,” green (***connecting threads are woven with MD threads***). *Id.*; *see* [0001].



Excerpt from Straub, Fig. 7b (annotated)

I. [GROUND 2D] – Sudre-Lee-Penven-Lidar Renders Obvious Claims 14

1. The Sudre-Lee-Penven-Lidar Combination

355. The Sudre-Lee-Penven-Lidar combination is structured similarly to the Sudre-Adanur-Lidar combination, which I discussed above.

Specifically, in the Sudre-Lee-Penven-Lidar combination, the “textile batt [that] is needled to at least one side of the endless base material” (*see my discussion above for claim 13*) includes “a batt of synthetic fibrous material 14 that contains a plurality of non-crimped reinforcing yarns 15” that “extend in the machine direction of the fabric,” as taught by Lidar. EX1014, 3:29-31; *see Fig. 1*. The reinforcing yarns are “at least partially encapsulated in and/or ... at least partially impregnated with ... polyurethane (e.g. thermoplastic polyurethane), polyester or copolyester, polyamide or copolyimide, silicone or thermoplastic elastomer.” EX1014,

2:24-27. Optionally, the combination base fabric also includes “a moulded mesh membrane 12.” EX1014, 3:20-21.

2. *Motivation for the Combination*

356. It is my opinion that a POSITA would have been motivated to implement reinforcing yarns in the batt based on the approach taught by Lidar, and would have expected success, for at least the same reasons that I discussed above for the Sudre-Adanar-Lidar combination. *See* EX1014, 2:3-8, 2:13-18.

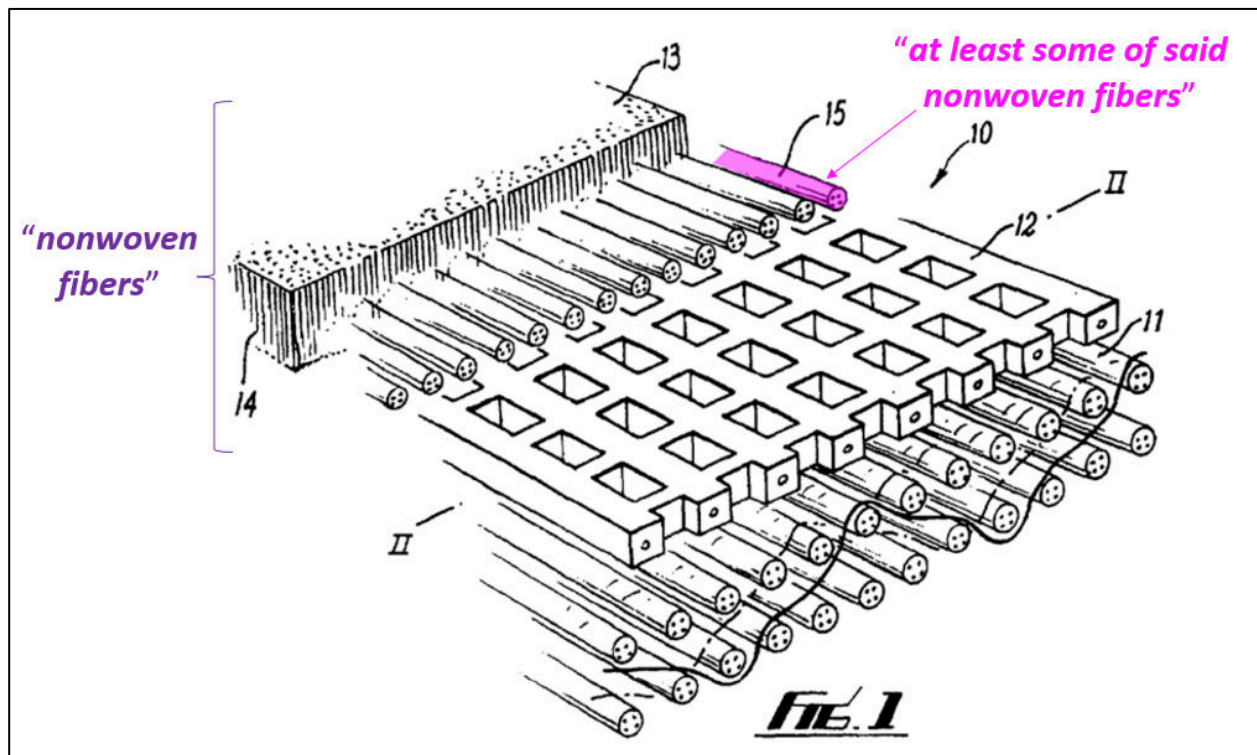
357. In addition to these specific reasons discussed above for the Sudre-Adanur-Straub combination, it is my opinion that a POSITA would have been motivated to incorporate reinforcing yarns into the batt of the combination fabric because simply incorporating reinforcing yarns in a batt layer in the context of papermachine clothing, such as press felts, was a known and conventional technique. And using this approach to joining would have produced a predictable result: a press felt having reinforcing yarns in its batt layer.

3. *Analysis*

(a) Claim 14

[14.0] The clothing according to claim 13, wherein at least some of said nonwoven fibers include or are formed of an elastomer or a polyurethane.

358. As I discussed above for the Sudre-Adanur-Lidar combination, in the Sudre-Lee-Penven-Lidar combination clothing, one or both of the layers of textile batt (*nonwoven fibers*; see my discussion for claim 13, above) includes “a batt of synthetic fibrous material 14 that contains a plurality of non-crimped reinforcing yarns 15” (*at least some of said nonwoven fibers*), which I have indicated in pink in Fig. 1, reproduced below, as taught by Lidar. EX1014, 3:29-31; see 1:38-40, 2:1-3, 3:49-54, claim 1, claim 13.



Excerpt from Lidar, Fig. 1 (annotated)

359. The reinforcing yarns of the batt layer (*at least some of said nonwoven fibers*) are “at least partially encapsulated in and/or ... at least partially impregnated with ... polyurethane (e.g., thermoplastic polyurethane) ... or thermoplastic elastomer” (*include or are formed of an elastomer or a polyurethane*). EX1014, 2:24-27; *see* 2:27-29, 3:33-34, claim 5, claim 12.

J. [GROUND 2E] – Sudre-Lee-Penven-Yook Renders Obvious Claim 15

1. *The Sudre-Lee-Penven-Yook Combination*

360. The Sudre-Lee-Penven-Yook combination is structured similarly to the Sudre-Adanur-Yook combination, which I discussed above. Specifically, in the Sudre-Lee-Penven-Yook combination, a “strip [] of flow-resistant material” is “is disposed over the seam region” of the Sudre-Lee-Penven fabric, and “attached thereto by sewing or by an adhesive,” as taught by Yook. EX1009, 5:6-10.

2. *Motivation for the Combination*

361. It is my opinion that a POSITA would have been motivated to incorporate a strip of flow-resistant material in the vicinity of the seam region of the combination fabric based on the approach taught by Yook, and would have expected success, for at least the same reasons that I discussed

above for the Sudre-Adanar-Yook combination. *See* EX1009, 3:37-41, 4:16-18.

362. In addition to these specific reasons discussed above for the Sudre-Adanur-Straub combination, it is my opinion that a POSITA would have been motivated to implement a strip of flow-resistant material in the seam region of the combination fabric because simply implementing such a strip in the context of papermachine clothing, such as press felts, was a known and conventional technique. And using this approach to joining would have produced a predictable result: a press felt having a strip of flow-resistant material in its seam region.

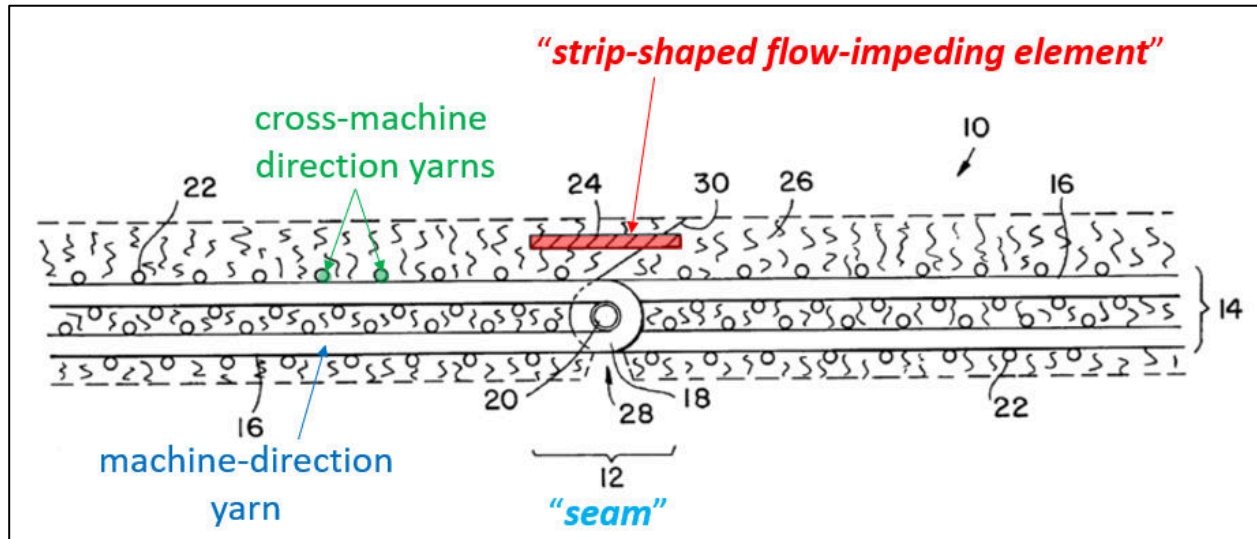
3. Analysis

(a) Claim 15

[15.0] The clothing according to claim 1, which further comprises at least one strip-shaped flow-impeding element provided in a vicinity of said seam, said at least one strip-shaped flow-impeding element being configured to cause a permeability for at least one of air or water in said vicinity of said seam to be substantially identical to a remainder of the clothing.

363. Consistent with my discussion above for the Sudre-Adanur-Yook combination, the Sudre-Lee-Penven-Yook combination fabric includes a “strip 24 of flow-resistant material ... disposed over the seam region” (***at least one strip-shaped flow-impeding element provided in a vicinity of said seam***), as taught by Yook and as illustrated in Yook’s Fig. 1, which I have

reproduced below. EX1009, 5:6-8; *see* 3:65-67, 4:15-16, 7:21-30, 4:22-32, 5:55-59, 7:6-9, claim 1, claims 4-9.



Excerpt from Yook, Fig. 1 (annotated)

364. This flow-impeding element “provides the seam with permeabilities to air and water substantially identical to that of the rest of the papermaker’s fabric” (*configured to cause a permeability for at least one of air or water in said vicinity of said seam to be substantially identical to a remainder of the clothing*). EX1009, 4:16-18; *see* 4:32-34, claim 1, claim 9, Abstract.

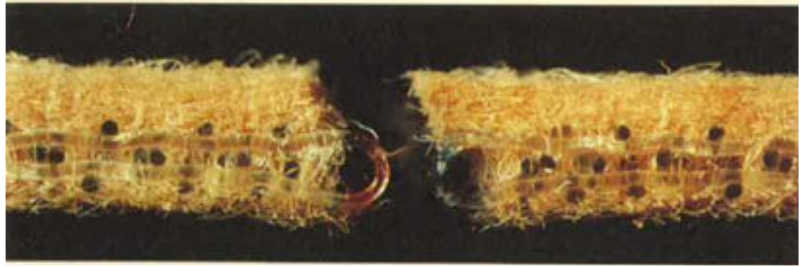
K. [GROUND 3A] – Sudre-Rydin Renders Obvious Claims 1, 3, and 12-13

1. Rydin

365. Rydin is a 1992 Swedish news article describing Nordiskafilt's⁴ “[n]ew generation seam felt.” EX1028⁵, 1; *see also* EX1027, 1. Rydin describes a felt design that has numerous benefits, such as “considerable seam improvement [] based on achieving a greater homogeneity in the seam zone in combination with an improved wad anchorage.” *Id.* I have provided below photographs from the Rydin article that show the new seam felt design. Fig. 2 shows a top view of the new design's underlying new seam (on the left) and Fig. 3 shows a cross-section of the “finished felt” (on the right). Fig. 3 image shows Petitioner's product, SeamTech. EX1028, 2 (Fig. 3); EX1029, 4 (Fig. 10); *see also* EX1027 (Fig. 3).

⁴ Nordiskafilt is a corporate entity of Albany International.

⁵ Rydin (EX1028) is a certified translation of EX1027.



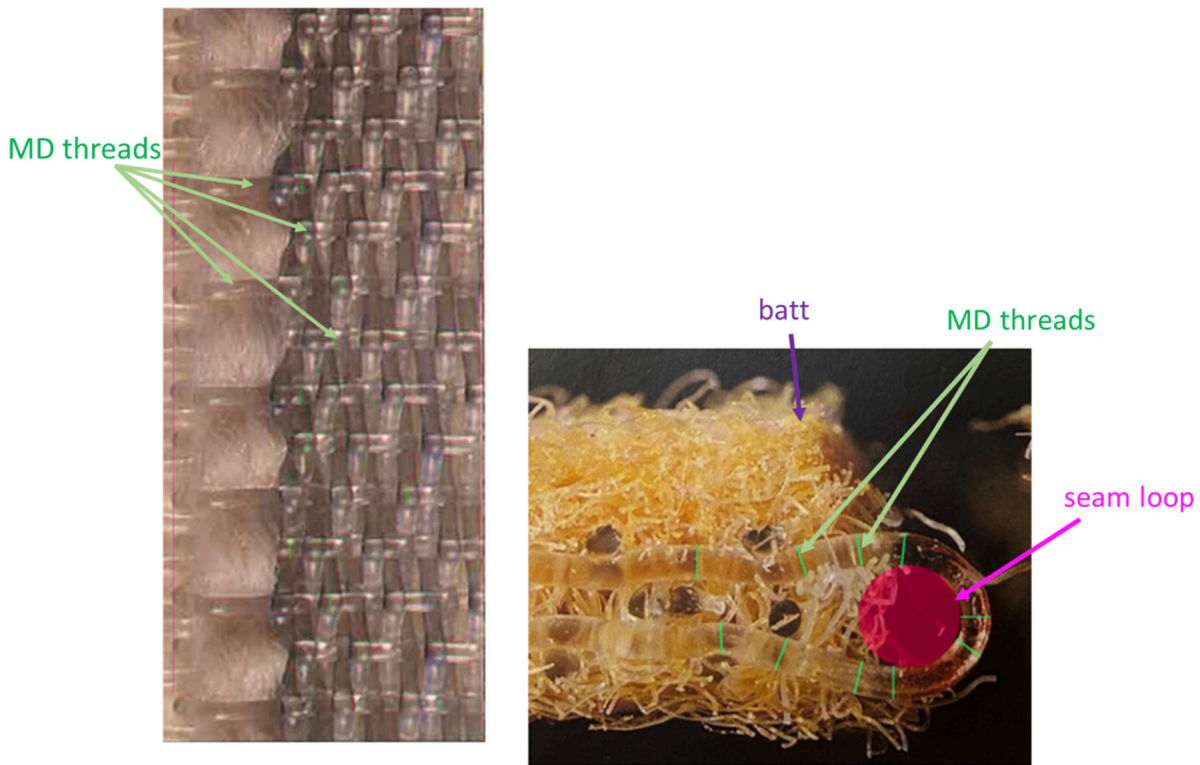
EX1028, Fig. 2 (left), Fig. 3 (right).

2. *Sudre-Rydin Combination*

366. For many of the reasons that I discussed previously in the *Sudre-Adanur* grounds (Grounds 1A-1E, *supra*), it would have been obvious that the combination of *Sudre* and *Rydin* renders obvious the challenged claims of the '566 patent. *Rydin* provides another example of PMC possessing the claimed loop density and loop ratio recited in claim 1 of the '566 Patent. Indeed, the main difference between the *Adanur*-based ground and the *Rydin*-based ground is that *Rydin*'s photographs are directed to a different PMC product – a PMC design that was known as early as 1992. In its Figures 2 and 3, *Rydin* shows a PMC that was available more than 25 years before the '566 patent was filed.

367. In the combination, the parameter details of the PMC, such as the shape and diameter of the MD (warp) threads, thread density, and loop size,

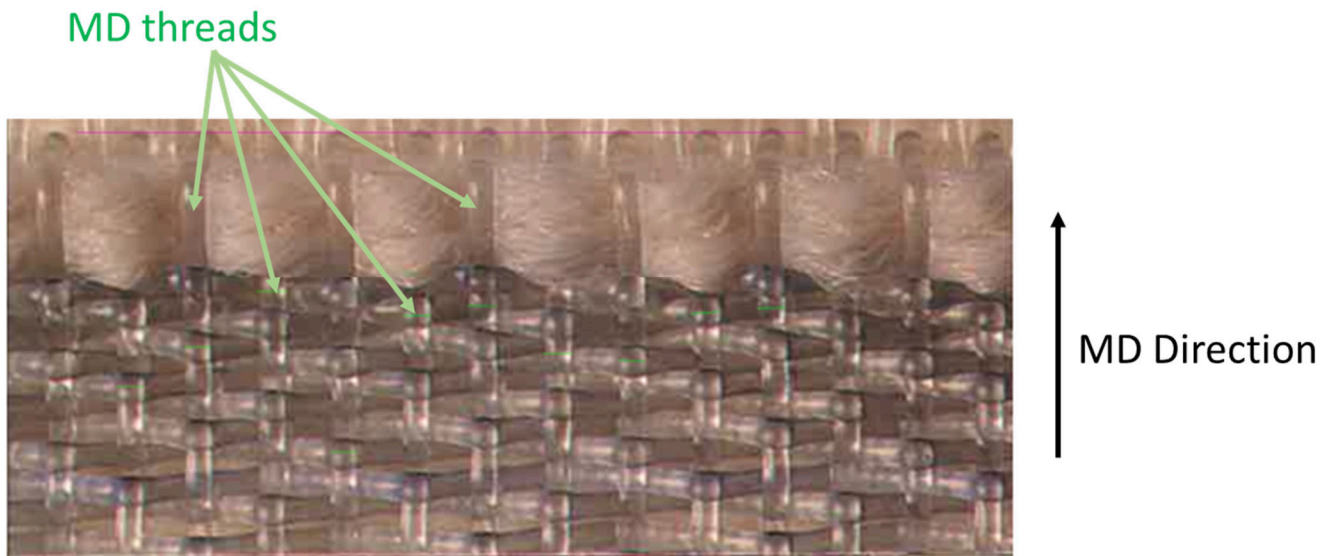
can be obtained from the photographs of an underlying seam and a finished product of the PMC shown in Rydin's Figs. 2-3 (see below). EX1027, EX1028, Figs. 2-3. As I described in greater detail in the sections below, these parameter details of Rydin's PMC correspond to the '566 patent's claimed features: a loop density of approximately 78%, and a LD/MDYD ratio of approximately 3.2.



EX1028, Fig. 2 (left, partial, annotated), Fig. 3 (right, partial, annotated).

368. For example, in Fig. 2 (shown below), by using the measurement techniques similar to the one that I described earlier (*see* Grounds 1A.3-4, *supra*) on the Rydin photograph, it can be determined that Rydin's MD

threads have a diameter of about 42.6 pixel and a thread density about 0.0091 threads/pixel. Specifically, the diameter of Rydin's MD threads was determined in a conventional way by measuring the diameter (in pixels) for ten (10) MD threads, which extend in an upward direction in the figure that is shown below.



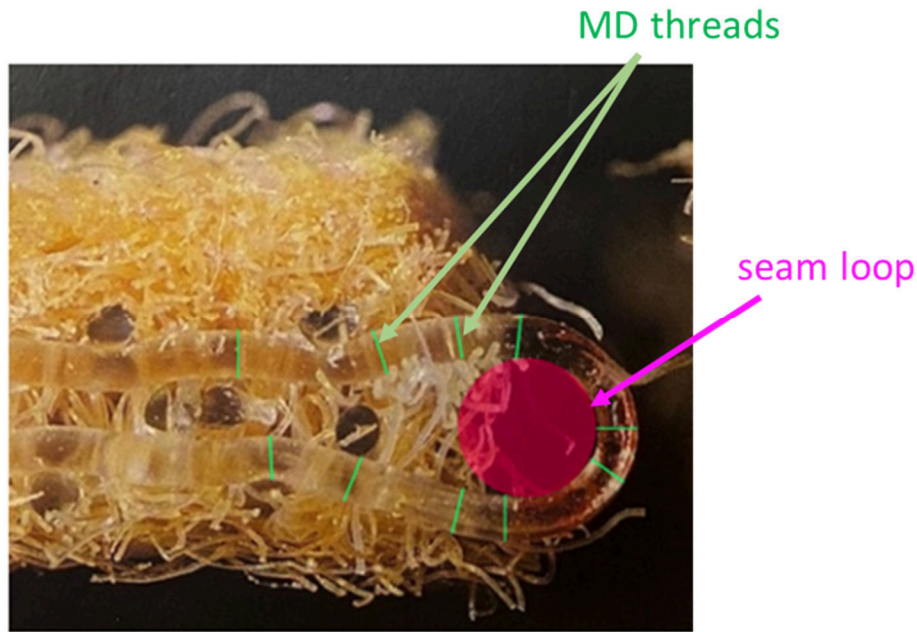
EX1028, Fig. 2 (left, partial, annotated)

369. Furthermore, the MD yarn density of Rydin's fabric was measured in a conventional way: ten MD threads in Rydin's Fig. 2 fabric span a distance (*i.e.*, the distance from the left edge of the first thread to the left edge of the tenth thread) of 1,090 pixels. The MD thread density (*i.e.*, number of threads per unit distance) was calculated to be approximately 0.0091 threads/pixel (*i.e.*, 10 threads divided by 1,090 pixels).

370. The loop density is calculated by multiplying twice the thread density times the MD thread diameter, consistent with the '566 Patent. *See* EX1001, 6:11-18. In the combination fabric, the loop density is about 78% (*i.e.*, $2 * 0.0091 \text{ threads/pixel} * 42.6 \text{ pixels}$) because the fabric parameters for the MD thread diameter (42.6 pixels) and MD yarn density (0.0091 threads/pixel) correspond to a loop density of approximately 78%, as further described in below.

371. By applying similar measurement techniques that I employed earlier (*see* Grounds 1A.3-4, *supra*), a seam loop diameter of about 167 pixels was determined from Rydin's Fig. 3. I measured the loop diameter from Rydin's Fig. 3 consistent with the '566 Patent, which states that "To determine the diameter of a seam loop, the largest circle which can be inserted completely into the seam loop is ascertained. The diameter of this circle is then viewed as the diameter of the seam loop." EX1001, 2:46-49. The largest circle that I placed into the seam loop of Rydin's Fig. 3, shown below, has a diameter of 167 pixels. Also, to ensure that measurements would be consistent with the same magnification of Fig. 3, I measured Rydin's MD thread diameter in Fig. 3 by measuring a diameter (in pixels) of the MD thread extending in Rydin's Fig. 3 at 10 different locations (measurements at locations depicted in green), yielding an average MD thread diameter of 53 pixels and a

standard deviation of 3.80 pixels. In the combination fabric, a seam loop diameter and a MD thread diameter of about 167 pixels and 53 pixels, respectively, based on measurements of Rydin's PMC in Fig. 3, corresponds to a ratio ***LD/MDYD*** of about 3.2 (*i.e.*, 167 pixels / 53 pixels).



EX1028, Fig. 3 (right, partial, annotated)

372. Unlike Adanur, Rydin's photographs lack a measurement scale. Units of measurement in centimeters, however, are not needed to determine the loop density and the LD/MDYD ratio since such values are simply mathematical ratios of fabric parameters (e.g., MD thread diameter, loop diameter, etc.) and are, therefore, dimensionless. *Id.* Furthermore, a POSITA interested in fabricating a PMC product would have been motivated in understanding the proportional relationship of basic fabric

parameters. Even though Rydin does not provide a unit of measurement for its parameters (e.g., MD thread diameter), that is not necessary for a skilled person who is interested in evaluating the relationships of various PMC parameters, e.g., thread shape, the spacing between MD threads relative to the MD diameter (e.g., MD thread density), and a loop density. A POSITA would have selected a thread diameter based on the needs of a particular application, and would have naturally looked to sources, like Rydin, to determine a relative loop density and loop ratio (i.e., LD/MDYD ratio) to determine a loop size relative to that thread diameter that relates to a suitable strain on the thread that is curved around the loop.

3. *Motivation for the Combination*

373. For many of the same reasons discussed above in the Sudre-Adanur grounds (Grounds 1A-1E, *supra*), a POSITA would have been motivated to looked to Rydin to identify the “particular requirements” for Sudre’s PMC to determine parameters informative of thread shape and relative loop sizing and thread spacing. EX1027, EX1028, Figs. 2-3. Because Sudre is silent as to specific parameters relating to its loop spacing and loop diameter, a POSITA seeking to make a particular PMC (e.g., press fabric) would have been motivated to look to other known sources, such as Rydin, to identify the parameters that result in a PMC meeting the desired “particular

requirements.” EX1004, 6:14-17. For example, a POSITA would have been motivated to seek sources, like Rydin, to determine how to make loops in relation to a particular thread diameter. Specifically, the relative proportions and sizes, such as a relative loop density and loop ratio (i.e., LD/MDYD ratio), for a particular thread would have provided important information to a POSITA on how to make suitable loops in seamed PMC. A POSITA would have understood that a loop size relative to a given thread diameter relates to a suitable strain on the thread that is curved around the loop.

374. Also, a POSITA would have expected success in dimensioning Sudre’s PMC using dimensions taught by Rydin. *Id.* Specifically, a POSITA would have looked to Rydin since it was published by a well-known PMC manufacturer and described a commercialized product in its publication. *Id.* A POSITA would have expected success in dimensioning Sudre’s PMC using parameters taught by Rydin because they both pertain to PMC, and specifically to press fabrics made “endless” by seaming flat-woven base fabrics, and because Sudre imposes no specific requirements that would provide any reason to deviate from the usage of these conventional parameters. *See* EX1004, 1:2-5, 6:14-17.

4. *Application of Sudre-Rydin to Claims*

Claim [1]

375. As I discussed above in the Sudre and Adanur ground (Ground 1A), Sudre teaches all limitations of Claim 1 except for select limitations in [1.2], [1.4] and [1.5].

A POSITA would have applied the teachings of Rydin to Sudre for reasons that I have already discussed in Grounds 1A to achieve the combination identified for Ground 1A identified in Section IV.A. Similarly, a POSITA would have also had a reasonable expectation of success in applying the teachings of Rydin to the Sudre.

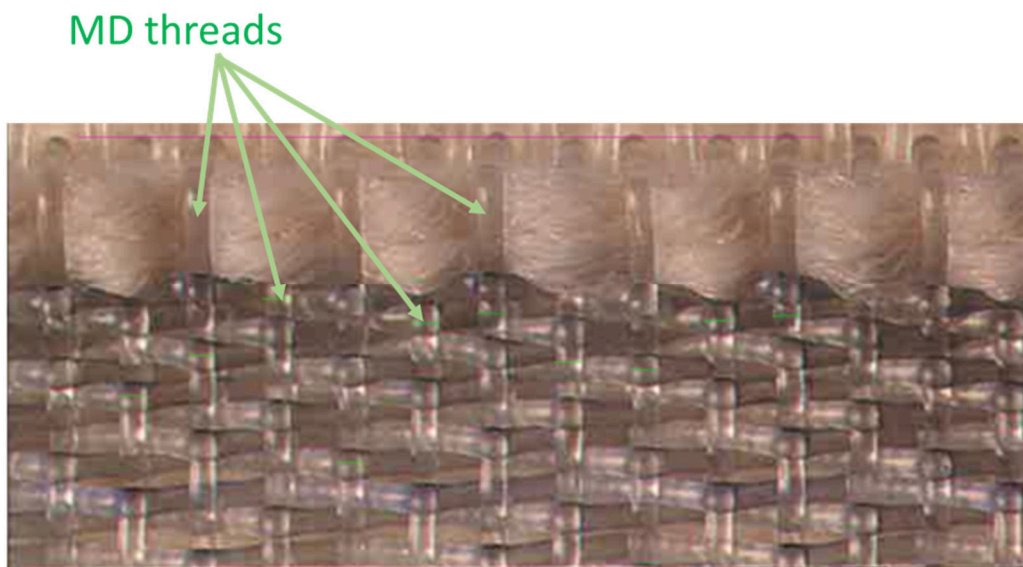
[1.2] said laminate structure having MD threads...with a round cross section...

376. With respect to claim limitation [1.2], Sudre-Rydin combination includes monofilament machine direction threads that are round (***MD threads being monofilaments with a round cross section***) since the use of round threads is taught by Rydin in its photographs of the finished product. *See* EX1027, EX1028, Figs. 2-3. For example, since the threads shown in Fig. 3 show a circular cross-sectional shape, it would have been reasonable for a POSITA would have reasonably expected both MD and CD threads to have a consistent cross-sectional shape. Moreover, for the same reasons discussed with respect to Ground 1A, a POSITA would have implemented round MD thread, as taught by Rydin.

[1.4] said seam having a loop density of between 64% and 90%; and

377. With respect to claim limitation [1.4], Sudre in combination with Rydin implements a MD thread diameter and a MD thread density of about 42.6 pixels and 0.0091 threads/pixel, respectively, based on measurements of Rydin's PMC in Fig. 2, which calculates to a loop density of about 78% (*i.e.*, $2 * 0.0091 \text{ threads/pixel} * 42.6 \text{ pixels}$). EX1028, Figs. 2-3; EX1027, Figs. 2-3.

378. As shown below, Fig. 2 of Rydin depicts an underlying seam of the "finished felt" shown in Fig. 3 in which batt has not yet been attached to the base structure. Since the absence of batt indicates that the seam of Fig. 2 is not "finished," it is possible that this seam has also not yet been thermally treated and could be subject to shrinkage that would change the value of its loop density.



EX1028, Fig. 2 (left, partial, annotated)

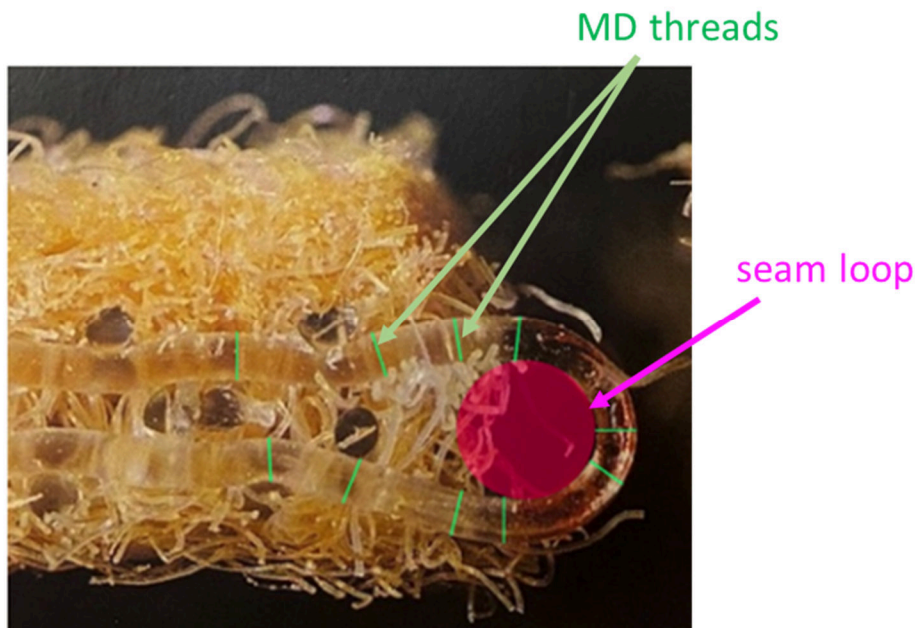
379. The '566 patent explains that “thermal method steps can lead to shrinkage of the clothing in the transverse direction” and it also provides a loop density range of “between 55% and 80%” for clothing before the thermal treatment is applied. EX1001, 6:27-40; *see also id.* (“the seam loop density before the first thermal method step is normally lower, usually between 55% and 80%, while in the finished clothing it is then higher.”).

380. Fig. 2 of Rydin depicts an underlying seam that has a loop density value of 78%, which falls within the '566 patent's claimed range of 64% and 90%. Moreover, this loop density value (78%) also falls within the '566 patent's description of a loop density range (“between 55% and 80%”) for clothing before it is subject to thermal treatment. EX1001, 6:27-40. So even if one were to assume that the seam of Rydin's Fig. 2 had not been

thermally treated, a POSITA would have reasonably assumed that the calculated loop density of about 78% would fall within the '566 patent's claimed loop density range of 64% and 90% based on the range provided for clothing before being thermally treated.

[1.5] said diameter LD of said seam loops and said diameter MDYD of said associated MD threads having a ratio LD/MDYD of between 2.7 and 3.6.

381. With regard to claim limitation [1.5], Sudre in combination with Rydin combination implements a seam loop diameter and a MD thread diameter of about 167 pixels and 53 pixels, respectively, based on measurements of Rydin's PMC in Fig. 3, which calculates to a ratio ***LD/MDYD*** of about 3.2 (*i.e.*, 167 pixels / 53 pixels). EX1027, Figs. 2-3; EX1028, Figs. 2-3.



EX1028, Fig. 3 (right, partial, annotated).

382. Accordingly, for the reasons that I have provided above and in the Sudre and Adanur ground (Ground 1A), claims 1, 3, and 12-13 are rendered obvious by Sudre and Rydin.

L. GROUND 3B-3E: The Modifications to the Sudre-Rydin Combination Render Obvious The Remaining Claims

383. The teachings of Shipley, Straub, Lidar and Yook can be applied to the Sudre-Rydin combination in a similar manner and for reasons that I have discussed in Grounds 1B-1E to achieve the combinations identified for Grounds 3B-3E identified in Section IV.A. A POSITA would have had a reasonable expectation of success in applying each of Shipley, Straub, Lidar and Yook to the Sudre-Rydin combination in a similar manner and for the reasons that I previously discussed in Grounds 1B-1E to achieve the combinations based on Sudre and Rydin with exception of obtaining fabric parameters from Rydin's PMC. All other elements of the claims identified with respect to Grounds 3B-3E are disclosed by the respective combinations for the reasons discussed in respective grounds 1B-1E.

VIII. LEGAL PRINCIPLES

A. Anticipation

384. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as anticipated. I have been informed by Counsel and understand that all prior

art references are to be looked at from the viewpoint of a person of ordinary skill in the art.

385. I have been informed by Counsel and understand that a challenged claim is unpatentable as “anticipated” under 35 U.S.C. § 102 if it is determined that all the limitations of the claim are described in a single prior art reference. I have been informed by Counsel and understand that, to anticipate a claim, a prior art reference must disclose, either expressly or inherently, each and every limitation of that claim and enable one of ordinary skill in the art to make and use the invention.

386. I have been informed by Counsel and understand that in an inter partes review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of anticipation, “by a preponderance of the evidence.” 35 U.S.C. §316(e).

B. Obviousness

387. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as obvious. I have been informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art at the time of the invention, and that this viewpoint prevents

one from using his or her own insight or hindsight in deciding whether a claim is obvious.

388. I have been informed by Counsel and understand that a claim is unpatentable for obviousness under 35 U.S.C. § 103 “if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.” I have been informed by Counsel and understand that obviousness may be based upon a combination of references. I have been informed by Counsel and understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. However, I have been informed by Counsel and understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.

389. I have been informed by Counsel and understand that when a patented invention is a combination of known elements, a court must determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue by considering the teachings of prior art references, the effects of demands known to people working in the field

or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art.

390. I have been informed by Counsel and understand that a patent claim composed of several limitations is not proved obvious merely by demonstrating that each of its limitations was independently known in the prior art. I have been informed by counsel for the Patent Owner and understand that identifying a reason those elements would be combined can be important because inventions in many instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. I have been informed by Counsel and understand that it is improper to use hindsight in an obviousness analysis, and that a patent's claims should not be used as a "roadmap."

391. I have been informed by Counsel and understand that an obviousness inquiry requires consideration of the following factors: (1) the scope and content of the prior art; (2) the differences between the claims and the prior art; (3) the level of ordinary skill in the pertinent art; and (4) any objective indicia of non-obviousness, such as commercial success, long-felt but unresolved need, failure of others, industry recognition, copying, and

unexpected results. I understand that the foregoing factors are sometimes referred to as the “Graham factors.”

392. I have been informed by Counsel and understand that an obviousness evaluation can be based on a combination of multiple prior art references. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but that the nexus linking two or more prior art references is sometimes simple common sense. I have been informed by Counsel and understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

393. I have been informed by Counsel and understand that if a technique has been used to improve one device, and a person of ordinary skill at the time of invention would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

394. I have been informed by Counsel and understand that practical and common sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I have been informed by Counsel and understand that a person of

ordinary skill looking to overcome a problem will often be able to fit together the teachings of multiple prior art references. I have been informed by Counsel and understand that obviousness analysis therefore takes into account the inferences and creative steps that a person of ordinary skill would have employed at the time of invention.

395. I have been informed by Counsel and understand that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill at the time of invention, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

396. I have been informed by Counsel and understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense of one of skill in the art.

397. I have been informed by Counsel and understand that secondary indicia of non-obviousness may include (1) a long felt but unmet need in the prior art that was satisfied by the invention of the patent; (2) commercial success of processes covered by the patent; (3) unexpected results achieved

by the invention; (4) praise of the invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the invention; (7) failure of others to find a solution to the long felt need; and (8) skepticism by experts. I understand that evidence of secondary indicia of non-obviousness, if available, should be considered as part of the obviousness analysis.

398. I have been informed by Counsel and understand that there must be a relationship between any such secondary considerations and the invention, and that contemporaneous and independent invention by others is a secondary consideration supporting an obviousness determination.

399. In sum, my understanding is that prior art teachings are properly combined where one of ordinary skill having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

400. I have been informed by Counsel and understand that in an inter partes review, “the petitioner shall have the burden of proving a proposition

of unpatentability,” including a proposition of obviousness, “by a preponderance of the evidence.” 35 U.S.C. §316(e).

IX. CONCLUSION

401. I reserve the right to supplement my opinions to address any information obtained, or positions taken, based on any new information introduced throughout this proceeding.
402. I declare under penalty of perjury that the foregoing is true and accurate to the best of my ability.

APPENDIX A

Curriculum Vitae

Christopher M. Pastore

Professional Experience

- 2019-present *Assistant Provost, Faculty Development: Classroom Pedagogy and Nexus Learning*
Professor, Transdisciplinary Studies
Associate Director, Institute for Smart and Healthy Cities
Thomas Jefferson University, Philadelphia, PA
- 2012- 2019 *Professor, Transdisciplinary Studies*
Co-Director, Engineering and Design Institute
Nexus Learning Advocate
Kanbar College of Design, Engineering, & Commerce
Thomas Jefferson University/Philadelphia University, Philadelphia, PA
- 2018 - present *Associate Editor, Journal of Engineered Fibers and Fabrics*
- 2017-present *Honorary Research Professor, Department of Clothing and Textiles,*
Durban University of Technology, Durban, South Africa
- 2017 *Visiting Research Scientist, Institute of Technical Textiles, RWTH*
Aachen University, Aachen, Germany
- 2014 *Visiting Research Professor, Oak Ridge National Laboratory, Oak*
Ridge, TN
- 2003-2007 *Chief Science Officer, Novacomp, Inc., Willow Grove, PA*
- 2002–2012 *Professor, Engineering*
Co-Director, Engineering and Design Institute,
Program Director, Architectural Engineering
Secretary of the Faculty (2008-2009)
Chair of the Faculty (2009-2010)
Kanbar College of Design, Engineering, and Commerce
Philadelphia University, Philadelphia, PA
- 1995-2002 *Associate Professor (tenured 2001),*
Director of Research,
Program Director: Textile Engineering
Program Director: Fibrous Materials Science,
School of Textiles and Materials Technology,
Philadelphia University/Philadelphia College of Textiles and Sciences,
Philadelphia, PA

1995	<i>Visiting Research Professor</i> , Department of Textiles, University of Gent
1993-95	<i>Associate Professor</i> , (tenured, 1995) Department of Textile Engineering, Chemistry, and Science, North Carolina State University, Raleigh, NC.
1990-93	<i>Assistant Professor</i> , Department of Textile Engineering, Chemistry, and Science, North Carolina State University, Raleigh, NC.
1988-94	<i>Visiting Research Professor</i> , NASA Langley Research Center, Hampton, VA (Summers)
1988-90	<i>Assistant Professor</i> , Department of Materials Engineering, Drexel University, and <i>Associate Director</i> , Fibrous Materials Research Center, Drexel University, Philadelphia, PA.
1984-88	<i>Research Engineer</i> , Department of Materials Engineering, Drexel University, Philadelphia, PA.

Education

Ph.D.	Materials Science, Drexel University, Philadelphia, PA, March 1988; <i>A Processing Science Model for Three Dimensional Braiding</i>
M.S.	Mathematics, Drexel University, Philadelphia, PA, June 1986. Concentration: Computer Aided Geometric Design.
B.A.	Mathematics, LaSalle University, Philadelphia, PA, June 1982

Recognized Creative and Professional Achievement

Provost's Career Achievement Award, Thomas Jefferson University, 2024

Provost's Award for Applied Research, Thomas Jefferson University, 2022

Marion Roadhouse Nexus Learning Award, Thomas Jefferson University, 2021.

Member, Scientific Committee, *International Conference on Technics, Technology, and Education (ICTTE 2020)*, Yambol, Bulgaria, Nov 4-6, 2020.

National Academy of Inventors, member (Thomas Jefferson University Chapter), 2018

Honorary Research Professor, Faculty of Applied Sciences, Durban University of Technology, Durban, South Africa, 2017 - present

Journal of Engineered Fibers and Fabrics, Associate Editor, SAGE, 2017 - present

Fulbright Specialist, Textile Engineering, 2017-2020

Dr. Jackie Rehkopf Best Paper Award, "Light weighting Composites through Selective Fiber Placement", C. Pastore, 2015 SPE Automotive Composites Conference and Exhibition, Sept. 2015.

President's Award for Excellence, Philadelphia University, 2014.

Citation for Distinction, National Institute of Building Sciences, for the MS Sustainable Design, February 2012,

Best Practices in Communication – Honorable Mention, (for EcoMan and The Skeptic podcast), Council for the Advancement and Support of Education, December 2009.

Excellence in Education Award, (for MS in Sustainable Design Program) United States Green Building Council, 2009

Excellence in Sustainability Education, Delaware Valley Green Building Council, 2007

Philadelphia Sustainability Award, Pennsylvania Environmental Council, 2007

Leadership in Sustainable Building, Pennsylvania Resources Council, 2004

Director's Award, Systems Competency, National Textile Center, 2004

Best Presentation, National Textile Center, 2002, "Architectural Fabric Structures"

Distinguished Achievement in Basic or Applied Fiber Science, Fiber Society, 2000

Commendation from Philadelphia School District - Career to School program, advising high school students in engineering curricula, 1998

Outstanding Teacher of the Year, 1994, College of Textiles, North Carolina State University

Academy of Outstanding Teachers, North Carolina State University, 1994

Scholarly Activities

BOOKS OR IN BOOKS

Textile Structural Composites, C. Pastore, C. Ayranci, and F. Ko, DESTech, January 2023.

"Silicon Carbide Fibers", B. Mahltig, and C. Pastore in Inorganic and Composite Fibers: production, properties, and applications, editors B. Mahltig & Y. Kyosev, Woodhead Publishing, November 2018.

"Mineral and Ceramic Fibers", B. Mahltig, and C. Pastore in Inorganic and Composite Fibers, editors B. Mahltig & Y. Kyosev, Woodhead Publishing, November 2018.

Environmental Science: A Systems Thinking Approach (2nd ed.). C. Pastore and J. A. Klemens, Kendall Hunt Publishing Co. Ebook, 2018.

"4D-Textiles: Hybrid textile structures that change structural form with time", D. Schmelzeisen, H. Koch, and C. Pastore, Chapter 17, *Narrow Fabrics and Smart Textiles*, eds. Y. Kyosev, B. Mahltig, and A. Schwarz-Pfeiffer, Springer International Publishing, Berlin, Germany, 2018.

Handbook of Advances in Braided Composite Materials: Theory, Production, Testing and Application, C. Pastore, et al., Chapters 3, 4, 9, and 10, J. Carey, editor. Woodhead Publishing, October 2016.

Environmental Science: A Systems Thinking Approach, C. Pastore and J. Klemens, Kendall-Hunt, August 2015.

Sustainable Composites and Advanced Materials, C. Pastore and A. Netravli, eds., DESTech Publishers, April 2015.

"Harness Student Creativity and Expertise", J. Klemens, C. Pastore & M. Hudson, in *It Works For Me, Flipping the Classroom*, eds. C. Sweet, H. Blythe, and R. Carpenter, New Forums Press, Stillwater, OK, April 2015.

"Structure and Mechanics of 2D and 3D Textile Composites", *Structure and Mechanics of Fiber Assemblies*, ed. P. Schwartz, Woodhead Publishing, Cambridge, UK, October 2008.

"High-Tech Textiles", *Encyclopedia of Clothing and Fashion*, Charles Scribner, Michigan, October, 2004

Soft Computing in Textile Sciences, C. Pastore and L. Sztandera, eds., Springer-Verlag, Berlin, October, 2002.

Surface Characteristics of Fibers and Textiles, editor: C. Pastore & P. Kiekens, Marcel Dekker, Inc., NY, Dec. 2000

Technology Encyclopedia, editor of textile and apparel entries: C. Pastore, Brown Partworks, London, September, 2000

Mechanics of Textile and Laminated Composites with Applications to Structural Analysis and Design, C. Pastore and A. Bogdanovich, Jun, 1996, Chapman and Hall, London.

Illustrated glossary of textile terms for composites. Christopher M. Pastore. NASA Contractor Report 191539, Hampton, VA, October 1993.

"Analysis of composite shallow shell structures reinforced with textiles." A. Bogdanovich, C. Pastore, and A. Birger. In P. Hamelin and G. Verchery, editors, *Textile Composites in Building Construction*, volume **2**, pages 35--44. Editions Pluralis, Paris, 1992.

"Mechanical properties of triaxially braided composites: Experimental and analytical results." John E. Masters, R. L. Foye, Christopher M. Pastore, and Yasser A. Gawayed. *Contract Report 189572*, NASA, January 1992.

"Design and fabrication of a composite monocoque bicycle frame." Christopher Pastore, Nick Casale, and Dan Bristow. In T. Vigo and A. Turbak, editors, *High Tech Fibrous Materials*, pages 90--101. American Chemical Society, March 1991.

"Applications of computer aided geometric modelling for textile structural composites." Christopher M. Pastore, Yasser A. Gawayed, and YunJia Cai. In C. Brebbia, W. de Wilde, and W. Blain, editors, *Computer Aided Design in Composite Material Technology*, pages 45--53. Computational Mechanics Publications, Southampton, UK, 1990.

Atkins and Pearce Handbook of Industrial Braiding, F. Ko, C. Pastore, and A. Head, Atkins and Pearce, Covington KY, October, 1989.

"CIM of braided preforms for composites." Christopher M. Pastore and Frank K. Ko. In C. A. Brebbia, W. P. deWilde, and W. R. Blain, editors, *Computer Aided Design in Composite Materials Technology*. Springer Verlag, 1990.

"A Comparison of the Japanese and American Primary Hand for Men's Winter Suiting Fabrics", F. Ko, C. Pastore and S. Kawabata, *Objective Measurement: Applications to Product Design and Process Control*, eds. S. Kawabata, R. Postle and M. Niwa, (TMSJ: Osaka, Japan, 1986), pp. 581-589.

PATENTS

Impact and Explosive Force Minimization Structures, US Patent #9,572,389, February 2017 (T. Twardowski, A. Faden, A. Ira, C. Pastore, T. Isaacson).

Impact and Explosive Force Minimization Structures, US Patent #9,462,847, October 2016 (T. Twardowski, A. Faden, A. Ira, C. Pastore, T. Isaacson).

Vandalism-resistant Insulating Panels for Building Exteriors and Building Having Vandalism-resistant Thermally Insulative Walls, US Patent #8,287,671, April 2009 (C. Pastore, R. Fleming and T. Twardowski)

Vandalism-resistant Insulating Panels for Building Exteriors and Building Having Vandalism-resistant Thermally Insulative Walls, US Patent #7,521,114, June 2006 (C. Pastore, R. Fleming and T. Twardowski)

A Method of making a three-dimensional stiffener having at least one wall extending outwardly from a generally planar base portion, Taiwan Patent #TW355696B (with A. Malek)

Automated Three-Dimensional Method for Making Integrally Stiffened Skin Panels, US Patent # 6,019,138, February 2000 (with A. Malek).

GAMES

Starchitect, Pastore, C. and Fleming, R. The Game Crafter, Madison, WI, to be released.

The Red Queen's Menagerie, Suss, J. and Pastore, C., The Game Crafter, Madison, WI, August 2016.

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Uluturk, I., Giardini, S., Ziegler, D., Zhang, J. Pastore, C., and Stapleton, S., "Scalable Electroactive Textile Production using Twisted Silver-Plated Nylon Yarn: A Novel Approach for Soft Robotics" submitted for review, 2025.

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Frostén, S., and Pastore, C., "Dancing Fabric: Micro-Tectonic Environmental Control System", *INPUT_OUTPUT: Adaptive Materials and Mediated Environments Symposium and Exhibition*, Temple University, Oct. 2010.

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Frank K. Ko and Christopher M. Pastore, "Virtual Manufacturing of Braided Composites", *Composites Tooling and Manufacturing*, SME, 2000.

Matthew Dunn and Christopher Pastore, "Determining Three Dimensional Weaving Design from Material Requirements", *Composites Manufacturing*, 1998.

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Yasser A. Gawayed, Christopher M. Pastore and Carl S. Howarth, "Modification and Application of a unit cell continuum model to predict the elastic properties of textile composites", *Composites: Part A*, **27A**: 149-155 (1996).

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Christopher M. Pastore. "Quantification of processing artifacts in textile composites." *Composites Manufacturing*, **4** (4):87-112, 1993.

John E. Masters, R. L. Foye, Christopher M. Pastore, and Yasser A. Gawayed, "Mechanical properties of triaxially braided composites: Experimental and theoretical results." *Journal of Composites Technology and Research*, **15** (2):112--122, Summer 1993.

E. Skott Greenhalgh, Christopher M. Pastore, and Moishe Garfinkle. "Aeroelastic airfoil smart spar." *Composites Manufacturing*, **4** (4):194--206, 1993.

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Yasser A. Gawayed and Christopher M. Pastore. "Analytical techniques for the prediction of elastic properties of textile reinforced composites." *Mechanics of Composite Materials*, **5**:579--596, Dec 1993.

E. Skott Greenhalgh, Christopher M. Pastore, and Moishe Garfinkle. "A continuous fiber composite wing box-beam exhibiting twist-bend coupling." *Composites Engineering*, **3** (7-8):691--698, 1993.

Y. A. Gawayed and C. M. Pastore. "An integrated approach to the mechanical and geometrical modelling of textile reinforced composites." In *Fall Annual Meeting*, Boston, MA, December 1992. Materials Research Society, MRS.

Yu. Dzenis, A. Bogdanovich, and C. Pastore. "Stochastic damage evolution in textile laminates." *Composite Manufacturing*, **4** (4):187--193, 1992.

C. M. Pastore, A. E. Bogdanovich, and J. E. Masters. "The effects of specimen width on tensile properties of braided laminates." In *3rd Advanced Composites Technology Symposium*, Long Beach, CA, June 1992. NASA/DoD.

Ralph McGregor, Don Mershon, and Christopher Pastore. "Perception, detection and diagnosis of appearance defects in fabrics." In A. Zucker, editor, *National Laboratory Technology Transfer*, pages 13--91, ASME Publications, November 1992.

C. M. Pastore. "Quantification of processing artifacts in textile composites." In *Fiber Tex '92*, Philadelphia, PA, October 1992. NASA Langley Research Center.

"Mechanical Properties of Triaxially Braided Composites: Experimental and Analytical Results", J.E. Masters, R.L. Foye, C.M. Pastore, and Y.A. Gawayed, *NASA Contractor Report 189572*, NASA Langley Research Center, Jan. 1992.

T. Tan, C. Pastore, and F. Ko. "Engineering design of tough ceramic matrix composites for turbine components." *Journal of Engineering for Gas Turbines and Power*, **113**(2):312--317, April 1991.

John E. Masters, R. L. Foye, Christopher M. Pastore, and Yasser A. Gawayed. "Mechanical properties of triaxially braided composites: Experimental and theoretical results." In *Proceedings of the NASA/DOD Advanced Composites Technology Conference*, pages 34--41, Hampton, VA, Nov. 1991. NASA/DOD, NASA.

Yasser. A. Gawayed and Christopher M. Pastore. "Analytical techniques for textile structural composites: A comparative study of US-USSR research." In Proceedings of FIBER-TEX 90. NASA, 1990. CP 3128.

Frank K. Ko and Christopher M. Pastore. "Modelling of textile structural composites: Part I: Processing science model for three dimensional braiding." *Journal of the Textile Institute*, 81(4), 1990.

Frank K. Ko and Christopher M. Pastore. *Structure and properties of an Integrated 3-D fabric for structural composites*. ASTM STP 1874. ASTM, 1990.

Christopher M. Pastore and Frank K. Ko, "Near Net Shape Manufacturing of Composite Engine Components by 3-D Fiber Architecture", Transactions of the ASME, 89-GT-315, *Gas Turbine and Aeroengine Congress*, June 1989, ASME, NY, NY.

Frank K. Ko and Christopher M. Pastore. "Design of complex shaped structures." In *Textiles: Product Design and Marketing*, pages 123--135. The Textile Institute, The Textile Institute, May 1987.

Christopher M. Pastore, Dennis W. Whyte, H. Benny Soebroto, and Frank K. Ko. "Design and analysis of multi-axial warp knit fabrics for composites." *Journal of Industrial Fabrics*, 5(1):84--91, September 1986.

P. Fang, F. Ko, C. Pastore and M. Koczak, *Stress/strain/time relationship of silicon carbide yarns*, Drexel Press, Philadelphia, PA 1986.

Frank K. Ko, Ping Fang, and Christopher M. Pastore, "Multilayer Multidirectional Warp Knit Fabrics for Industrial Applications" *Journal of Industrial Fabrics*, 4(2):73--85, December 1985.

F. Ko and C. Pastore, "Development of Multi-bar Weft Insertion Warp Knit Fabrics for Industrial Applications", *Journal of Engineering for Industry*, Vol 11, 1980.

PRESENTATIONS AND NON-REFEREED PUBLICATIONS

"Sustainable Textiles of the Future", C. Pastore, H. Jani & H. Singh, Keynote Lecture, AUTEX 2025, Dresden, Germany, June 2025.

"Using System Dynamics Modelling for Sustainable Apparel Production", G. Kaur & C. Pastore, The Fiber Society Spring Annual Meeting, Greensboro, NC, May 2024.

"Impact of Consumer Awareness on Fast Fashion", G. Kaur & C. Pastore, *The Fiber Society's Fall 2023 Technical Meeting and Conference*, Philadelphia, PA, Oct 25-27, 2023.

"Designing 3D Braided Composites", T. Liao, C. Pastore, H. Lam, M. Grudza, & B. Ong, *The Fiber Society's Fall 2023 Technical Meeting and Conference*, Philadelphia, PA, Oct 25-27, 2023.

"Learning from Covid-19: How the pandemic led to improved digital and remote learning in textile engineering", C. Pastore, *Co-Creating the future in education and the textile industry, 4th T-CREPE Workshop*, Tourcoing, France, March 15-16, 2023.

"Imagineering at Thomas Jefferson University", C. Pastore, *Alumni Day at Disney 100*, Franklin Institute, Philadelphia, March 11, 2023.

"How to Host an Inter-professional Academic Book Club", D. Verbit and C. Pastore, *Innovative Strategies to Advance Student Learning*, ITLC Lilly, Asheville, NC, Aug 8-10, 2022.

"Finding Joy in Game Design", C. Pastore and J. Suss, *Faculty Day 2022*, Thomas Jefferson University, June 2022.

"Talking Teaching", C. Pastore, *Faculty Day 2022*, Thomas Jefferson University, June 2022.

"Development of a 3D Braided Preform for Rotorcraft flex beams", C. Pastore, D. Nguyen, T. Chen, S. Ng, B. Ong, H. Lam, M. Grudza, D. Jann, R. Ciccarelli, and T. Liao, *Vertical Flight Society Forum 78*, Fort Worth, TX, May 10-12, 2022.

"Characterization of Residual Monomer in Acrylic Emulsion Medical Adhesives", M. Ugwuanyi, C. Pastore, & T. Twardowski Jr, Thomas Jefferson University College of Health Sciences Student Poster Session. Thomas Jefferson University. April, 2021.

"Introduction to 4D Textiles", C. Pastore, *AATCC Workshop*, online, March 5, 2021

"Textile education during the 2020 pandemic: experiences in US, South Africa and Germany", Fassihi, A., Flax, B., Kyosev, Y., and Pastore, C., refereed proceedings of *International Conference on Technics, Technology and Education*, Yambol, Bulgaria, Nov 4-6, 2020.

"Assessment of Biodegradable Weed Control Fabrics Made of Flax and Polylactic Acid Fibers", W. Chanprapanon, B. George, & C. Pastore, *PaperCon 2019*, TAPPI, Indianapolis, IN, May 5-8, 2019.

"Shape Memory Polymers for Recovery of 4D Textiles", C. Pastore, Keynote Speaker, *Aegean Textile Conference*, Mytilene, Greece, Sept 4-7, 2018.

"4D Textiles and Shape Memory Polymers", C. Pastore, D. Schmelzeisen, S. Shajoo, and J. Hairer, *Kármán Conference: Additive Fabrication of Interactive Material Systems*, Bergisch Gladbach, Germany, July 15-18, 2018.

"Game-Based Learning to Enhance Student Engagement", J. Suss, C. Pastore, R. Fleming & D. Orsetti, *Faculty Days*, Thomas Jefferson University, June 5, 2018, Philadelphia, PA.

"4D Textiles: Defined shape-change through 3D printed hybrid textiles", D. Schmelzeisen, C. Pastore, J. Haller, and T. Gries, *Fiber Society Annual Meeting 2017*, November, Athens, GA.

"Advances in Technical Textiles", *Dean's Lecture Series*, Durban University of Technology, Durban, South Africa, 20 September, 2017.

"Use of Elastomers and Bingham Plastics for Energy Absorption", *Plastics Institute of Southern Africa*, invited lecture, Durban, South Africa, 19 September, 2017.

"Implications of Industry 4.0 to the Textile Industry", C. Pastore, *Textile Industry Symposium*, US Consulate, Durban, South Africa, 12 September, 2017.

"Optimization of Textile Composites", C. Pastore, *4D Textile Workshop*, RWTH Aachen University, Institute of Textile Technology, Aachen, Germany, July 27, 2017.

"Tailored Materials Properties using Textile Composites", C. Pastore, *AUTEX 2017*, Corfu, Greece, 29 May, 2017.

"Reinforced Bingham plastics for energy dissipation", C. Pastore and T. Twardowski, *AATCC International Conference*, Williamsburg, VA, April 2016.

"The importance of game play in engaging students in serious gaming", C. Pastore and J. Suss, *3rd Annual Lilly Conference - Austin*, Austin, TX, January 2016.

"Lightweighting Composites through Selective Fiber Placement", C. Pastore, 2015 SPE Automotive Composites Conference and Exhibition, Detroit, MI, Sept. 2015.

"Integrating Building Automation into Academic Programs", R. Waligora & C. Pastore, *Honeywell Users Group*, Scottsdale, AZ, June, 2015.

"Transportation Applications of Textile Composites", session chair, C. Pastore, *TexComp 12*, Raleigh, NC, May 2015.

"Optimizing Price-Performance of Hybrid Short Fiber Composites", C. Pastore, R. Norris, C. Eberle, D. Hartman, and T. Sudbury, Keynote Presentation, *TexComp 12*, Raleigh, NC, May 2015.

Multi-material Preforming of Structural Composites, R. E. Norris, C. C. Eberle, C. Pastore, T. Z. Sudbury, F. Xiong, D. Hartman, ORNL/TM-2015/174, CRADA/NFE-14-04920, ORNL, Oak Ridge, TN, April 2015.

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"High Tenacity Polyester Yarns: the New Generation of High Performance Biomaterial", M. King, C. Pastore, and R. Torgeson, *Pioneering the Future of Biomaterials*, Society for Biomaterials 2014 Annual Meeting, Denver, CO, April 2014.

"Noncontact Ultrasonic Characterization Techniques for Fibrous Materials Analysis", Periyaswamy, T., Balasubramanian, K., and Pastore, C. *Fiber Society 2012 Spring Conference*, St. Gallen, Switzerland, May 2012.

"The Sustainable Home: Today and Tomorrow", C. Pastore, *Eco-Expo 2012*, guest speaker, Ambler, PA, Jan 2012

"Future of Green Technologies", C. Pastore Panel Leader, *Green Building Product Summit*, Pittsburgh, PA, June 2011

"The Art and Science of Glass-making", C. Pastore, *Philadelphia Science Festival*, Philadelphia, PA, April 2011

"Green Plastics", C. Pastore, *SPE Plastic Magic*, Philadelphia, PA April 2011

"Sustainability and BioPolymers", C. Pastore, *ANTEC 2010*, keynote presentation, Orlando, FL, May 2010.

"Sustainability and Developments in Metallurgy", *Emerging Technologies Seminar*, Carpenter Technologies, April 2010.

"EcoMan and The Skeptic", *Earth Day Festival*, Cheltenham Township, April 2010.

"Here Comes the Sun", C. Pastore and R. Thompson, *Electrical and Computer Engineering Day*, Villanova University, November, 2009.

"Recent Advances in Green Materials", C. Pastore, session developer and chair, *Build Green 2009*, Philadelphia, PA, October 2009.

"Biobased Polymers for Structural Composites", C. Pastore and Y. Rane, *Society of Plastics Engineers Technical Symposium*, Newark, DE, October 2009.

"Rapidly Renewable Structural Composites", Y. Rane and C. Pastore, *International SAMPE Symposium and Exhibition (Proceedings)*, Baltimore, MD, May 2009.

"Green Materials for Brownfield Reclamation", C. Pastore, *Greening the Post-Industrial City: Innovative Reuse of Philadelphia's Idle Lands*, Philadelphia, PA April 2009.

"Commercialization of Green Products", C. Pastore, *Pa Green Growth Forum*, Hershey, PA September 2008

"Chitosan based renewable composites", Y. Rane and C. Pastore, *PA Green Growth Forum*, Hershey, PA September 2008.

"Trade Study of an Interface for a Removable/Replaceable Thermal Micrometeoroid Garment", Janet Ferl, Linda Hewes, Bobby Jones, Lindsay Aitchison, Ed Hodgson, Christopher Pastore, Bryce Beamer, and Frank Sneeringer, *International Conference on Environmental Systems*, June, 2008.

"Sustainable Textiles", C. Pastore, *Reading Public Museum*, Reading, PA, 2008.

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"Green Composites", C. Pastore and C. Schauer, *Innovations in Nanotechnologies, Composites, and Sports/Military Materials Symposium*, AATCC, Atlanta, GA, April 2007.

"Creative Design of Urban Spaces", Panelist, *Global Creative Economy Convergence Summit*, Philadelphia, PA June 14, 2006

"Opportunities for Textiles and Sustainability", C. Pastore, *TechTextil North America*, Atlanta, GA, March 2006

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"Structural Composites from Harvest Waste", C. Pastore, invited speaker, Cornell University, Ithaca, NY, October, 2003.

"Industrial Applications of 3D Textiles", C. Pastore, keynote speaker, *Textile Engineering at the dawn of a new millennium*, Bruges, Belgium, April 2002.

"Critiquing, Clarifying, Rewriting and Expanding Current Definitions of Sustainability to Include Aesthetics as a Core Value of Sustainable Design", R. Fleming and C. Pastore, *90th ACSA Annual Meeting*, New Orleans, April, 2002.

"Renewable Nonwoven Composites for a Sustainable Future", Matthew W. Dunn, Rob Fleming, and Christopher M. Pastore, *INTC 2001*, Baltimore, MD, Oct. 2001.

"Textile Composites for High Temperature Applications", C. Pastore, invited lecture, NASA Glenn Research Center, July, 2001.

"Textile Composites: Barriers to Commercial Acceptance", C. Pastore, keynote address,, *The Fiber Society Fall 2000 Annual Technical Conference*, Nov. 7-10, 2000, Pine Mountain, GA.

"The performance of hybrid braided composite rebar", C. Pastore, E. Armstrong-Carroll and F. Ko, 32nd International SAMPE Technical Conference, Boston, MA, Nov 2000.

"Modelling the Tensile Response of Composite Rebar", E. Armstrong-Carroll, M. Dunn and C. Pastore, International Mechanical Engineering Congress and Exposition, ASME, Orlando, FL, Nov. 2000

"The Science of Art," C. Pastore and M. Dunn, special workshop for the *Franklin Institute Discovery Science Camp*, August 2000

"Opportunities and Challenges for Textile Composites", C. Pastore, invited keynote speaker, *MCM 2000 (11th International Conference on Mechanics of Composite Materials)*, June 11-15, 2000, Riga, Latvia.

"Virtual Manufacturing of Braided Composites", F. Ko and C. Pastore, *Composites Manufacturing and Tooling, 2000*, Long Beach, CA, February 23, 2000,

"3D Weaving Technologies", C. Pastore, *Carbon Fibers '99*, Nov, 1999, San Diego

"Dynamic Mechanical Response of Woven Fabrics", C. Pastore, Invited Seminar Speaker, *15th AIAA Aerodynamic Decelerator Systems Conference*, Toulouse, France, June 1999.

"Property-Driven Three-Dimensional Weave Design," M. Dunn and C. Pastore, *International Conference on Composites Engineering V*, Las Vegas, NV, July 1998.

3-D Weaving for Composites, C. Pastore, workshop for SME Composites '97, Anaheim, CA 1997.

"The Role of Fiber Architecture in the Air Flow Resistance and Permeability of Renitent Textile Composites," M. W. Dunn and C. Pastore, *Fall General Meeting of the Fiber Society*, Newport, RI, October, 1996.

"Nonlinear impact response of textile reinforced composites.", C. Pastore, *Joint Air Force/Army Workshop on Structural Mechanics*, 22-25 September, 1997, Myrtle Beach, SC.

"Renitent Composites from Commingled Yarns," M. W. Dunn and C. Pastore, 42nd International SAMPE Symposium and Exhibition, May 1997, Anaheim, CA.

"Elastic Properties of Three-Dimensionally Woven Composites," M. W. Dunn, C. Pastore, and A. Saeys, *Advances in Fibre and Textile Science and Technologies*, Fiber Society International Meeting, April 1997, Mulhouse, France.

"Property-Driven Three-Dimensional Weave Design," M. Dunn and C. Pastore, *ICCE-V*, July 1998, Las Vegas, NV.

Geometrical Modeling of Textiles for Composites, C. Pastore and Y. Goward, Fiber Society Fall Meeting, Nov. 11-13, 1995, Philadelphia, PA (International meeting)

Drapability Evaluation of Woven Glass Fabrics, P. Kiekens, C. Pastore, and L. Vangheluwe, Fiber Society Fall Meeting, Nov. 11-13, 1995, Philadelphia, PA (International meeting)

Applications of Textile Composites - Problems and Pitfalls, C. Pastore, University of Gent, "New Products, Processes, and Applications of Textiles", July 12, 1995, Gent, Belgium. (International meeting)

"Glass-Thermoplastic Composite Building Materials From Reclaimed Waste Fibers", P. Duke and C. Pastore, *Proceedings, Tech-Textil* 1994, Frankfurt.

"Composite Panels from Reclaimed Textile Waste", C. Pastore, A. Morales and E. Skott Greenhalgh, *Proceedings, TAPPI Conference, 1995, March, 1995, Petersburg, FL*.

"3-D Stress Analysis in Textile Composite Plates Using a Combination of ANSYS and Sub-Element/Deficient Approximation Function Analysis", C. M. Pastore, A. E. Bogdanovich, V. Kumar, M. German, 10th Annual ASM/ESD, Detroit, MI, Nov. 1994.

"Effects of Heterogeneity Hierarchy on the Mechanical Response of Three Dimensional Woven Composites", A. E. Bogdanovich, C. M. Pastore, V. Kumar and M. German, Winter Annual Meeting of the ASME, Chicago, IL, Nov, 1994.

"Application of the Meso-Volume Concept to the Prediction of Elastic Properties of Rigid Textile Structures", C. M. Pastore, Fall General Meeting of the Fiber Society, Atlanta, GA, Nov. 1994.

"3-D Stress Analysis in Composite Plates Using a Combination of ANSYS and Sub-Element Deficient Approximation Function Analysis", C. M. Pastore, A. E. Bogdanovich, V. Kumar, M. German, American Society for Composites Annual Meeting, Newark, DE, Sept. 20-22, 1994.

"Three Dimensional Static Analysis of Laminated Composite Cylinders", A. E. Bogdanovich and C. M. Pastore, Annual Meeting of the American Society for Composites, Newark, DE, Sept. 1994.

"Modelling of Textile Composites", E. Glaessgen, C. Pastore, H. Griffin, A. Birger, First Annual ICCE, New Orleans, LA, Aug 29-31, 1994.

"Material Characterization of Textile Composites", C. M. Pastore and A. E. Bogdanovich, First Annual ICCE, New Orleans, LA, Aug 29-31, 1994.

"Glass-Thermoplastic Composite Building Materials From Reclaimed Waste Fiber", P.W. Duke and C. M. Pastore, Tech Textil, Hamburg, Germany, July 1994.

"Generalized Analysis of Nonuniform Inhomogeneous Structure", A. E. Bogdanovich and Christopher M. Pastore, Army Workshop on Impact of Composites, August, 1994.

"Critical Review of Materials Property Modelling for Textile Composites", C. M. Pastore, TexComp-2, Leuven, Belgium, May 17-19, 1994.

"Effects of Fiber Architecture on the Performance of Textile Composites", C. M. Pastore, Gordon Conference on Composites, January 10-14, 1994, Ventura, CA

"Elastic Properties of Triaxially Braided Glass/Urethane Composites", J. Jaranson, C. Pastore, J. Singletary, T. Kniveton, and H. Rushing, *Proceedings of the 9th Annual the Advanced Composites Conference and Exposition: Technology Exchange and Partnerships*, November 8-11, 1993, Dearborn, MI.

"Some Basic Concepts for the 3-D Analysis of Transverse and Interlaminar Stresses in Composite Structures", A. E. Bogdanovich and C. M. Pastore, *Proceedings of the 9th Annual the Advanced Composites Conference and Exposition: Technology Exchange and Partnerships*, November 8-11, 1993, Dearborn, MI.

"Role of Inhomogeneities in the Damage Resistance of Textile Composites", C. M. Pastore, *Proceedings of the 25th International SAMPE Technical Conference*, Oct. 26-28, 1993, Phila. PA.

"Analytical and Experimental Results for a Quasi-Unbalanced Composite Double Box Beam Spar", *Proceedings of the American Society for Composites 8th Technical Conference*, October 19-21, 1993, Cleveland, OH.

"Three-Dimensional Deformation and Failure Analysis of Textile Reinforced Composite Structures", A. E. Bogdanovich, C. M. Pastore and A. B. Birger, *Proceedings of the Ninth International Conference on Composite Materials (ICCM/9)*, Madrid, 12-16 July, 1993,

"Neural Network Modelling of the Mechanical Behavior of Textile Composites", W. J. Jasper and C. M. Pastore, *1992 Fall Meeting of the Materials Research Society*, Nov. 30 - Dec. 4, 1992, Boston, MA.

"Geometrical and Mechanical Modelling of Textile Reinforced Composites", Y. A. Gawayed and C. M. Pastore, *1992 Fall Meeting of the Materials Research Society*, Nov. 30 - Dec. 4, 1992, Boston, MA.

"Symmetry Conditions in Textile Structures", E. Armstrong-Carrol C. M. Pastore, and F. Ko, *1992 Fall Meeting of the Materials Research Society*, Nov. 30 - Dec. 4, 1992, Boston, MA.

"Quantification of Processing Artifacts in Textile Composites", C. Pastore, *Fiber-Tex 1992*, Philadelphia, PA, October 27-29, 1992, NASA Conference Publication 3211, 1993,

"Perception, Detection and Diagnosis of Appearance Defects in Fabrics", R. McGregor, D. H. Merzhon, and C. M. Pastore, *113th Winter Annual Meeting*, Anaheim, CA, Nov. 1992.

"Manufacture of an Aeroelastic Smart Spar", M. Garfinkle, E. S. Greenhalgh, and C. M. Pastore, *Fiber-Tex 1992*, Philadelphia, PA, October 27-29, 1992, NASA Conference Publication 3211, 1993,

"Stochastic Damage Evolution in Textile Laminates", Y. A. Dzenis, A. E. Bogdanovich and C. M. Pastore, *Fiber-Tex 1992*, Philadelphia, PA, October 27-29, 1992, NASA Conference Publication 3211, 1993, pp. 235-248.

"On The Structural Analysis of Textile Composites", A. Bogdanovich, and C. Pastore, *ASME Summer Annual Meeting on Materials and Structures*, Tempe, AZ, April, 1992.

"Analysis of Composite Shallow Shell Structures Reinforced with Textiles", A. Bogdanovich, C. Pastore, and A. Birger, *Textile Composites in Building Construction*, Lyon, France, June 1992.

"Aeroelastic Continuous Fiber Smart Spar", E. S. Greenhalgh, C. M. Pastore, and M. Garfinkle, American Society for Composites, *7th Technical Conference on Composite Materials*, Oct. 13-15, 1992, University Park, PA.

"Quantification of Processing Artifacts in Textile Composites", C. M. Pastore, *Fiber Tex '92*, Oct. 27-29, 1992, Phila., PA.

"The Effects of Specimen Width on Tensile Properties of Braided Laminates", C. M. Pastore, A. E. Bogdanovich, and J. E. Masters, *3rd Advanced Composites Technology Symposium*, Long Beach, CA, Jun 8-11, 1992.

"Applications of Structural Analysis to Textile Composites", C. Pastore, A. Bogdanovich, and Y.A. Gowayed, *Proceedings, 5th Textile Structural Composites Symposium*, Phila., PA Dec. 2-5, 1991.

"Thermal and Thermo-mechanical Characterization of Three Dimensionally Reinforced Fibrous Composites", R. Gabel, A. Fahmy, and C. Pastore, *25th International SAMPE Technical Conference*, Tokyo, Japan, Nov. 1991.

"Modelling of Euclidean Braided Fiber Architectures to Optimize Composite Properties", E. Armstrong-Carroll, F. Ko, and C. Pastore, *Fiber-Tex 91*, Raleigh, NC Oct. 15-17, 1991, NASA CP-3176, pp. 153-157.

"Modelling Textile Composites: An Integrated Process, Property, Structure Approach", E. Greenhalgh, Y. Gowayed, and C. Pastore, *Fiber-Tex 91*, Raleigh, NC Oct. 15-17, 1991.

"Analytical Techniques for Textile Structural Composites: A Comparative Study of US-USSR Research", Y. Gowayed and C. Pastore, *FiberTex '90*, Aug. 14, 1990, Greenville SC

"Computer Aided Design of Three Dimensional Woven Fabrics for Composites", A. Morales, C. Pastore, *FiberTex '90*, Aug. 14, 1990, Greenville SC

"Effects of Processing on the Behavior of 3-D Braided SiC/SiC Composites", C. Pastore, P. Khandelwal, and F. Ko, *Proceedings, 13th Annual Conference on Composites and Advanced Ceramic Materials*, Cocoa Beach, FL, Jan. 1989.

"Fabric Geometry and Finite Cell Models for Three Dimensional Composites", F. Ko and C. Pastore, *1st US/USSR Conference on Composite Materials*, Riga, USSR, May 20-25, 1989.

"Modelling of Three Dimensional Braided Carbon/Carbon Composites", C. Lei, F. Ko, and C. Pastore, *Proceedings, High Temperature Composites*, Dayton, OH, 1989.

"A Fabric Geometry Model for Brittle Matrix Composites", C. Pastore, E. Armstrong, and F. Ko, *Proceedings, Ceramic Matrix Composites*, Indianapolis, IN, April 24-26, 1989.

"Near Net Shape Manufacturing of Composite Engine Components by 3-D Architecture", C. Pastore and F. Ko, *Proceedings, Gas Turbine and Aeroengine Congress*, Toronto, Ontario, Canada, June 4-8, 1989.

"Evaluation of CVI Processing on SiC Yarns", C. Pastore, P. Khandelwal, and F. Ko, *Proceedings, 12th Annual Conference on Composites and Advanced Ceramic Materials*, Cocoa Beach, FL, Jan. 1988.

"CAD/CAM of Braided Preforms for Advanced Composites", G. Yang, C. Pastore, *Proceedings, 3rd Annual ASM/ESD Advanced Composites Conference*, Detroit, MI, Set 15-17, 1987.

"A Generalized Processing Science Model for Braided Structures", C. Pastore and F. Ko, *Fiber-Tex 1987*, NASA Publication

"Advanced Preforming Concepts for Structural Carbon/Carbon Composites", *Proceedings, 12th Annual Conference on Composites and Advanced Ceramic Materials*, Cocoa Beach, FL, Jan. 1988.

"Structure and Properties of SiC/LAS III Ceramic Matrix Composites", F. Ko, P. Fang, and C. Pastore, *Proceedings, Whisker and Fiber Reinforced Ceramic Matrix Composites*, Oak Ridge National Laboratories, Oak Ridge, TN, May 1988.

"Analytical Techniques for Modelling Mechanical Properties of Multi-axial Textile Composites", C. Pastore, *Proceedings, 3rd Annual Textile Structural Composites Symposium*, Philadelphia, PA June 1-2, 1988.

"Structure and Properties of Hybrid SiC/LAS III Glass Ceramic Matrix Composites", C. Pastore, P. Fang, F. Ko and M. J. Koczak, *Proceedings, Fabricating Composites '88*, Philadelphia, PA, Sept. 1988.

"Structure and Properties of Hybrid SiC/Al-Li Composites", C. Lei, C. Pastore, and F. Ko, *Proceedings, Metal Matrix Composites, '88*, Philadelphia, PA, Sept. 1988.

"A Processing Science Model for Three Dimensional Braiding", C. Pastore and F. Ko, *Proceedings, Advanced Composites Conference*, 1988, Detroit, MI, Sept. 1988.

"An Integrated Design Methodology for Fabric Reinforced Composite Structural Components", T. M. Tan, C. Huang, C. Pastore and F. K. Ko, *Proceedings, ASME Winter Annual Meeting 1988*, Chicago, IL, Oct. 1988.

"Processing Science Model for Three Dimensional Braiding", C. Pastore and F. Ko, *Proceedings, ASME Winter Annual Meeting*, Chicago, IL, Oct. 1988.

"CAD of 3-D Composites", C. Pastore, *Proceedings of the 2nd Textile Structural Composites Symposium*, Philadelphia, PA, Feb. 10-11, 1987.

"Structure and Properties of Cardable Glass Composites", F. Ko, M. Williams, C. Pastore, and J. Carey, *Proceedings, International Nonwovens Technical Conference, INDA Tec 87*, Hilton Head, SC, May 18-21, 1987.

"A Fabric Geometry Model for 3-D Braid Reinforced FP/Al-Li Composites", F. Ko, C. Pastore, C. Lei, and D. Whyte, *1987 International SAMPE Metals Conference: Competitive Advances in Metals/Metal Processing*, Cherry Hill, NJ, Aug. 18-21, 1987.

"Textiles: Product Design and Marketing", F. Ko and C. Pastore, *Proceedings, Annual World Conference of the Textile Institute*, Como Italy, May 5, 1987.

"The Effects of Fiber Architecture on SiC/SiC Composites", F. Ko, C. Burklund, C. Pastore, and M. Koczak, *Tenth Conference on Composites and Advanced Ceramic Materials*, Cocoa Beach, FL, Jan. 19-24, 1986.

"Control of Fiber Architecture for Tough, Net Shaped Structural Composites", F. Ko and C. Pastore, *Proceedings, Symposium on High Temperature Materials for the 1990's and Beyond*, Phila. PA, May 16, 1986.

"Cardable Glass Fibers for Composites", M. Williams, F. Ko, and C. Pastore, *Proceedings, IFAI Conference*, Boston MA, Oct. 1986.

"Tensile and Shear Properties of Composites by Various Reinforcement Concepts", A. Mayadas, C. Pastore and F. Ko, *Proceedings of the National SAMPE Technical Conference*, Anaheim, CA, 1985.

"Computer Aided Design of Nonwoven Fabrics", F. Ko and C. Pastore, *Proceedings of INDA Technical Symposium*, Boston MA, 1985.

"Design and Formation of 3-D Fabrics for Advanced Composites", Ko, F.K. and Pastore, C.M., *Composite Materials, NASA Publication CP-2420*, Annapolis, MD, November 1985

"Multilayer, Multidirectional Warp Knit for Industrial Applications", F. Ko, P. Fang, and C. Pastore, *Proceedings, IFAI Textile Technology Forum*, New Orleans, LA, Oct. 31, 1985.

"Nonlinear Viscoelasticity of Natural Polyamide Fibers", Ko, F.K. and Pastore, C.M., *Proceedings, 7th International Wool Textile Research Conference*, Tokyo. 1985.

Role of Processing in the Performance of Textile Reinforced Composite Materials, C. Pastore, NCSU COT Graduate Seminar Series, Sept. 1992.

Use of Textile Composites in the Aerospace Industry, C. Pastore, Society for Plastic Engineers, Southern Pines, NC, April, 1992.

Design and Analysis of Three Dimensional Preforms for Composites, C. Pastore, SAMPE Long Island Division, March 14, 1989.

Manufacture, Design and Analysis of Braided Fabrics and Composites, C. Pastore, Proceedings, 4th Annual Textile Structural Composites Symposium, Philadelphia, PA July 24-26, 1989.

Model for Silk-Like Spun Bonded Fabrics, F. Ko, P. Fang, C. Pastore, INDA-TEC: The International Nonwovens Technical Conference, Philadelphia, PA, 1988.

Courses Taught

THOMAS JEFFERSON UNIVERSITY

Advanced Textile Composites
Analytical Methods^S
Architectural Engineering Senior Design
Behavior of Materials^A
Chemical Protective Clothing^C
Composite Materials: Design and Analysis
Design of Green Materials^A
Eco-Innovation and Sustainability^S
Engineering Dynamics
Engineering Senior Design I & II
Engineering Statics
Experimental Materials^A
Experimental Structures^A
Fabric Mechanics
Fabric Studies
Fibrous Composite Materials
Foundations: Fabric Studies
Integrative Design Process
Introduction to Computer Programming
Introduction to Structural Analysis
Introduction to Textile Materials^C
Introductory Materials Science
Mechanics of Materials
Mechanics of Textiles
Numerical Methods
Probability and Statistics
Processing of Polymers and Fibers
Research Methods
Structural Design of Compressive Systems
Structural Design of Tensile Systems

Structures I ^A
Structures II^A
Textile Engineering Senior Design I & II
Textile Materials
Textile Problem Solving
Yarn Mechanics

NORTH CAROLINA STATE UNIVERSITY

Design of a Composite Baja Vehicle
Introduction to Fiber Science
Introduction to Textiles
Mechanical Properties of Textiles
Physical Properties of Textile Fibers
Physical Properties of Textiles
Textile Composite Materials
Textile Composites
Textile Honors Seminar
Textile Materials Science Design I
Textile Materials Science Design II

DREXEL UNIVERSITY

Advanced Mechanical Behavior of Materials
Introduction to Materials Science
Numerical Methods for Materials Engineering
Senior Design Thesis

A: College of Architecture and the Built Environment

S: College of Science, Health and the Liberal Arts

C: School of Continuing and Professional Studies

Graduate Student Committees

CHAIR

T. Liao, *Three Braided Composites for Aerospace Applications*, PhD, Engineering, Thomas Jefferson University.

D. Forry, *Properties of knitted fabrics for garment modeling*, MS Textile Engineering, Thomas Jefferson University

C. Anderson, *Development of 3D Printed Gelatinous Composites*, PhD, Textile Engineering, May 2018, Thomas Jefferson University.

C. Huang, *Thermal Conductivity and Tensile Properties of Icelandic Horse Hair Fiber Reinforced Poly(Lactic Acid) Green Composites*, MS Textile Engineering, May 2012, Philadelphia University

J. Xu, *The Influence of Braid Angle and Yarn Twist Match on the Mechanical Properties and Knot Performance of Surgical Sutures*, MS Textile Engineering, May 2012, Philadelphia University

K. Fu, *Influence of Alkali Treatment on the Mechanical Properties of Aligned Jute Yarn/PLA Composites*, MS Textile Engineering, May 2011, Philadelphia University

X. Qiu, *Acoustic Qualities of Natural Fiber Reinforced Polylactic Acid Composites* MS Textile Engineering, May 2011, Philadelphia University

R. Wu, *Characterization and Development of Flax/PLA Composites for acoustic properties*, MS Textile Engineering, December 2010, Philadelphia University

Y. Rane, *Development of Triggered Degradation for Chitosan Composites*, Ph.D., August 2009, Textile Engineering, Philadelphia University

M. Owens, *Organic Material for Bone Replacement*, MS December 2009, Textile Engineering, Philadelphia University

T. Periyaswamy, *Ultrasonic Characterization of Flexible Textile Materials*, Ph.D., March 2009, Textile Engineering, Philadelphia University

K. Darrah, *Luminous Fabric Structures*, M.S. May 2010, Textile Engineering, Philadelphia University

- H. Khurana, *Effect of Processing on Mechanical and Physical Properties of Chemical Protective Clothing*, M.S., May 2006, Textile Engineering, Philadelphia University
- A. Naik, *Ultra-light weight cement products for built environments*, M.S., May 2005, Textile Engineering, Philadelphia, University
- S. Ram, *Highly extensible knit fabrics for architectural applications*, M.S., May 2004, Textile Design, Philadelphia University
- C. Wollner, *Non-linear anisotropic fabrics for architectural structures*, M. S., May 2002, Textile Engineering, Philadelphia University
- K. Hristov, *Tensile Characteristics of Hybrid Braided Structures*, M. S., May 2002, Textile Engineering, Philadelphia University
- D. Lee, *Moisture Diffusion in Kevlar®-Epoxy Composites*, M.S. May 2000, Textile Engineering, Philadelphia University.
- L. DellaPutta, *Dynamic Response of 3D Woven Tapes Subject to Axial Tensile Load*, M.S., August 1998, Textile Engineering, PCT&S
- J. N. Singletary *Analysis of Transverse Compressive Response of Anisotropic Single Fibers*, Ph.D., June 1998, Fiber and Polymer Science, NCSU.
- T. Chen, *Effect of Glass Fiber Surface Treatments on the Bonding of Glass Fiber in Resin Matrix Composites*, M. S. , May 1998, Textile Engineering, PCT&S
- M. W. Dunn, *Renitent Textile Composites: Formation and permeability analysis of porous media*, M.S., May 1997, Textile Engineering, PCT&S.
- A. B. Birger, *Development of Curvilinear Spline Aided Techniques for Structural Analysis of Textile Composites*, Ph.D., June 1997, Fiber and Polymer Science, NCSU.
- B. Deepak, *Application of Parametric Splines in Curvilinear Coordinate Systems for the Structural Analysis of Inhomogeneous Materials*, Ph.D., June 1997, Fiber and Polymer Science, NCSU.
- G. Loughry, *Analysis of Shear Testing Methods for Braided Composite Cylinders and Plates*, M.S., Dec. 1995, Textile Engineering and Science, NCSU.
- S. Khedekar, *Modelling of Braided Composites with Architectural Defects*, M.S. Sep. 1995, Mechanical and Aerospace Engineering, NCSU.

C. G. Green, *Cost-Effective Textile Reinforcements for Complex Shaped Automotive Components*, M.S., Dec. 1995, Textile Engineering and Science, NCSU.

P. W. Duke, *Commingled Thermoplastic-Glass Composites Formed from Recyclable Carded Webs*, M.S., Dec. 1995, Textile Engineering and Science, NCSU.

B. Deepak, *Application of Parametric Splines to the Displacement Solution of Textile Composites*, M.S. March. 1995, Textile Engineering and Science and Mechanical and Aerospace Engineering Co-major, NCSU.

E. C. Clyburn, *Application of Neutron Tomography to the Investigation of Textile Reinforcement Geometry in Composites*, M.S., Feb. 1995, Materials Engineering, NCSU.

E. S. Greenhalgh, *Development of Biomimetic Prosthetic Heart Valve Leaflets*, Ph.D., Dec. 1994, Fiber and Polymer Science, NCSU.

Y. Gawayed, *An Integrated Approach to the Mechanical and Geometrical Modelling of Textile Structural Composites*, Ph.D. March 1992, Fiber and Polymer Science, NCSU.

E.S. Greenhalgh, *Fabric Geometry Modelling Applied to Finite Element Methodology for the Prediction of Mechanical Behavior of Cylindrical Composite Structures*, M.S., March 1992 Fiber and Polymer Science, NCSU.

Funded Research Activities

3D Braided rotorcraft components, Phase 2, STTR	Naval Air Warfare Center	2021-2023
3D Braided rotorcraft components, Phase 1 Option, STTR	Naval Air Warfare Center, Patuxent River	2020-2021
3D Braided rotorcraft components, Phase 1 STTR	Naval Air Warfare Center, Patuxent River	2019-2020
Development of a Medical Adhesive with Thermal Release Properties	Saligman Family Surgery Pilot Grant	2018
Effect of Temperature on Strength of Biocompatible Adhesives	Faculty Research Grant	2018
Game Based Learning	Nexus Research Grant	2017
Multi-material preforming of structural automotive composites	Oak Ridge National Laboratory	2013
Development of warp knitted heater panels for helicopter rotors	Cox & Co.	2012-2016
Optimization of braided sutures	Ethicon	2011-2013
Evaluation of energy efficient classrooms	CertainTeed	2011-2012
Development of Cellulose/PLA composites as hardwood replacement	DCED/Comins Guitars	2011
Life Cycle Assessment and Environmental Impact of Textile Products	Federal Mogul	2010-11
Development of braided nerve conduits	Rutgers Univ.	2010-13

Design of Sustainable Classroom Components	CertainTeed	2010
Development of new building products	CS Group	2008
Design of ergonomic, comfortable carriage vests	KDH, Inc.	2007-2009
Effectiveness of stretch fabric for enhanced athletic performance	Lontex, Inc.	2007-2008
Design and Characterization of transparent exterior building insulation materials	Roofscapes, Inc.	2007-2008
Residential Complex Design Charette	Earth Rising, Inc.	2007
Development of wheat gluten polymers	Green Materials R&D	2008
Evaluation of through thickness reinforcement of Carbon/Carbon Composites	MR&D	2007
Pa Green Growth Partnership	PA DCED	2006-2011
Consortium for Sustainable Design and Research	PA DCED	2003-2006
Bioinductive Scaffolds	NIH	2004-2005
Sustainability as a Source of Competitive Advantage	NTC	2003-2005
Representations and Algorithms for Deformable Objects	NSF	2002-2005
Trans-Atlantic Textile Network	FIPSE	2002-2004
Spray-on Insulation System for Housing	State of PA	2002-2004
Engineering and Design Studio	State of PA	2000-2002
Haptic Simulation of Fabric Structures	NTC	2000-2002

Exploring Architectural Fabrics	NTC	2000-2002
Novel Textiles for Military Applications	DARPA	1999
Educating the Educators	NTC	2000-2002
Scale Sensitive Modelling of Braided Hybrid Composites	NTC	1998-2000
Development of self-sealing spacesuit materials	ILC Dover	1998
Materials Characterization of Elastomeric Nonwoven Fabrics	Kimberly Clark	1998
Conversion of natural fiber to textile products	Crane Paper	1998
Dynamic Response of Woven Arresting Tapes	Navy SAWC	1997-99
Apparel Research Network	DLA	1996-1999
Evaluation of Z Fiber Component in Needle Punched Nonwovens	Fiberite	1996-97
A Comparative Theoretical Study of Quasi-Static and Impact Response of Laminated and Textile Composite Structures	ARO	1996-1999
Testing and Analysis of Braided Composite Materials for Automotive Applications	Ford Motor	1994-96
Stress Analysis in Thick Walled Composite Cylinders	ONR	1995-97
Manufacturing and Analysis of Braided Composite Materials	Ford Motor	1993-94
Textile Composite Panels for Improved Indoor Air Quality	EPA	1992-95
Composite Materials for Energy Efficient Structures	Duke Power	1993-95
Prediction of Mechanical Properties of Textile Reinforced Composites	DoC	1992-95

Appearance Defects in Fabrics	DoC	1992-95
Development of Technical Glossary for Textile Composites Industry	NASA	1992
Modelling of Transverse Shear Deformation of Three Dimensionally Woven Composites	State of NC	1992-93
Geometric Modelling of Textile Reinforcements for Structural Analysis	NASA	1991-95