

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: TORSTEN WICH
U.S. Patent No.: 9,982,388 Attorney Docket No. 59054-0016IP1
Issue Date: May 29, 2018
Appl. Serial No.: 14/825,350
Filing Date: August 13, 2015
Title: FABRIC FOR A MACHINE TO PRODUCE A FIBER WEB AND
METHOD OF PRODUCING A FIBER 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: July 30, 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. 9,982,388 (“’388 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 ’388 Patent.

2. I have been asked to provide my independent analysis of the ’388 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 ’388 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 ’388 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. 9,982,388 (EX1001), and its accompanying prosecution history (EX1002)
- U.S. Patent No. 7,473,336 (“Hawes”) (EX1004)
- U.S. Patent No. 8,043,477 (“Crook”) (EX1005)
- U.S. Patent No. 6,776,878 (“Yook”) (EX1006)
- U.S. Publication No. 2014/0069549 (“Ryan”) (EX1007)
- WO International Publication No. 2006/045892 (“Virtanen”) (EX1008)
- Sabit Adanur, *Paper Machine Clothing* (1st ed. 1997) (“Adanur”) (EX1011)
- DE Publication No. 102004044568 (EX1012), and its certified translation (“McGill”) (EX1013)
- International Publication WO89/12717 (“Sudre”) (EX1014)
- U.S. Publication No. 2016/0069022 (“Lee”) (EX1015)
- U.S. Patent No. 5,939,176 (“Yook ’176”) (EX1016)
- U.S. Patent No. 7,892,402 (“Hawes ’402”) (EX1018)

- EP Patent Application Publication 0099836 (“Sarrazin”) (EX1019)
- U.S. Patent No. 5,110,672 (“Zehle”) (EX1020)
- Teknisk Information Fran Albany Nordiskafilt, SEAMTECH, Pressfilter med söm (1996). (EX1021)
- U.S. Patent No. 6,797,121 (“Hyvonen”) (EX1022)
- Horrocks & Anand, *Handbook of Technical Textiles*, Woodhead Publishing (2000) (EX1023)
- “Nylons (Polyamide)”,
<https://www.bpf.co.uk/plastipedia/polymers/Polyamides.aspx> (2011), as archived at
<https://web.archive.org/web/20110724053756/https://www.bpf.co.uk/plastipedia/polymers/Polyamides.aspx> (EX1024)
- Emery, *The Primary Structures of Fabrics*, The Spiral Press, New York (1966) (EX1025)
- U.S. Patent No. 5,360,656 (EX1026)

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 '388 Patent at the time of the earliest possible priority date of the '388 Patent, and I have done so during my review of these materials.

17. The '388 Patent has a filing date of August 13, 2015 (“the Critical Date”). Counsel has informed me that the '388 claims no earlier priority and that the Critical Date represents the earliest possible priority date to which the challenged claims of '388 Patent are entitled, and I have therefore used that Critical Date in my analysis below.

18. 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.

19. 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.

20. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '388 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 '388 Patent and the prior art discussed below.

III. SUMMARY OF CONCLUSIONS FORMED

21. 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 1-15 are obvious over Ryan and Yook
- Claims 1-15 are obvious over Hawes and Crook
- Claims 7-9 are obvious over Hawes, Crook, and Yook
- Claims 1-8 and 11-15 are obvious over Hawes and Zehle
- Claims 7-10 are obvious over Hawes, Zehle, and Yook

IV. LEVEL OF ORDINARY SKILL IN THE ART

22. In my opinion, a person of ordinary skill in the art as of the Critical Date of the '388 Patent (hereinafter a "POSITA") as of August 13, 2015 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*.

23. 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 '388 PATENT

A. Technology Background

24. Humans have made paper from raw plant materials since ancient times. EX1011 (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.

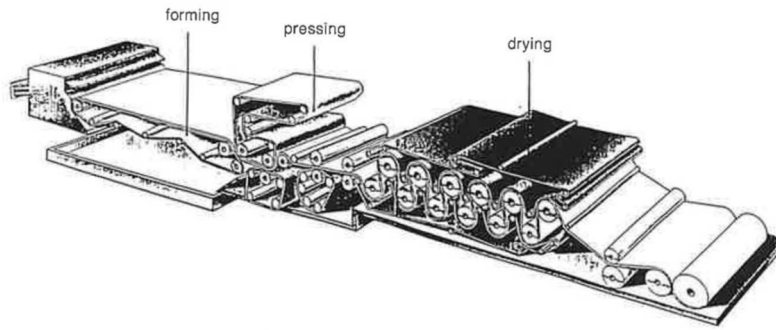


FIGURE 1.10. Schematic of a fourdrinier paper machine.

25. A typical papermaking machine consists of three distinct sections: a forming section, a pressing section, and a 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 acts as a conveyor belt to support and move materials through the machine. *Id.*, 24, 37.

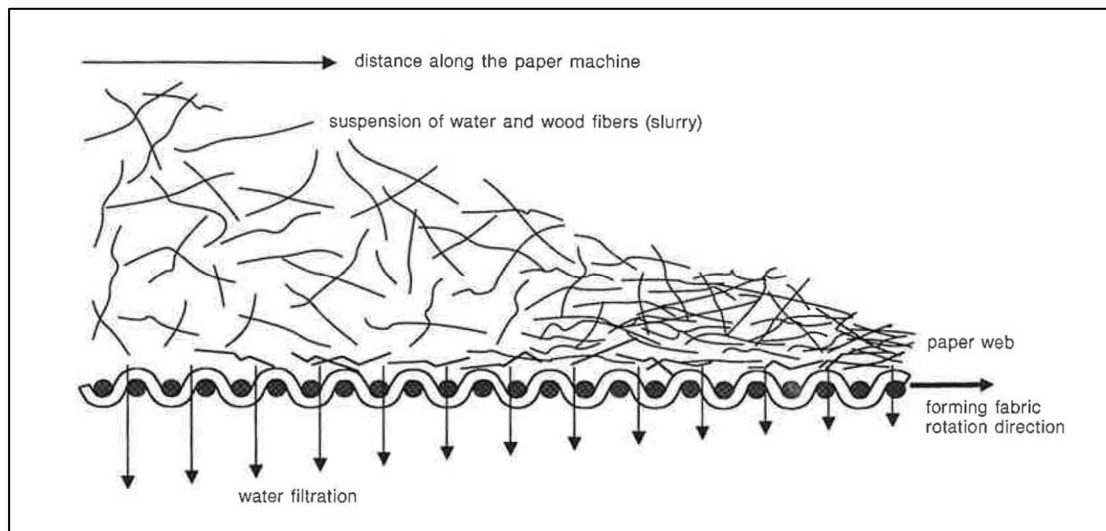
1. Paper Machine Clothing

26. The '388 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”***

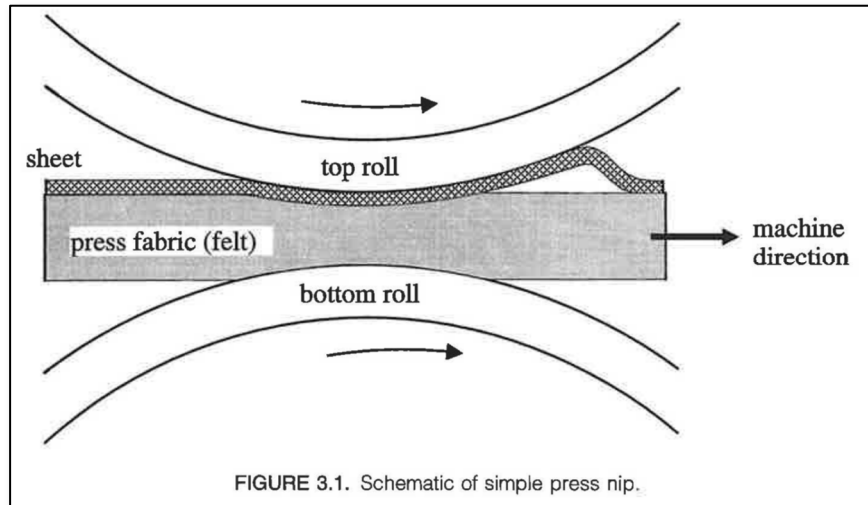
27. The papermaking process starts in the forming section of the papermaking machine. *Id.*, 6. In this section, a slurry of pulp is distributed onto a conveyor belt of specialized porous PMC called “forming fabric.” *Id.* As shown in the schematic below, water filters through the porous forming fabric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



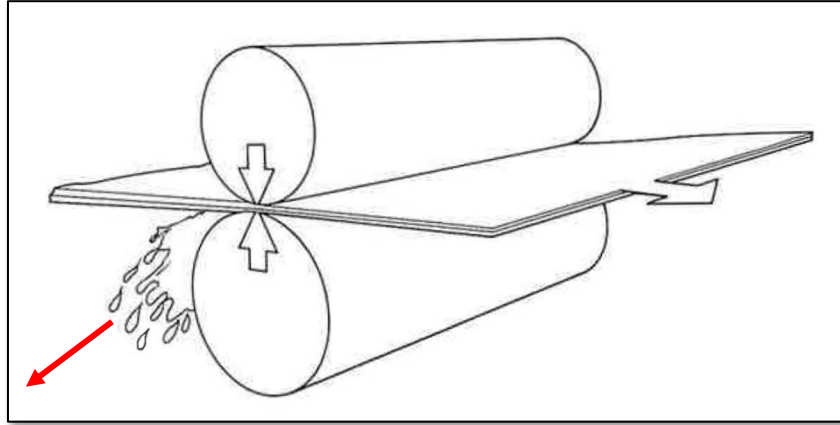
(b) ***“Press felt”***

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

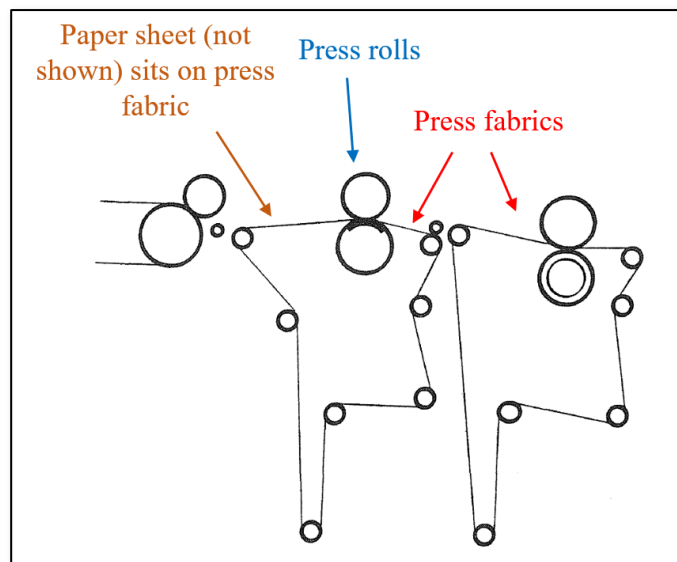
fabric” or “press felt” conveys the sheet between press rolls, as shown in the schematic below. *Id.*, 154.



29. The press rolls 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.



30. The press felt may be wrapped around multiple rolls that rotate to move and press the press felt, as shown below. *Id.*, 187.

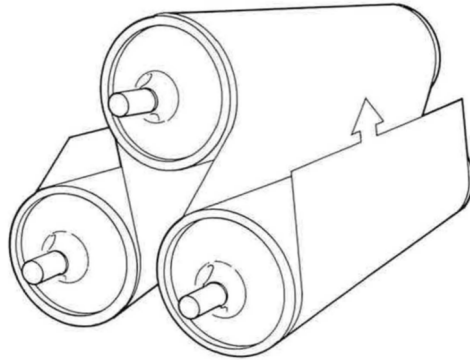


31. In addition to extracting water from the sheet, press felt influences the surface texture and finish of the resulting paper product. *Id.*, 24.

(c) **“Dryer felt”**

32. 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.



33. 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.

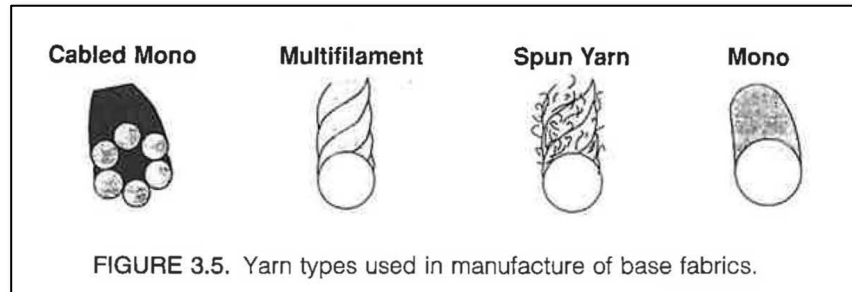
2. Threads and Weave Patterns

34. PMC can be produced by weaving on a loom using many different types of threads¹ and different weave patterns. EX1011, 38-58.

35. 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. Thread type influences the functional properties of the

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

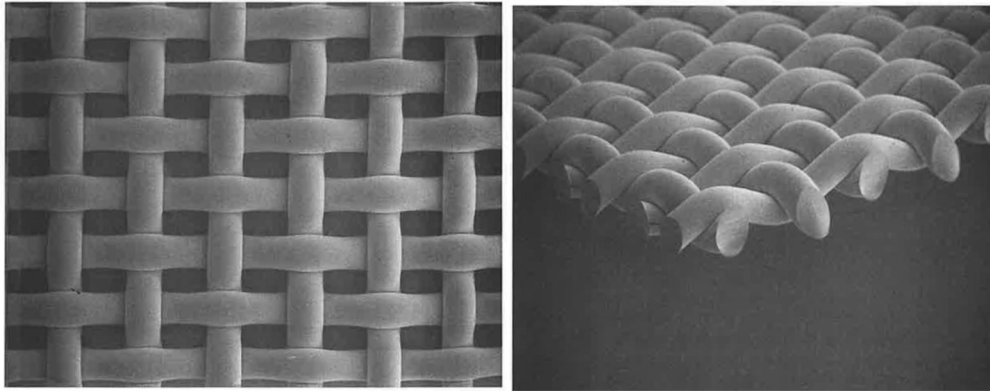
press felt, including its ability to manipulate pressure, flow resistance, void volume, and compression. *Id.*, 159.



36. Similarly, the number of fabric layers in a PMC may also differ. Press felt, for example, may consist of a single fabric layer or multiple fabric layers. *Id.* Some press fabrics include multiple separately-woven fabrics, each typically called a “base fabric.” *Id.* Each of the base fabrics may have one or more layers. *Id.* By way of example, the simplest 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.*, 38-39 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.

37. Given the close interaction between press felt and paper sheet, it has long been understood that the structure of the press fabric is important for obtaining desired paper characteristics. *See, e.g.*, EX1011, 24, 153-190; EX1004, 3:62-4:2; EX1020, 1:52-2:29.

38. The following photographs show a single layer plain weave design from a top view (left) and from a perspective view (right). EX1011, 41.



39. The following drawing shows a single layer plain weave 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-machine direction). *Id.*, 38-39. The CD wavy line (weft thread) is interwoven with the MD black circles (warp threads). *Id.*

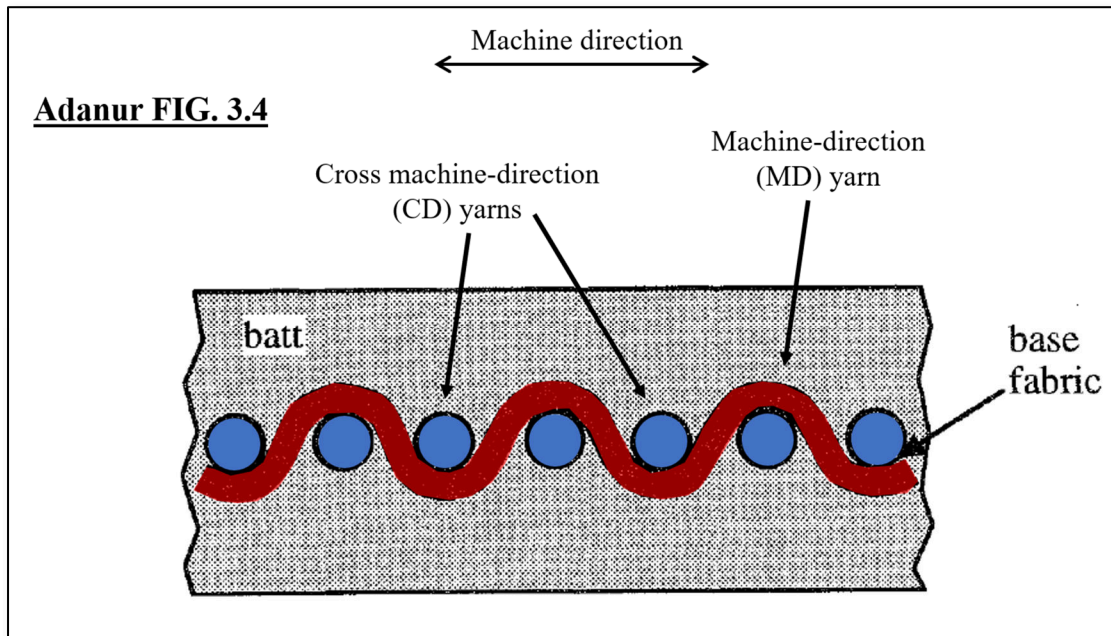
40. In the context of press felt, the PMC also typically includes a “batt”—a layer of either natural or synthetic fibers that are randomly bonded together rather than woven—that surrounds the flat-woven base fabric. *Id.*, 29, 159-60. The photograph below is a side view cross-section of a portion of a two-layer press felt,

where the gold non-woven material surrounding the threads is batt. EX1021, 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 (EX1021, 1, 3-5)

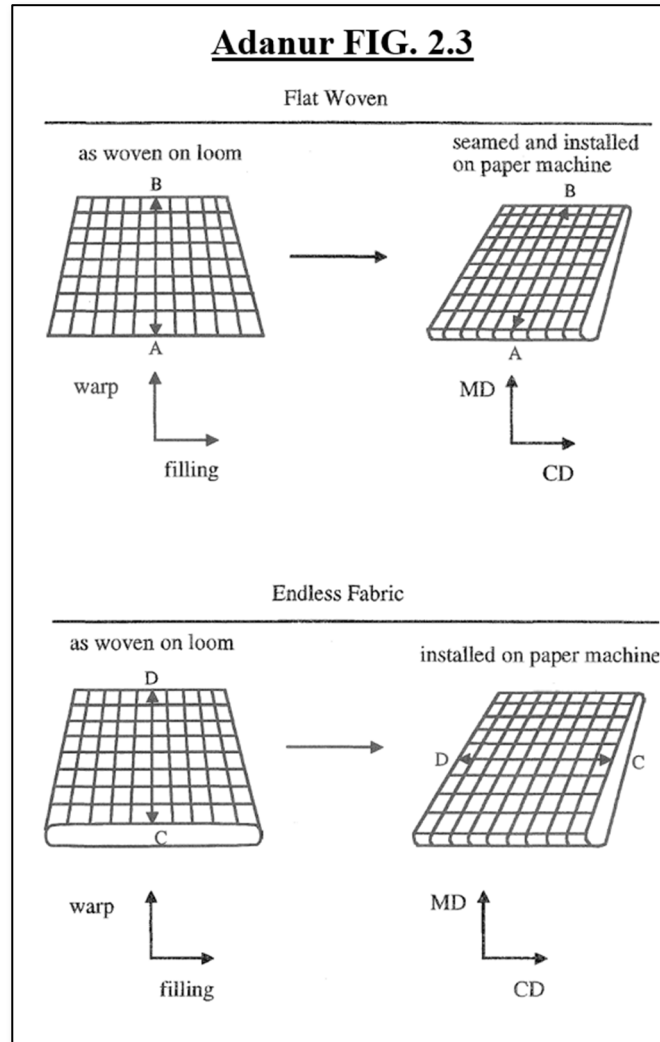
41. Adanur FIG. 3.4 illustrates an example of a PMC. Generally, the base fabric of PMC is composed of machine-direction (MD) threads (or “yarns”) (wavy red line) interwoven with cross machine-direction (CD) threads (blue circles). PMC also includes batt, which, as noted above, is a layer of fibers that are randomly bonded together rather than woven. The batt surrounds the base woven fabric (gray shading). *See* EX1011, 29, 38-58, 159;



Adanur, FIG. 3.4

3. Seaming PMC

42. PMC is typically prepared by either “flat weaving” or “endless weaving.” *Id.*, 38. Both processes are, and were, well-known in the art. EX1011, 38-39, 159. As the name suggests, endless weaving directly produces a continuous belt. *Id.*, 38-39. Yarns in an endless-woven fabric are “turned back” to define a closed loop through weaving, as shown below. Flat weaving, on the other hand, produces a sheet of fabric. In a process called “seaming,” opposite ends of the flat-woven fabric are joined (or “seamed”) in the machine direction to form a continuous belt (a closed loop) for installation on a paper-making machine.

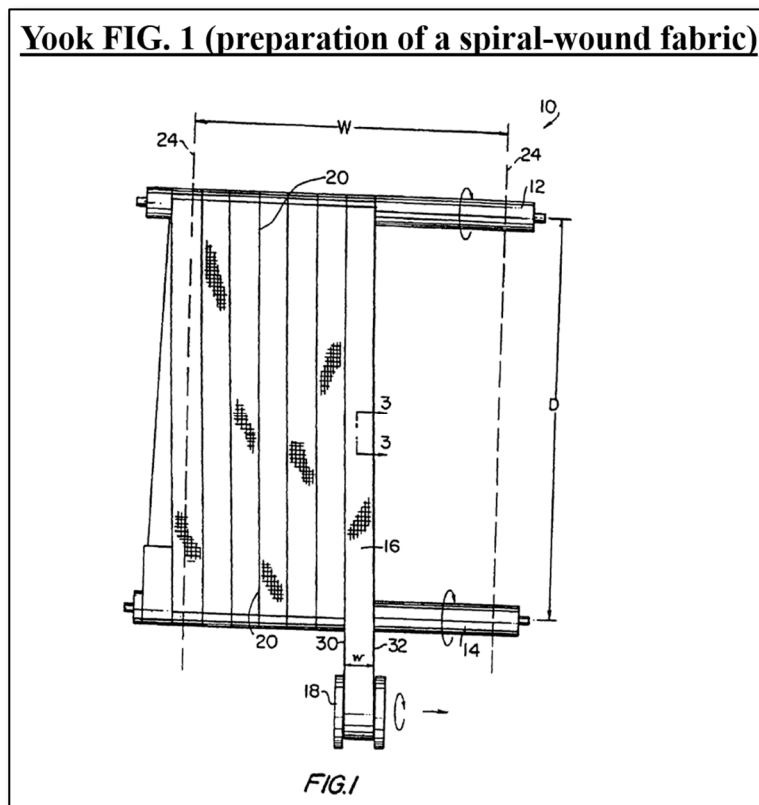


Adanur, FIG. 2.3

43. A third, newer approach takes features from both the flat-woven and endless-woven approaches. EX1006, 2:52-5:34, 7:19-8:47, FIGS. 1-5. This approach, called “spiral-winding,” is based on winding a flat-woven fabric strip in a spiral shape around two-spaced apart rolls. Successive turns of the fabric strip are placed adjacent one another in the cross-machine direction, and adjacent turns are joined to one another, e.g., by welding or gluing. *Id.* The resulting fabric is “multiaxial,” so-called because its yarns lie non-perpendicular and non-parallel to

the fabric's machine direction and cross-machine direction. EX1006, 8:9-29.

Although this fabric is flat-woven, it is wound directly in endless form and lacks terminal ends separated along the machine direction of the fabric. In that sense, although flat-woven, a spiral-wound fabric has important similarities to an endless-wound fabric, because the spiral-wound fabric is manufactured directly in endless form like an endless-woven fabric. *See also* related discussion below in §VII.B.



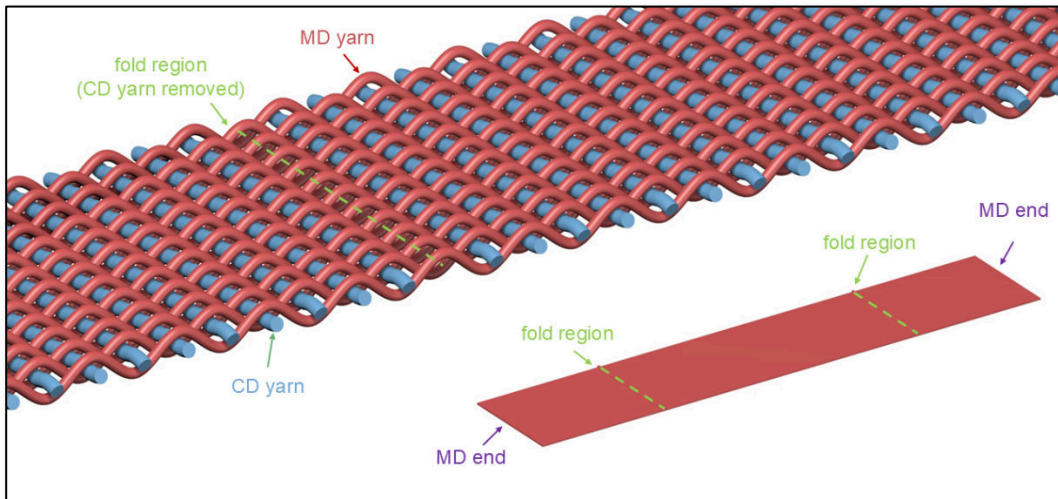
44. Notably, when installed on a paper machine, flat-woven, endless-woven, and spiral-wound/multiaxial fabrics are interchangeable and function substantially identically. That is not to say the fabrics are **fully** identical. For example, it would be possible to distinguish a flat-woven fabric from the other two

types of fabric by identifying its terminal ends separated in the machine direction. As another example, spiral-wound/multiaxial fabrics can provide certain advantages relating to, e.g., their mechanical response, due to their yarns' non-parallel extension directions. EX1006, 4:8-27. However, once prepared, the various different types of fabrics are used in the same way, in the same types of machines, to perform the same functions, and they fundamentally represent interchangeable ways of arriving at the same objective.

45. Continuous fabric belts—no matter their method of manufacture—have long been used by manufacturers. Petitioner, for example, advertised its SeamTech product—a seamed press felt—in 1996. EX1021, 1, 3, 5. Continuous belts can be easily installed on papermaking machines by a second seaming process (“on-machine seaming”), allowing for fast and efficient installation. EX1011, 159.

46. 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 a two-layer endless structure by a second seaming process. This is a conventional PMC process and it is similar to the process in prior-art references Ryan (EX1007) and Crook (EX1005), as well as the approach taken in the '388 Patent.

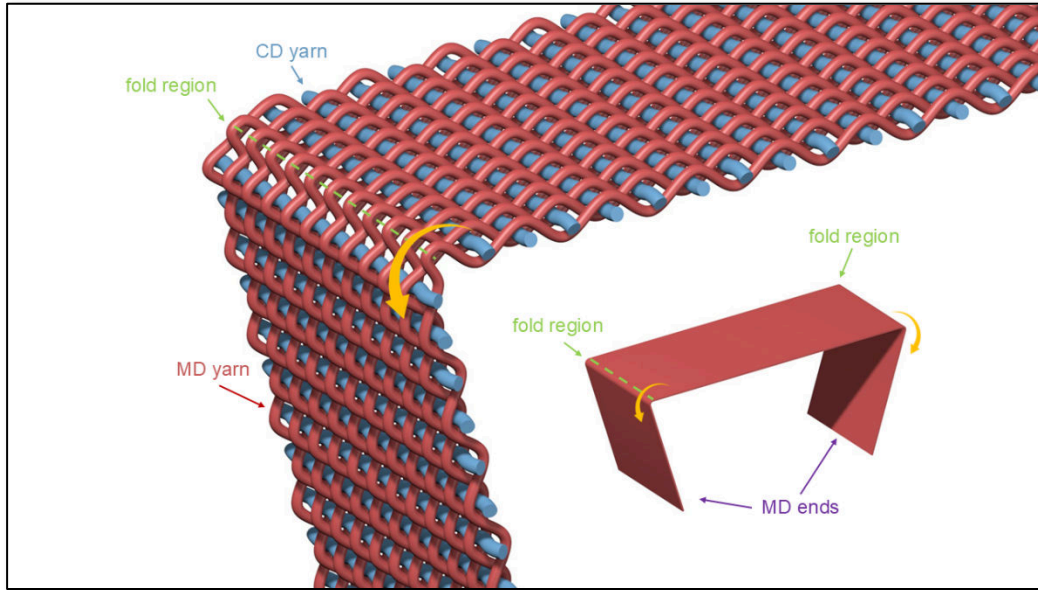
47. First, a flat-woven fabric is prepared on a loom as a flat fabric having two free long-ends, as shown below. EX1011 (Adanur), 38-39. The warp threads (red) run in the machine direction (MD), while the weft threads (blue) run in the cross direction (CD).



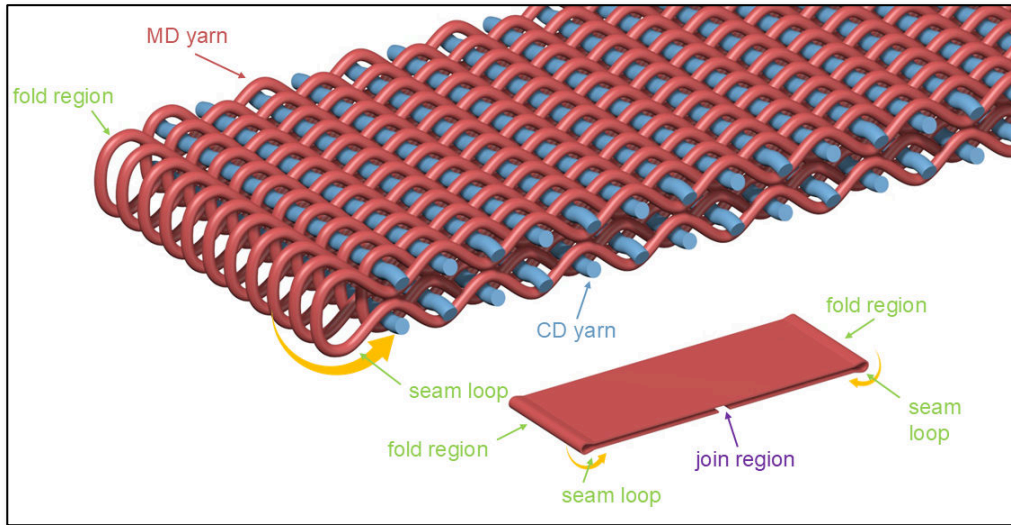
48. The flat-woven fabric has two fold regions, marked in green, where the fabric is folded to produce a two-layer structure. EX1005, 4:38-52. At the fold regions, some CD threads are removed from the fabric. EX1014, 3:22-23. As an alternative, the CD threads can be mechanically separated to leave a space without CD threads. EX1005, 4:48-54. Accordingly, each fold region shown lacks one or more CD threads, where only MD threads remain. These MD threads are referred to as “seam loops,” because they form loops through which the fabric can eventually be seamed.

49. 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

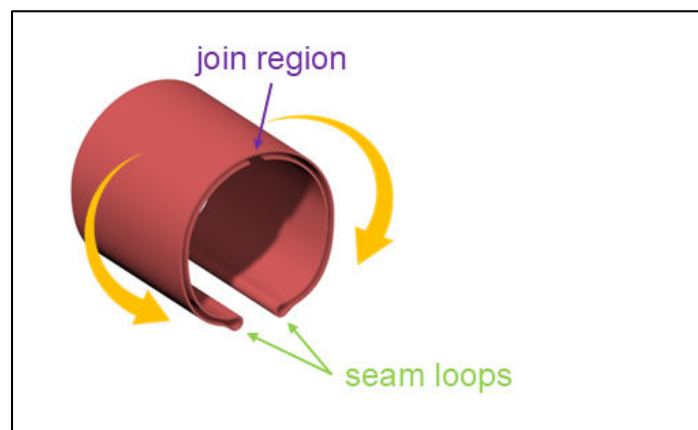
to be folded at the fold regions, while the bottom schematic shows the two-layer fabric when the folding is completed. EX1005, 4:38-45, 5:6-8.

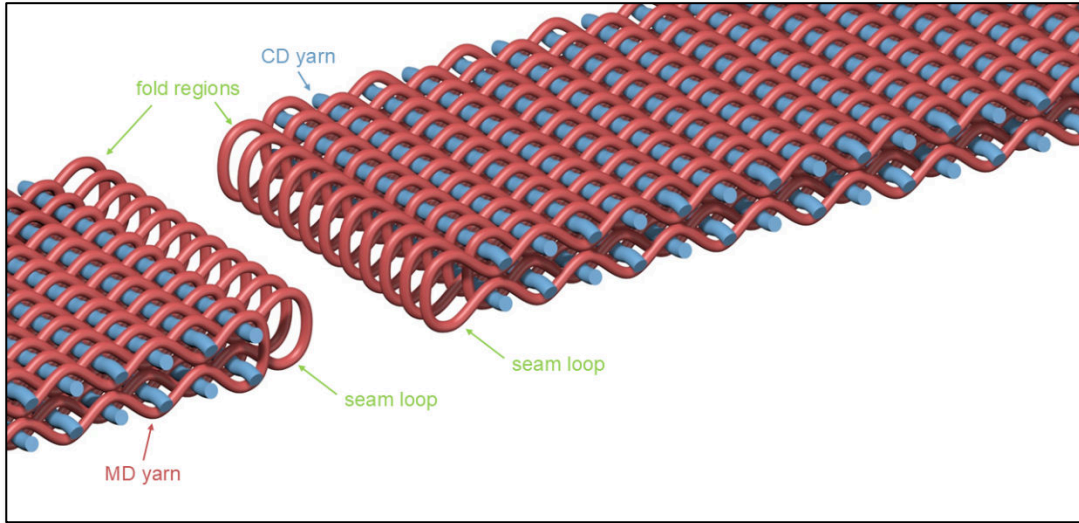


50. In the folded fabric, the free ends substantially abut (illustrated as a “join region”), and can be connected, for instance, by a welding process. EX1014, 3:18-21. This produces a two-layer structure. Importantly, as a result of folding, “seam loops” formed by the MD threads (in the absence of the CD threads) are created at the fold regions. EX1014, 3:12-21; EX1005, 4:45-48; EX1001, 1:41-45.

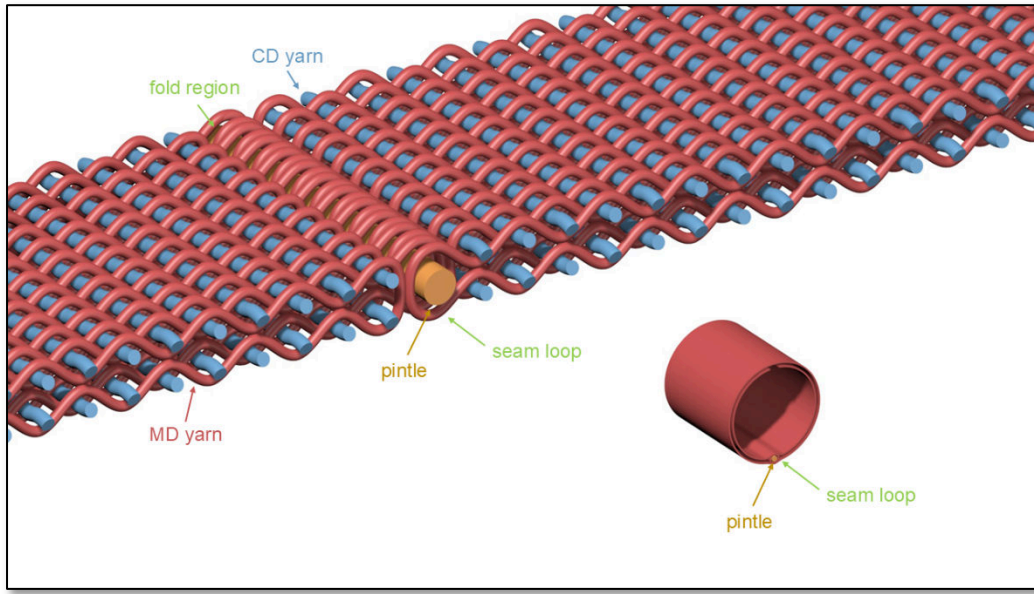


51. To make the two-layer structure “endless” for use on a papermaking machine, the two-layer structure is folded again to bring the seam loops of both fold regions together, as illustrated in the next two drawings. EX1014, 3:22-24; EX1005, 5:46-51; EX1001, 2:32-34. The top schematic shows the entire fabric, folded such that the loops are brought together, and the bottom shows a close-up view of the loops placed in close proximity.





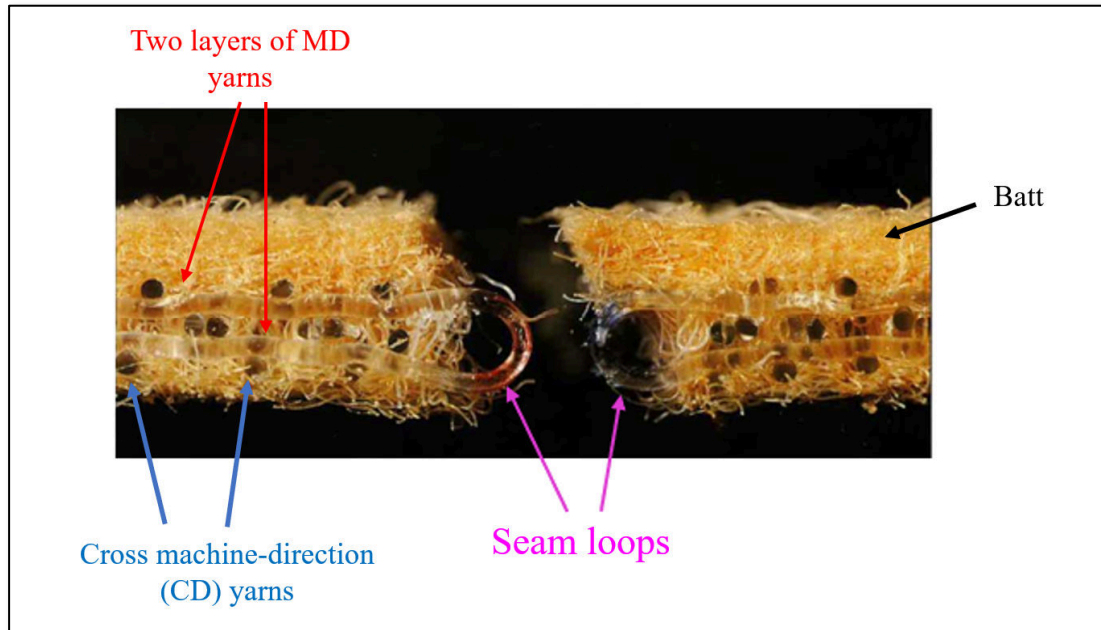
52. In this process, the seam loops from one side of the folded two-layer fabric are then interdigitated with the seam loops from the other side. EX1005, 5:48-51. This forms a channel that extends through the openings of the interdigitated loops. A pintle (for example, a pin or a bolt), is then inserted into this channel to bind the two sides together, forming a seam and making the fabric into a closed-loop, two-layer, endless belt. EX1014, 3:24-4:1; EX1005, 5:48-51. 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.



53. This seaming process is typically performed when the fabric is installed on a paper machine. EX1004, 2:22-34. That is, the fabric can be transported in unseamed form, placed on the machine in unseamed form, and seamed while on the machine. This is easier than seeking to loop an already-seamed fabric around the rolls of the machine. For example, Adanur describes that “pin seaming is used which makes installation of the fabric on paper machine a lot easier.” EX1011, 165. On-machine seaming is also typically safer than seaming prior to installation, because operators need not wrap an endless fabric around the large rolls of the machine. Fabrics configured to be installed in this way are referred to as “on-machine seamable.”

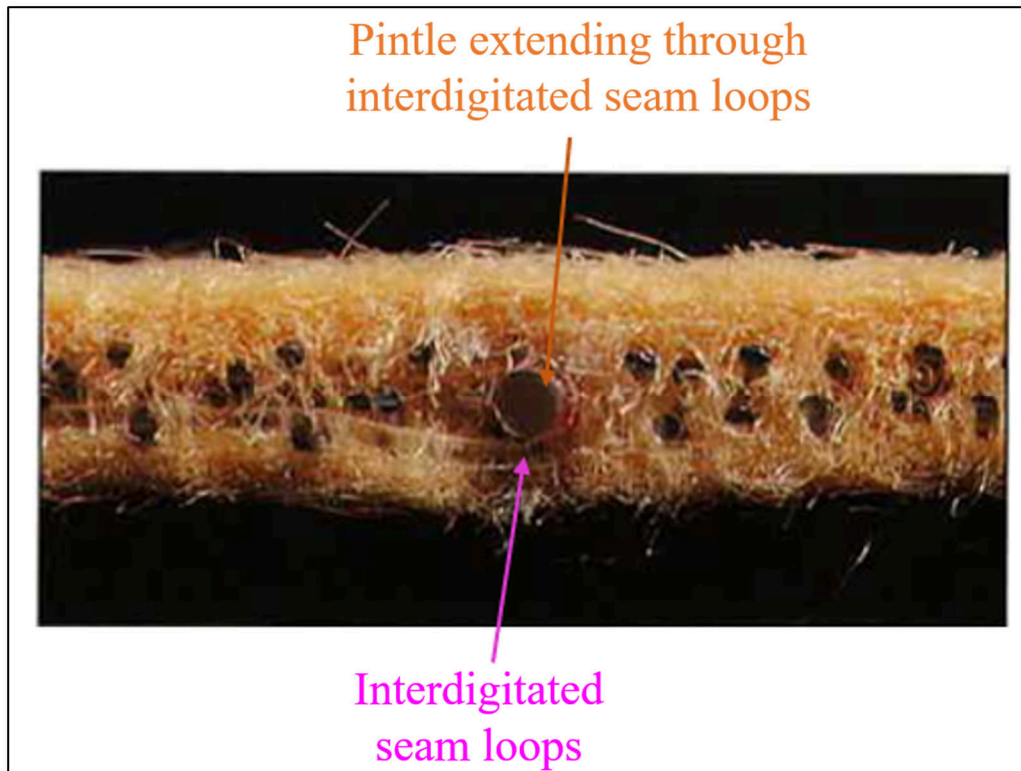
54. A photograph of a press felt with translucent seam loops, from Petitioner’s 1996 SeamTech brochure, is shown below. EX1021, 1, 7. This press

felt has two distinct layers of MD yarns, and batt extends through both layers. In the following drawing, the seam loops have not yet been joined.



EX1021

55. Another SeamTech photo (annotated with an arrow, below) shows a pintle (in brown) connecting the ends of the press felt. The pintle extends through the interdigitated seam loops. EX1021, 3-7.



EX1021

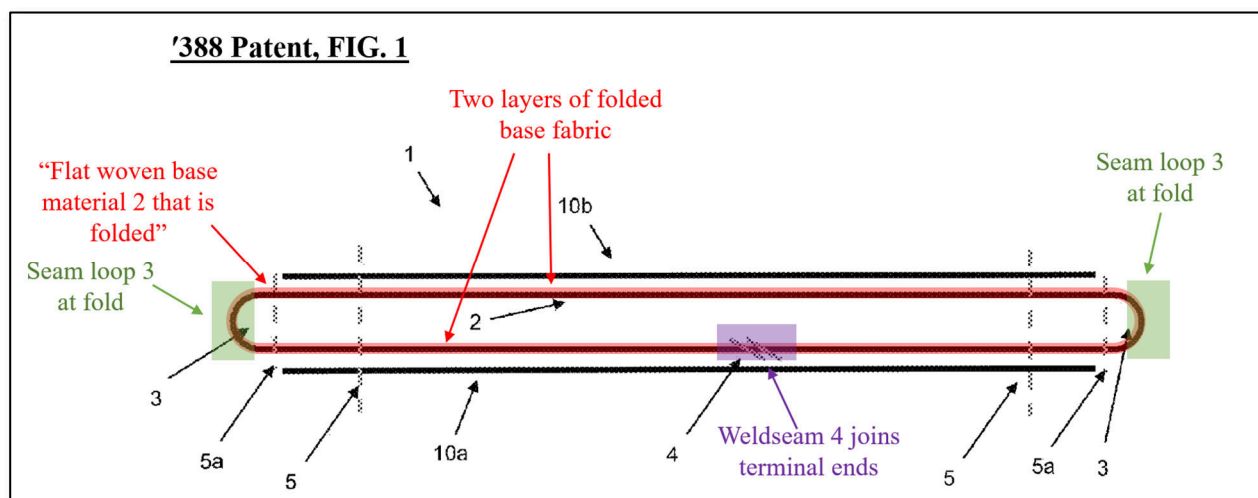
B. Summary of '388 Patent

56. The '388 Patent relates to PMCs such as those I discussed above, for example, "forming fabric[s]," "press felts," and "press fabrics." EX1001, 1:61-2:58. In line with the overview above, these fabrics are used as a conveyor belt to support a paper sheet (or "web") in the papermaking process. EX1001, 1:61-2:58.

57. The '388 Patent begins by describing a "known" PMC. EX1001, 1:40-52. This PMC is made through "use [of] a simple, flat woven material and [] folding it in order to produce a two ply base structure with seam loops for a seamable fabric." EX1001, 1:41-45. This is exactly the structure reviewed above, which is common to the '388 Patent, Crook, Ryan, Sudre, and Zehle. Moreover,

this “known” structure includes all elements of claim 1 except the specific arrangement of the “one or more sheet plies” on only the outside.

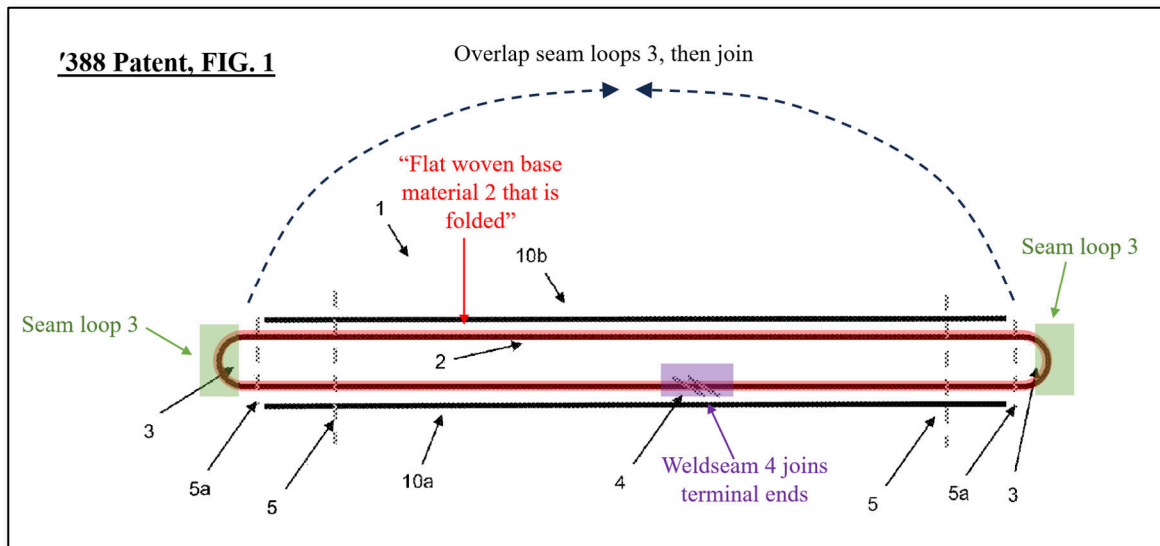
58. An example of this structure is shown in FIG. 1, annotated below. This structure is formed as described in the preceding §V.A.3. Specifically, the fabric includes two woven layers (red) obtained by folding the two opposite ends of a flat-woven fabric below another portion of the fabric. EX1001, 4:40-53; The two machine direction ends of the fabric (“terminal ends,” purple) are joined. EX1001, 4:43-45. At the folds, “seam loops” (green) are illustrated; as I explained above in §V.A.3, these seam loops are formed by exposed portions of MD yarns, for example, as a result of removing or displacing CD yarns at the folds. EX1001, 4:43.



'388 Patent, FIG. 1

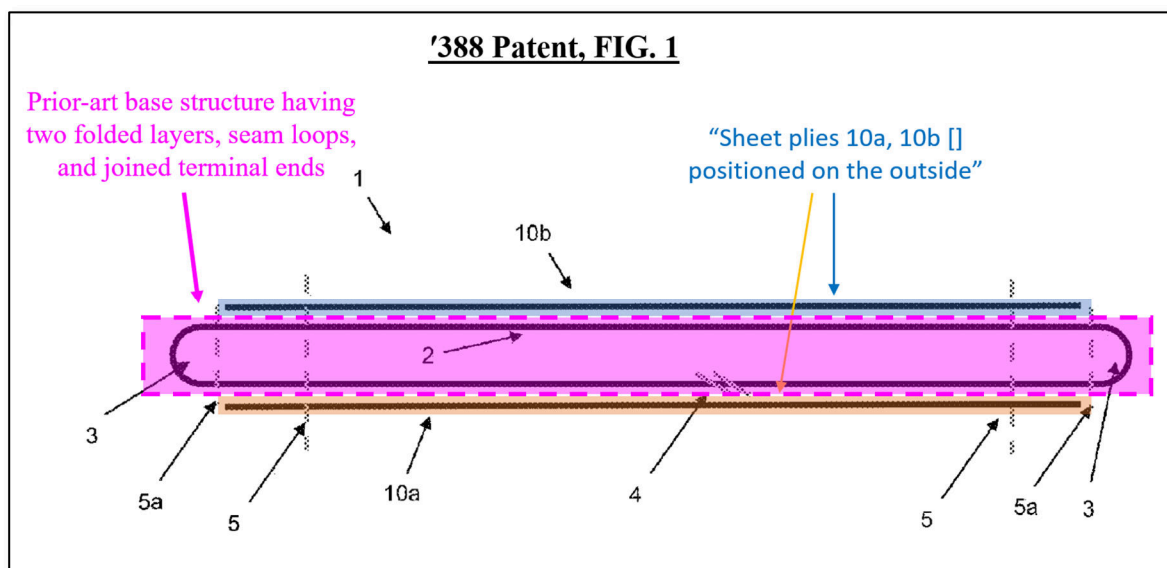
59. This base structure was widely known to be desirable because it permitted on-machine seaming of the fabrics. For example, from the configuration of FIG. 1, the fabric could be looped around rolls of a papermaking machine to

overlap the seam loops, after which the seam loops could be joined with a pintle extending through the overlapped seam loops, as shown below.



'388 Patent, FIG. 1

60. In addition to this "known" base structure, the FIG. 1 fabric also includes two sheet plies 10a (orange), 10b (blue) "positioned on the outside," as shown below. EX1001, 4:51-53.



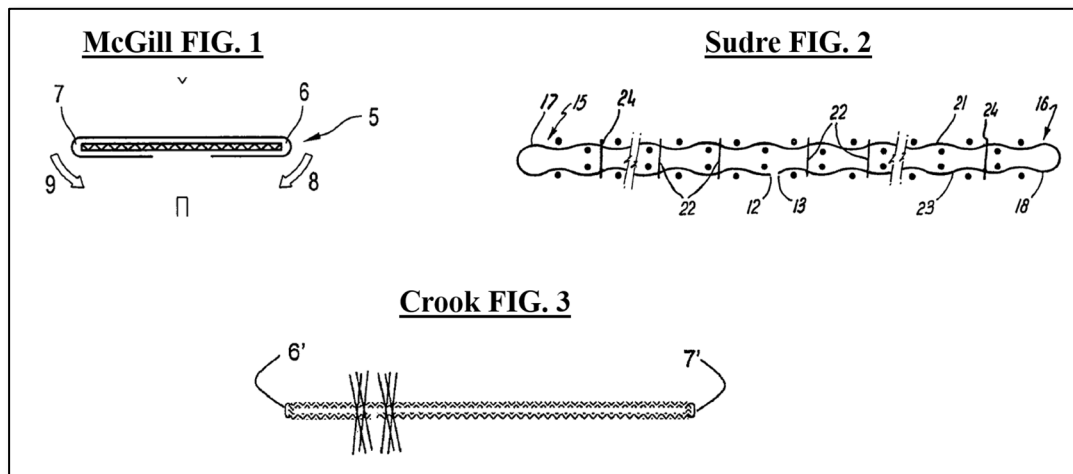
61. The prosecution history of the '388 Patent indicates that the arrangement of these sheet plies only on the outside (as opposed to the inside) was the sole factor allegedly distinguishing the claims over the prior art. EX1002, 15-16, 29.

62. The '388 Patent states that previously-known fabrics “do not provide enough void volume to guarantee sufficient dewatering properties.” EX1001, 1:53-57. “Void volume” is the proportion of empty space in a fabric. EX1011, 89. In a press fabric, high void volume is desirable because void volume provides space to receive water pressed from paper sheets during manufacture. EX1011, 154. If the void volume is too low, the press fabric may not be able to receive the considerable amounts of water removed from the paper sheets. The '388 Patent states that “one or more sheet-like plies,” such as plies 10a, 10b in FIG. 1 above, “provide additional void volume to the fabric.” EX1001, 2:35-38.

63. The '388 Patent is correct that void volume is a desirable characteristic of press fabrics. The patent’s purported method of improvement, however, was well-known. So-called “laminated” press fabrics, which include outer layers that improve void volume, were described extensively in the prior art, as I discuss in more detail below. *See* EX1008, [0012]; EX1011, 154.

C. Summary of the Prosecution History of the '388 Patent

64. The '388 patent issued on May 29, 2018, from U.S. Patent Application No. 14/825,350, filed on August 13, 2015. *See* EX1002. Claim 1 was rejected as anticipated by DE102004044568 (EX1012/EX1013, “McGill”), WO89/12717 (EX1014, “Sudre”), and Crook (EX1005). EX1002, 58-62. Each document shows a similar folded fabric structure. EX1012, FIG. 1; EX1014, FIG. 4; EX1005, FIG. 3; For example, each of McGill, Sudre, and Crook shows a flat-woven fabric that is folded into two layers with seam loops at the folds, as shown below. *Id.*



Similar folded fabric in each applied reference

65. In response, the applicant amended claim 1 to recite “at least one of the sheet plies is disposed on the outside.” EX1002, 47-49, 51. Applicant also argued that Sudre’s “non-woven batt” is not a “polymer film, foam layer, knitted structure, [or] warp knit structure,” as claim 1 was amended to recite. EX1002, 48-49, 51.

66. A final Office Action rejected claim 1 as anticipated by Crook and US2016/0069022 (EX1015, “Lee”). EX1002, 34-37. The Examiner found that dependent claim 14 was allowable, stating that “[t]he prior art does not disclose or suggest...[that] *all* of the sheet plies are disposed on the outside.” EX1002, 38. Applicant then amended claim 1 to recite that limitation, as the cited art illustrated sheet plies only either *inside* or *both* inside *and* outside the folded layers. EX1002, 15-16, 38. The claims were then allowed. EX1002, 29.

67. The examiner does not appear to have considered any additional prior art disclosing sheet plies on the outside of the folded layers. Nor did the examiner address the cited art’s disclosures of “laminated fabrics” having multiple layers and/or base fabrics attached to one another. EX1005, 6:57-7:3; EX1015, [0005].

VI. SUMMARY OF THE PRIOR ART

68. In my opinion, claims 1-15 of the ’388 Patent are obvious in view of combinations of the references that I have listed in the sections above.

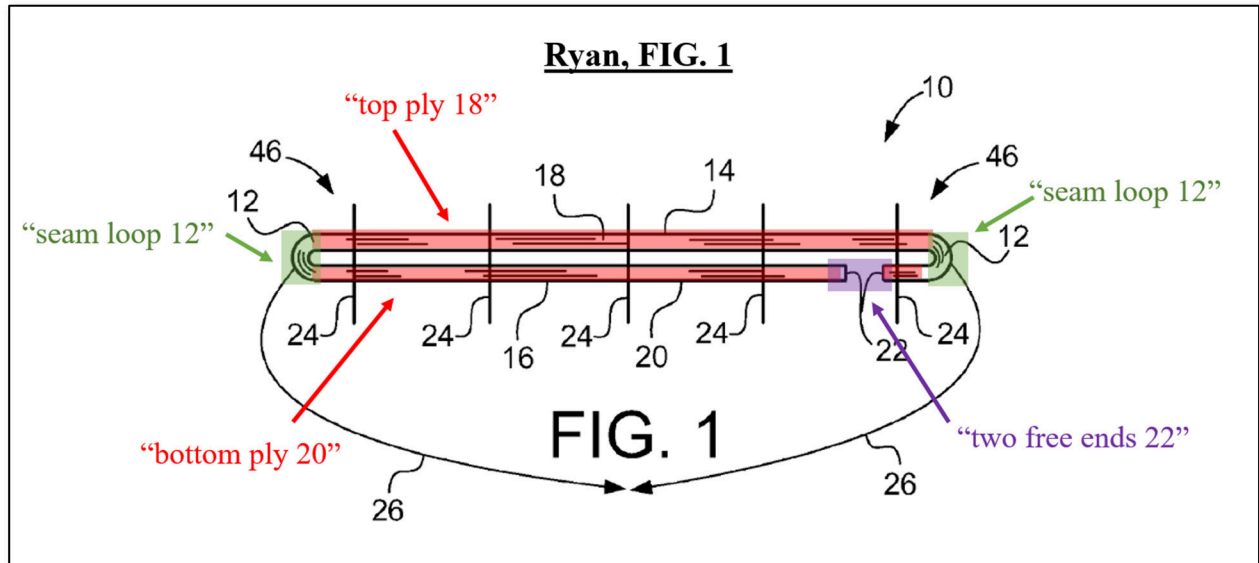
VII. PRIOR ART ANALYSIS

A. [Ground 1] Ryan-Yook Renders Claims 1-15 Unpatentable

1. Ryan

69. Ryan describes a “process for preparing a seam area for a PMC base fabric.” EX1007, [0011]. The process, which can be used “for forming a forming fabric, a press fabric, a dryer fabric, or other fabrics of a paper making machine,”

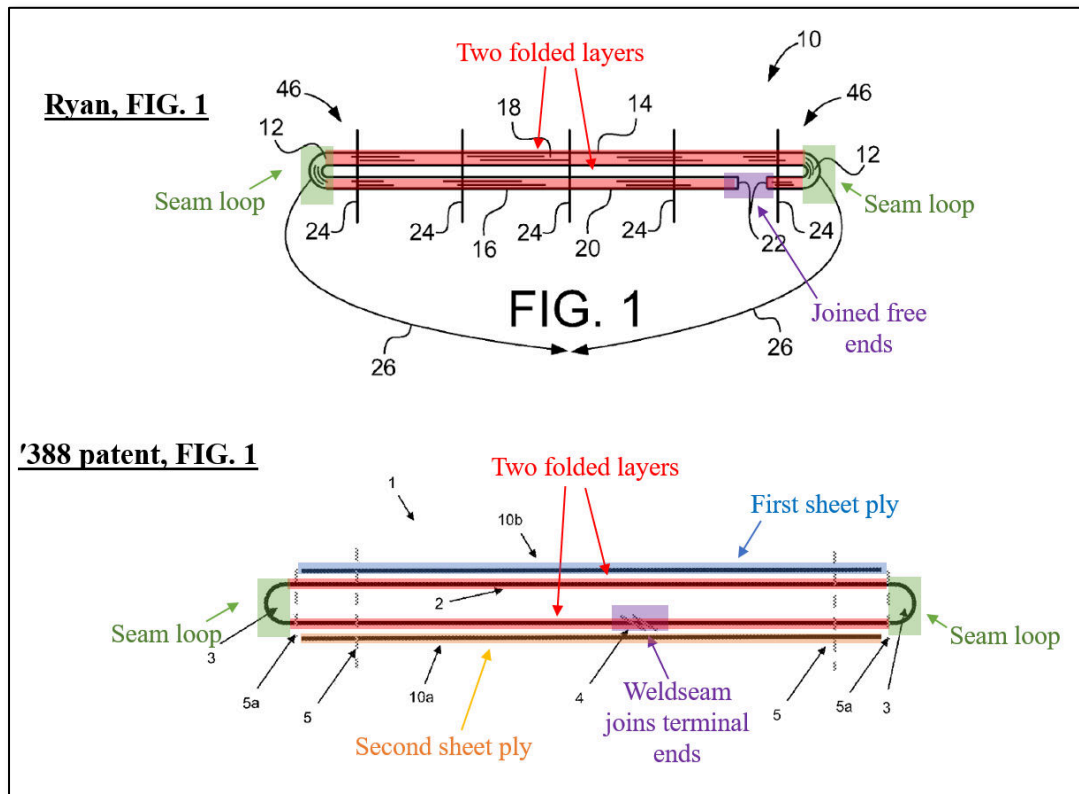
manufactures a “flat-woven PMC base fabric 10,” shown below. EX1007, [0029], FIG. 1.



Ryan, FIG. 1

70. Figure 1, as annotated above, illustrates Ryan’s base fabric 10. This fabric is essentially the same as the base structure of the ’388 Patent’s FIG. 1 discussed in §V.B. The “[b]ase fabric 10 has been folded to form a seam loop 12” (shown in green), the same configuration as the ’388 Patent’s seam loops, which are “located at the folds.” EX1007, [0031]; EX1001, 1:17-20. Ryan describes that the folded fabric has a “top ply 18” (red) and a “bottom ply 20” (red) that connect at the seam loops/folds (green), matching the configuration of the ’388 Patent’s “two folded layers,” which, as shown in FIG. 1, are connected at the folds. EX1007, [0029]; EX1001, FIG. 1. Ryan’s “free ends 22” (purple) have the same configuration as the ’388 Patent’s “terminal ends”; in both cases, the ends are

adjacent at the bottom of the fabric, and Ryan describes that the free ends can be “joined” to one another, the same configuration as the ’388 Patent’s terminal ends, which are “joined together.” EX1007, [0029], [0042]; EX1001, 4:43-45.



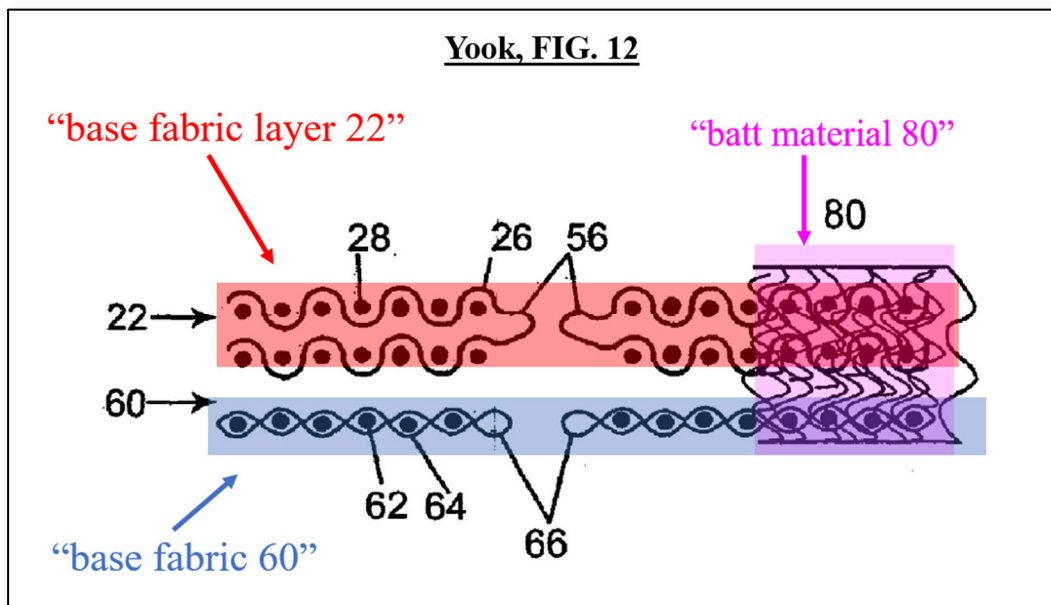
Top: Ryan, FIG. 1
Bottom: '388 Patent, FIG. 1

71. As shown above, Ryan’s base fabric 10 matches the base fabric of the ’388 Patent. The sole difference between the fabrics is that Ryan’s fabric lacks the ’388 Patent’s outer sheet plies 10a (orange) and 10b (blue). It is my opinion, however, that the addition of those sheet plies to Ryan’s fabric would have been obvious. Indeed, “lamination” of one or more sheet plies to Ryan’s fabric would have been a typical, well-known modification that would have endowed well-

known improvements to the performance of the fabric, as I discuss in more detail below in §VII.A.4(a).

2. Yook

72. Yook describes a laminated press fabric that is obtained by attaching multiple base fabrics to one another. EX1006, 10:16-18, 10:26-28. As shown in the annotated figure below, the press fabric includes a woven two-layer “base fabric layer 22” (red) and a woven one-layer “base fabric 60” (blue) that are attached to one another by “batt material 80 [pink] needled into and through” the two fabrics. EX1006, Abstract, 10:16-18, FIG. 12 (Substitute). The base fabric layer 22 and the base fabric 60 are separate, independent fabrics, which are combined in the “laminated” structure to form a single press fabric.



73. While Yook's base fabric 60 is illustrated as being attached to the base fabric layer 22, Yook describes that either base fabric 22 or 60 can be laminated to the outside. EX1006, 10:16-21. Base fabric layer 22 is a spiral-wound fabric, whereas base fabric 60 can be any of a number of different fabric types, for example, "either single- or multi-layer." EX1006, 8:17-20, 10:9-15.

3. **Ryan-Yook combination**

74. As discussed in further detail below, Ryan teaches all elements of claim 1 except for the "*all of said sheet plies are disposed outside said folded layers.*" It is my opinion that it would have been obvious to a POSITA to apply Yook's teaching of a "first base fabric and a second base fabric laminated to one another" to Ryan. The most straightforward way to apply this teaching would be to attach a second base fabric to Ryan's base fabric. This simple addition – merely the addition of one known structure to another known structure, to obtain the well-known advantages of a laminated press fabric – would have been obvious. And the resulting fabric would satisfy claim 1 of the '388 Patent.

4. **Analysis of claims**

75. For the reasons below, claims 1-15 are obvious over Ryan and Yook.

(a) ***Claim 1***

[Ipre]: A fabric for a machine for producing a fiber web, comprising:

76. Both Ryan and Yook disclose this preamble. EX1006, 1:11-26; EX1007, [0002], [0015], [0029]. It would have been immediately clear to a person

skilled in the art, based on Ryan and Yook's repeated references to papermaking, PMC, press fabrics, and the like, that the disclosed fabrics were intended to be placed on a machine to make paper, or "produc[e] a fiber web." See EX1006, EX1007.

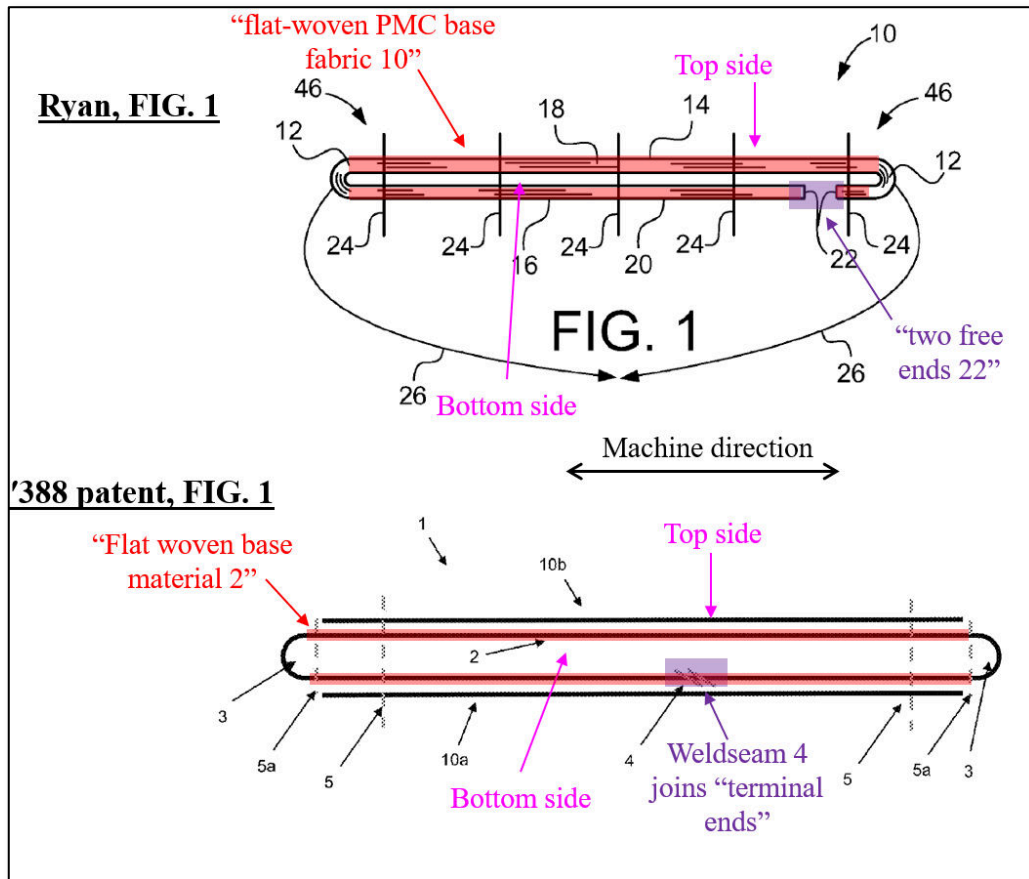
77. For example, Yook describes that forming fabrics and press fabrics are used for producing a fiber web, explaining that "[d]uring the papermaking process, *a cellulosic fibrous web is formed* by depositing a fibrous slurry...onto a moving *forming fabric* in the forming section of a paper machine....The cellulosic fibrous web passes through the press nips *supported by a press fabric*...to turn the cellulosic fibrous web into a paper sheet."² EX1006, 1:11-14. These are the same fabric types disclosed by Ryan, which describes that "the PMC [paper machine clothing] base fabric can be used for forming a *forming fabric*, a *press fabric*, a dryer fabric, or other fabrics of a paper making machine." EX1007, [0015]. As to FIG. 1, cited throughout this declaration, Ryan discloses that "[s]heet side 14 is the side of base fabric 10 which faces the *web of fibrous material* (or a nascent such web) [] when base fabric 10 is used in a paper making machine." EX1007, [0029].

[1a]: a flat woven base material having a top side and a bottom side, two terminal ends separated from one another in a machine direction;

² Emphasis is added throughout, except where noted otherwise.

78. This flat-woven base structure was well-known in the art and matches the structure discussed above in §V.3, referred to in the '388 Patent's background, and shown in Crook, Ryan, Sudre, and Zehle. For example, Ryan discloses a flat woven base material ("flat-woven PMC base fabric 10") which includes top and bottom sides (the top and bottom of the red "ply 18," respectively, as illustrated by pink arrows) and two terminal ends ("two free ends 22", labeled with purple). EX1007, [0029], [0030], FIG. 1. The top and bottom sides correspond to the top and bottom sides before the fabric was folded under itself.

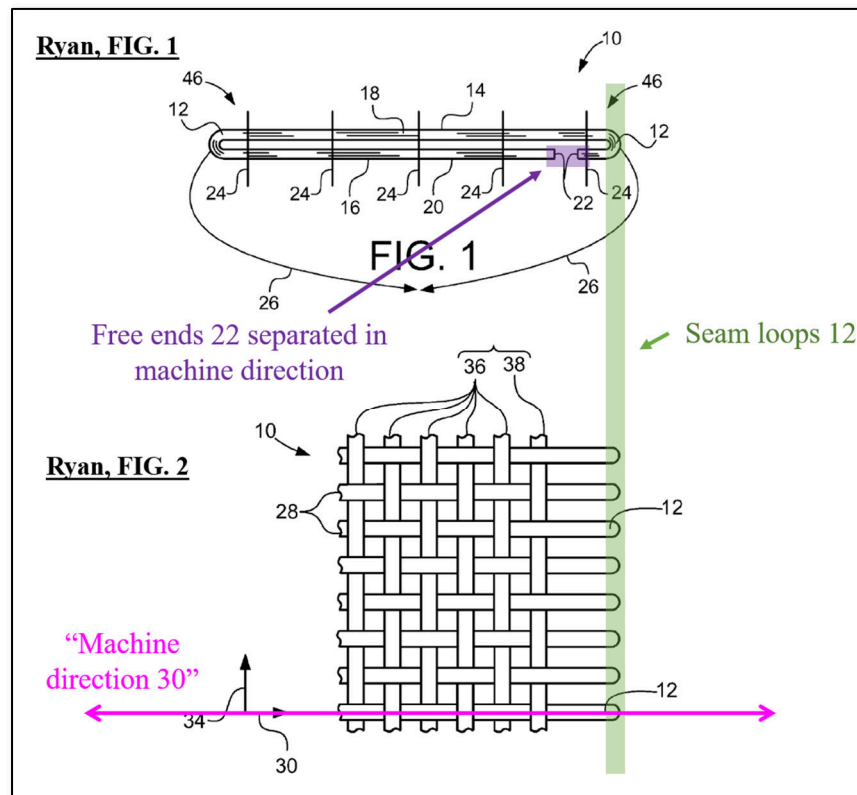
79. As shown below, this base structure, illustrated in FIG. 1 of Ryan, matches that of the '388 Patent. Each two-layer base structure includes a folded flat-woven fabric (red), with the two ends of the fabric adjacent one another (purple) as a result of the fold.



Top: Ryan, FIG. 1
Bottom: '388 Patent, FIG. 1

80. Ryan's free ends 22 are separated from one another in a machine direction, in the same way as the "terminal ends" of claim 1. EX1007, [0030], FIG. 2. The figure below shows FIG. 1 (a side view) and FIG. 2 (a top view) aligned at the seam loops 12. The MD yarns 28 extend left-right in both views, while the CD yarns 36 are omitted from FIG. 1 (but would run in/out of the page) and extend top/bottom in FIG. 2. The MD yarns 28 also define the top and bottom plies 18 and 20, labeled in FIG. 1. In both figures, the seam loops 12, formed by a loop of the MD yarns 38, are at the right. From this aligned drawing, it can be seen that the

free ends 22 are separated from one another in the left-right direction, which is the machine direction.

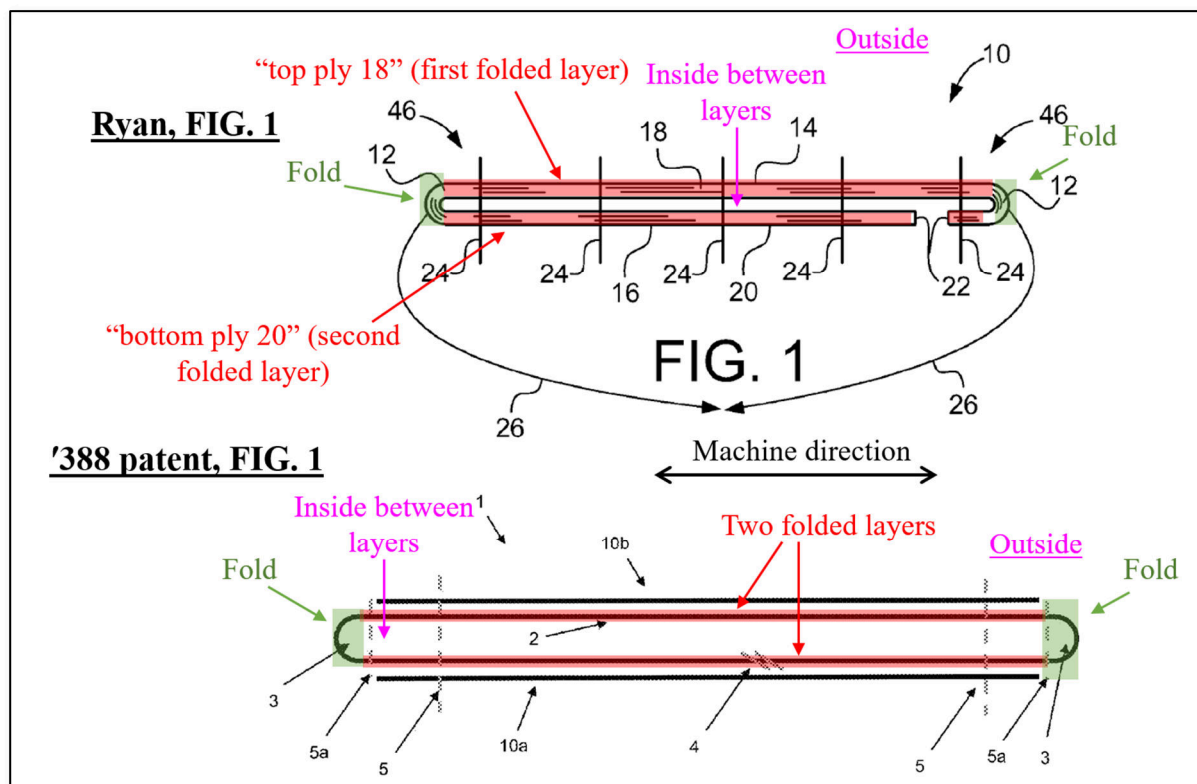


Aligned FIGS. 1 and 2 of Ryan

[1b]: said flat woven base material being folded in two folded layers with folds being separated from one another in the machine direction and defining an inside between the two folded layers and an outside;

81. Both Ryan and Yook teach the folded structure of [1b]. EX1007, [0029]-[0031], FIG. 1; EX1006, 5:61-65, 8:48-58. As illustrated below, Ryan’s base fabric 10 “has been folded” at its “seam loops 12” to form “a top ply 18” (a first red folded layer) and a “bottom ply 20” (a second red folded layer). EX1007,

[0029], [0031], FIG. 1. The two plies 18 and 20 are the “two folded layers.” This fold, and the resulting two layers, defines an inside between the top ply 18 and the bottom ply 20, and an outside above the top ply 18 and below the bottom ply 20, as illustrated below. Ryan’s two-layer folded base fabric 10 matches that of the ’388 Patent, with the ’388 Patent’s red upper and lower folded layers having the same configuration as Ryan’s red top and bottom plies, and with each structure including folds at opposite machine-direction ends.

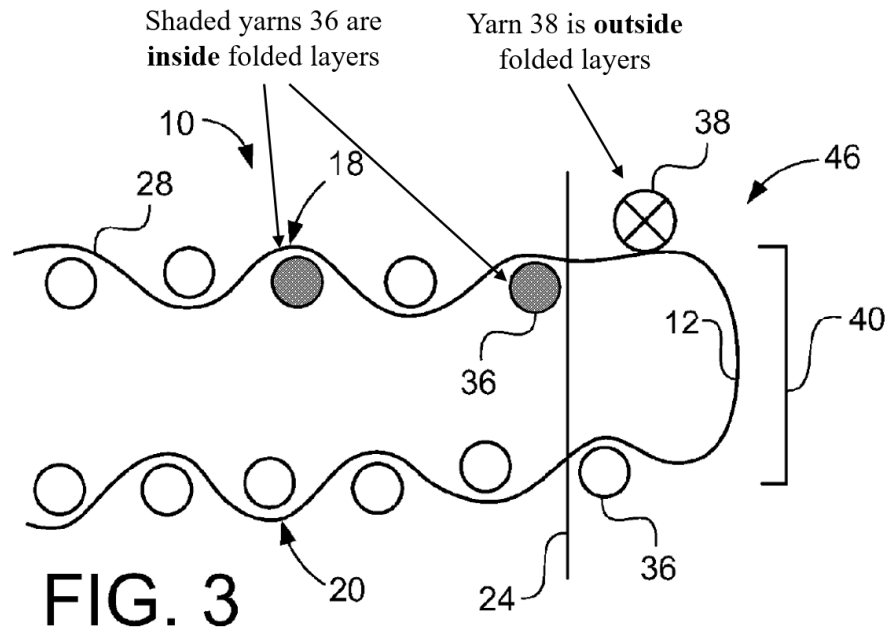


Top: Ryan, FIG. 1
Bottom: '388 Patent, FIG. 1

82. The “inside” and “outside” defined in Ryan’s fabric can be seen, for example, in Ryan FIG. 3, reproduced below. In FIG. 3, “multifilament yarn 38” is

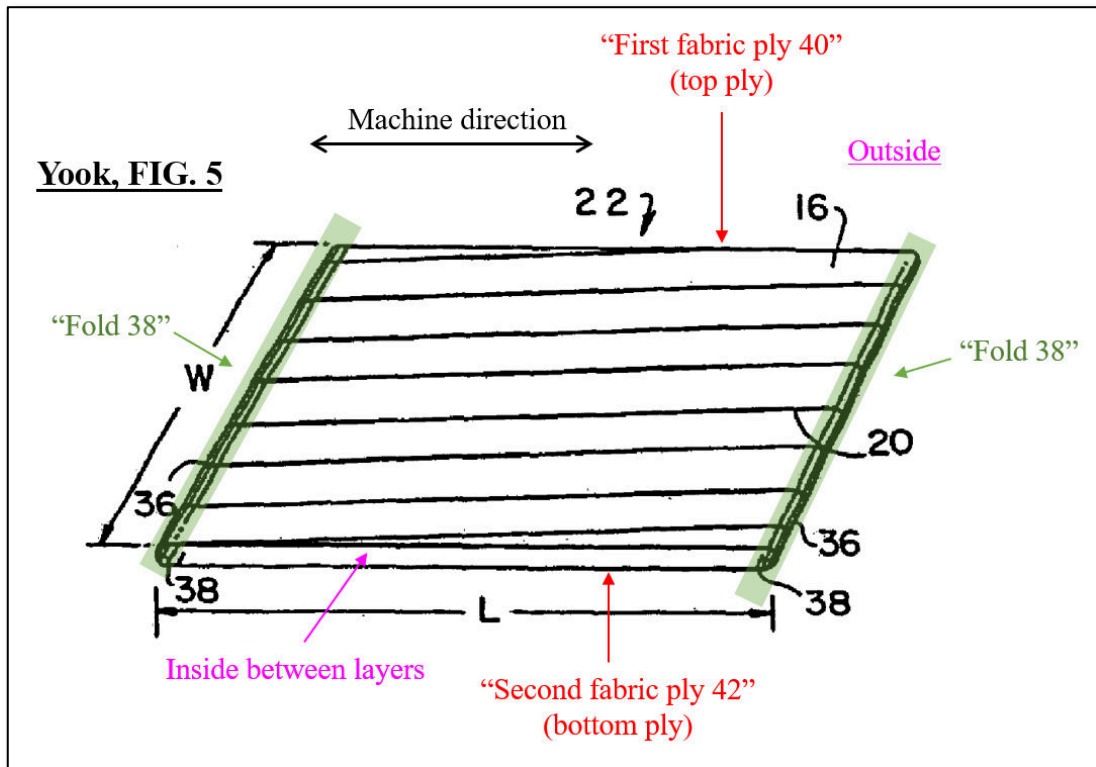
located “on the sheet side 14 of top ply 18,” that is, outside the two folded layers.

EX1007, [0031]. The indicated CD yarns 36, by contrast, are illustrated inside the two folded layers.



Ryan, FIG. 3

83. Yook’s fabric also has two folded layers. For example, Yook describes that a “base fabric layer is flattened to produce [a] first fabric ply and the second fabric ply having two widthwise edges. The first fabric ply and the second fabric ply are connected to one another at folds along the two widthwise edges.” EX1006, 5:61-65. This configuration is illustrated in FIG. 5. EX1006, 8:48-51.

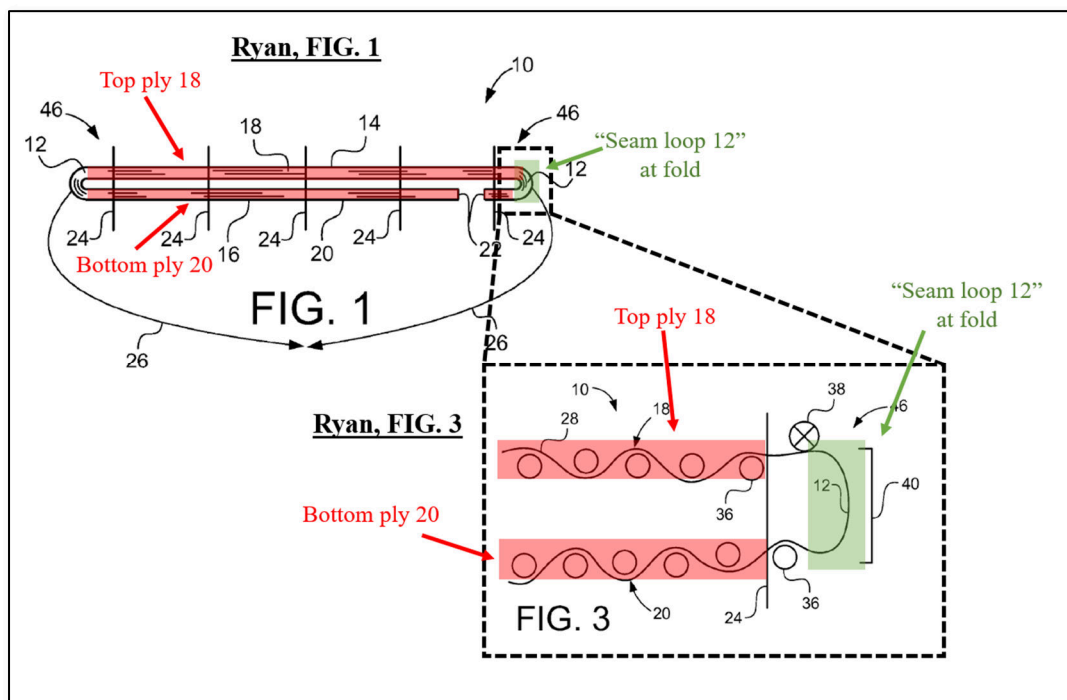


Yook, FIG. 5

[1c]: said two terminal ends being located under the bottom side surface and said two terminal ends being adjacent one another or overlapping one another, and wherein seam loops are located at said folds; and

84. Ryan's base fabric 10 has the terminal ends and seam loops of [1c]. EX1007, [0007], [0012]-[0013], [0029], [0031], [0042]. For example, Ryan's two terminal ends ("two free ends 22") are located under the bottom side surface (bottom of top ply 18). EX1007, [0029], FIG. 1. The two free ends 22 "come together and are joined," such that they are "adjacent one another or overlapping one another." EX1007, [0042]. Ryan's language mirrors that of the '388 Patent, which describes that the "two terminal ends...are joined." EX1001, 4:43-45.

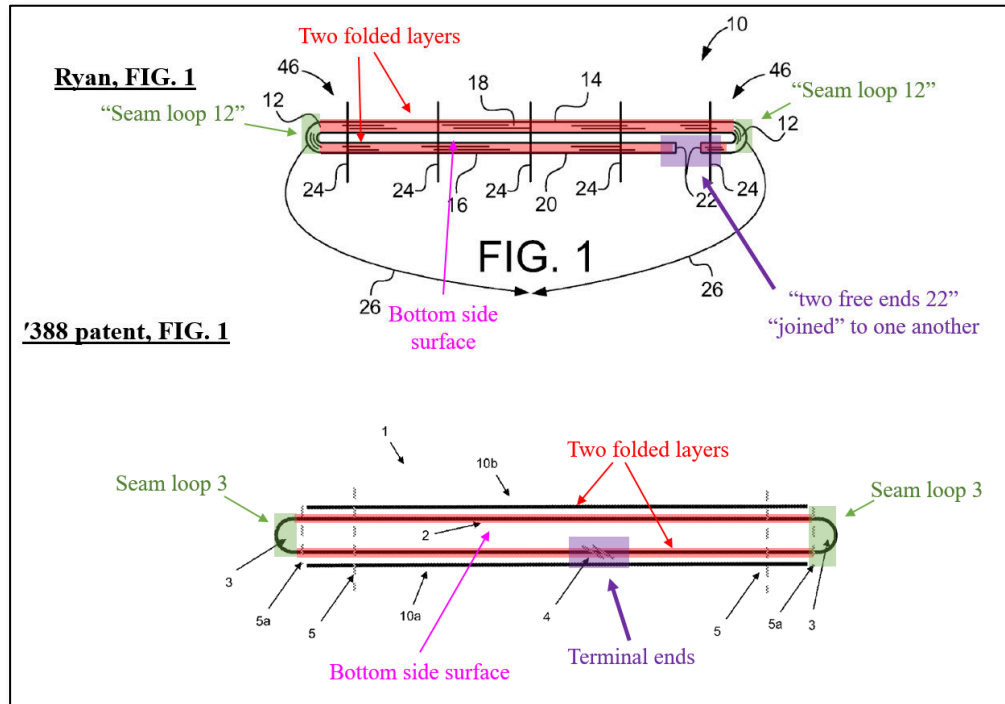
85. Ryan's base fabric 10, like the fabric of the '388 Patent, has "seam loops 12" at its folds. EX1007, [0007], [0012]-[0013], [0031], FIGS. 1-8. For example, the seam loops are described as being "along the ends of the fabric," and Ryan comments that the "[b]ase fabric 10 has been **folded** to form a seam loop 12." EX1007, [0006], [0031]. As I described in §V.A.3, and as reflected in Ryan FIGS. 1 and 3 shown below, the seam loops are loops formed by the MD yarns, at the position where the top ply and bottom ply meet at a fold.



Ryan, FIGS. 1 and 3

86. As shown below, Ryan's structure matches that of the '388 Patent: each includes seam loops (green) at the folds between their top and bottom layers (red); Ryan refers to these layers as the top and bottom plies 18 and 20. EX1007,

[0029]. In addition, in both Ryan’s fabric and the ’388 Patent’s, “terminal” or “free” ends of the folded fabric (purple) are at the bottom and adjacent one another.



Top: Ryan, FIG. 1
Bottom: '388 Patent, FIG. 1

87. Yook also teaches seam loops at the folds of the base fabric, attesting to the widespread use of this configuration in the art. EX1006, 4:47-50; 8:47-58; FIGS. 5-6, 9-16. For example, Yook discloses that “[a]t least one crosswise yarn in each of the turns of the fabric strip are *removed at each of the folds* at the two widthwise edges to provide unbound sections of lengthwise yarns of said fabric strip at the folds, the unbound sections being *seaming loops*.” EX1006, 5:65-6:2.

[1d], [1e]: one or more sheet plies, wherein: all of said sheet plies are disposed outside said folded layers; and

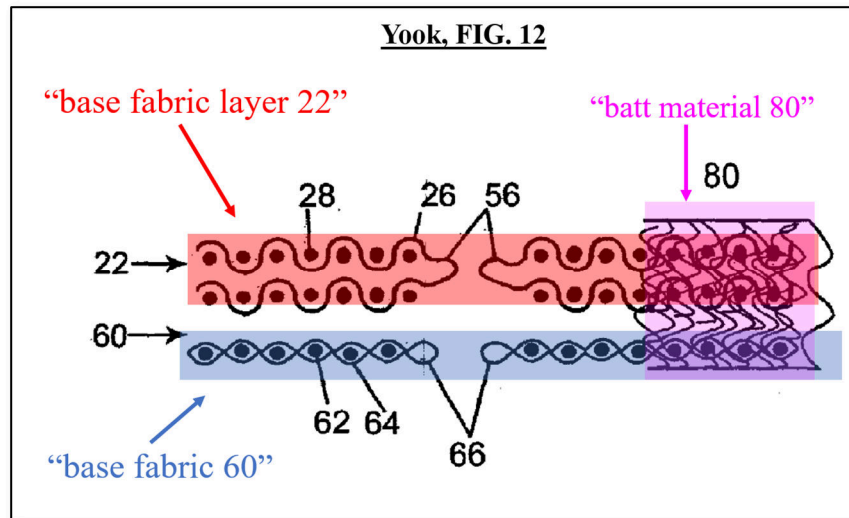
88. Ryan teaches the base fabric of claim 1 (the two-layer folded base fabric 10 shown in Figure 1). Ryan, however, is focused on the manufacture of base fabrics, and does not discuss how the base fabric may be combined with other elements for use in a paper making machine. EX1007, [0015]. For example, Ryan describes that the disclosed base fabrics can “be used for forming a forming fabric, a press fabric, a dryer fabric, or other fabrics of a paper making machine,” but does not go into detail on how those fabrics would be formed from Ryan’s base fabrics. EX1007, [0015]. For example, Ryan does not explicitly disclose additional sheet plies that are all “disposed outside said folded layers,” as recited in claim 1. In my opinion, however, it would have been obvious to add Yook’s base fabric 60 to Ryan’s two-layer base fabric 10, to obtain a fabric in having one or more sheet plies (Yook’s base fabric 60) exclusively located outside the two-layer base structure.

89. Specifically, Yook describes a “laminated fabric comprising...[a] base fabric layer 22 and...[a] base fabric 60.” EX1006, 10:16-18. A laminated fabric is simply a fabric having two or more layers attached to one another. EX1011, 163. In many cases, a laminated fabric includes multiple independent base fabrics

attached to one another, with each base fabric having an independent weave system. *Id.* This is the case for Yook's laminated fabric.

90. One way to attach layers of fabric together is by needling with batt. EX1006, 10:22-28; EX1014, 5:8-18; EX1005, 6:6-9. As I discussed in §V.2, batt is a layer of either natural or synthetic fibers that are randomly bonded together rather than woven. In a needling process using batt, the batt is placed in contact with one or more of the base fabrics to be attached together. A set of barbed needles is moved through the batt and the base fabrics, such that the barbs on the needles pull the batt fibers through the base fabrics, entangling them with one another. *See* EX1011, 165-66.

91. Yook uses this common method. As shown in FIG. 12, reproduced and annotated below, Yook's two-layered base fabric 22 (red) and single-layered fabric 60 (blue) "are joined to one another by one or more layers of staple fiber batt material 80 needled into and through the superimposed base fabric layer 22 and base fabric 60." EX1006, 10:22-26.

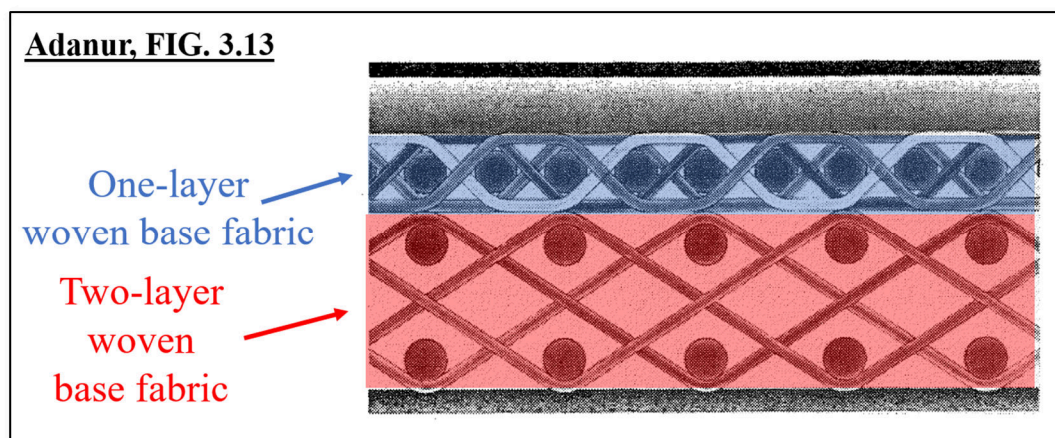


92. Yook’s laminated fabric is not identical to the claimed invention. For example, Yook’s fabric, which is prepared using a spiral-winding method I discuss in §§V.3 and VII.B.1, lacks the “terminal ends” of claim 1. However, like the claimed invention, Yook’s laminated fabric includes a folded fabric with seam loops at its folds, and one or more sheet plies outside the folds. Figure 12, above, shows this structure as a single layer laminated to the outside of a two-layer folded base fabric.

93. Laminated press fabrics, like the one shown above, were conventional in the art and provided well-known advantages for PMC. For example, Adanur, a textbook published in 1997, describes that, in a laminated press felt, “two or more base fabric structures are included in the fabric.” EX1011, 163. Adanur explains that laminated fabrics are preferable because they “allow a wider range of base fabric pressure uniformity and low batt-to-base ratio which is critical for open and

clean operation.” *Id.* “Open” refers to the capacity of the fabric to allow water to flow easily through the fabric, and “clean” refers to the relative lack of contaminants in the fabric. In keeping with this “open” operation, Adanur also describes that laminated fabrics provide “high void volume...to handle the water flow” associated with pressing. EX1011, 154.

94. Adanur FIG. 3.13, below, illustrates a “[c]ross section of a laminated press fabric.” EX1011, 165. Like Yook’s combination of base fabrics 22 and 60, Adanur’s laminated press fabric includes a one-layer base fabric (on the top, blue) laminated to the outside of a two-layer base fabric (on the bottom, red). EX1011, 163, 165. Various other configurations were also known—Adanur references “Laminated two layer,” “Laminated three layer,” and “Laminated four layer” fabrics, and describes that “[t]he top base fabric is usually a single layer,” and further describes that “[t]he bottom base fabric can be a one, two, or three layer integrally woven fabric.” EX1011, 163, 166.



Adanur, FIG. 3.13

95. I point out Adanur’s extensive disclosure to make clear that the attachment of layer(s) to the outside of base fabrics, which according to my understanding was the important feature that led to the allowance of the ’388 Patent, was known long before the Critical Date. For example, Adanur was published *eighteen years* before the Critical Date. The lamination of one base fabric to another base fabric—for example, laminating Yook’s one-layer base fabric 60 to Ryan’s two-layer folded base fabric 10—was a known technique that, in my opinion, a POSITA would have found obvious to apply to Ryan’s known two-layer folded base fabric 10.

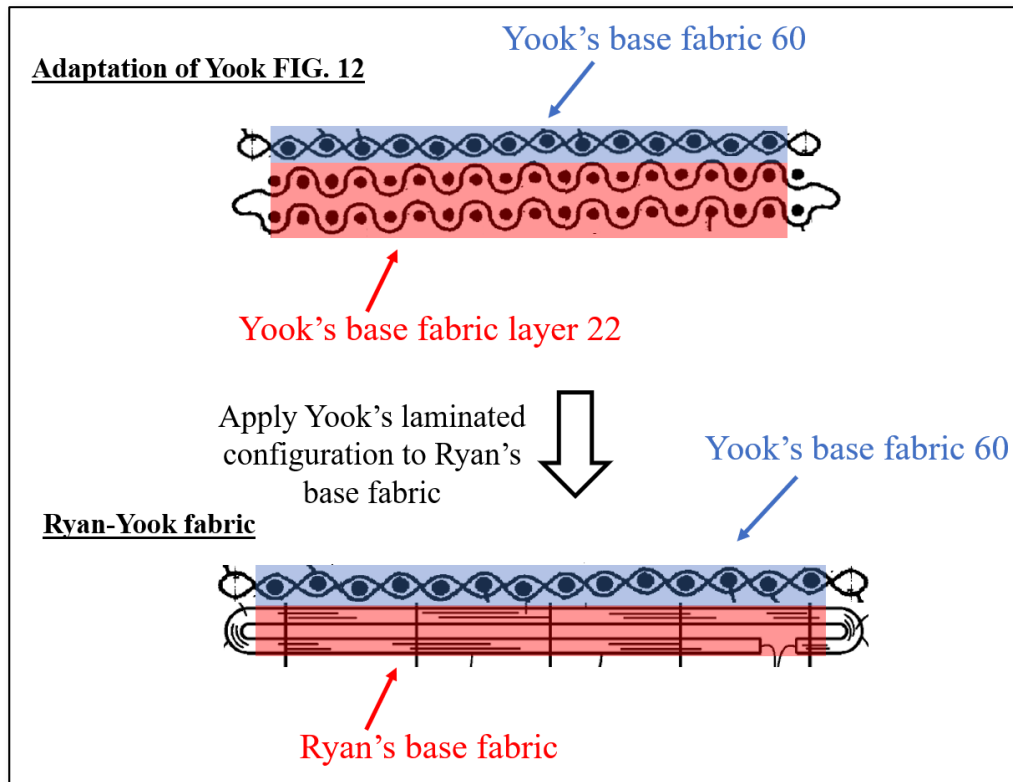
96. As further examples of the advantages of laminated structures, Virtanen describes that “a laminated structure” has a “relatively large water retention capacity” (associated with the high void volume of laminated fabrics), “good resistance against compression,” and “greater flexibility compared with a single-base structure;” EX1008, [0012]. Hyvonen provides a lengthy description of the advantages of laminated press fabrics:

In general, the laminated felts have an advantage that it is easier to provide the laminated felts with a sufficient space for water, but nevertheless an even surface. Moreover, the laminated felts remain longer unclogged. The distribution of pressure is more even in the laminated felts, and consequently they are less liable to permanent compression. In the laminated felt the compression of the batt fibre is no longer so critical a factor as previously[.] Further, when the laminated felt is used, less vibration occurs in the press section, because variations in the felt thickness are smaller.

EX1022, 3:15-24. In Hyvonen’s description, the “sufficient space for water” is a reference to the higher void volumes of laminated fabrics.

97. Zehle describes that the multiple base fabrics of a laminated fabric can advantageously be selected with different characteristics depending on the positions of the base fabrics. EX1020, 5:16-23. For example, “[a] coarse base fabric with high void volume and a high degree of compaction resistance is desirable for the inside or wear surface of the press felt which contacts the machine and rolls. A finer fabric for the side of the press felt which faces the paper sheet will provide uniform pressure and prevent marking from the coarse machine side base fabric which reduces the quality of the paper sheet.” EX1020, 5:16-23.

98. In my opinion, it would have been obvious and entirely conventional for a POSITA to realize these advantages by adapting Ryan’s two-layer folded base fabric into a laminated fabric, by laminating a base fabric to Ryan’s base fabric. For example, it is my opinion that, based on Yook, it would have been obvious for a POSITA to attach Yook’s one-layer base fabric 60 to the outside of Ryan’s two-layer base fabric 10 using the attachment methods disclosed by Yook (for example, by needling with batt as was well-known). In this laminated fabric, Yook’s base fabric 60 constitutes the “one or more sheet plies” of claim 1. A combination of Ryan and Yook—referred to below as “the Ryan-Yook fabric”—is illustrated in the schematic below.

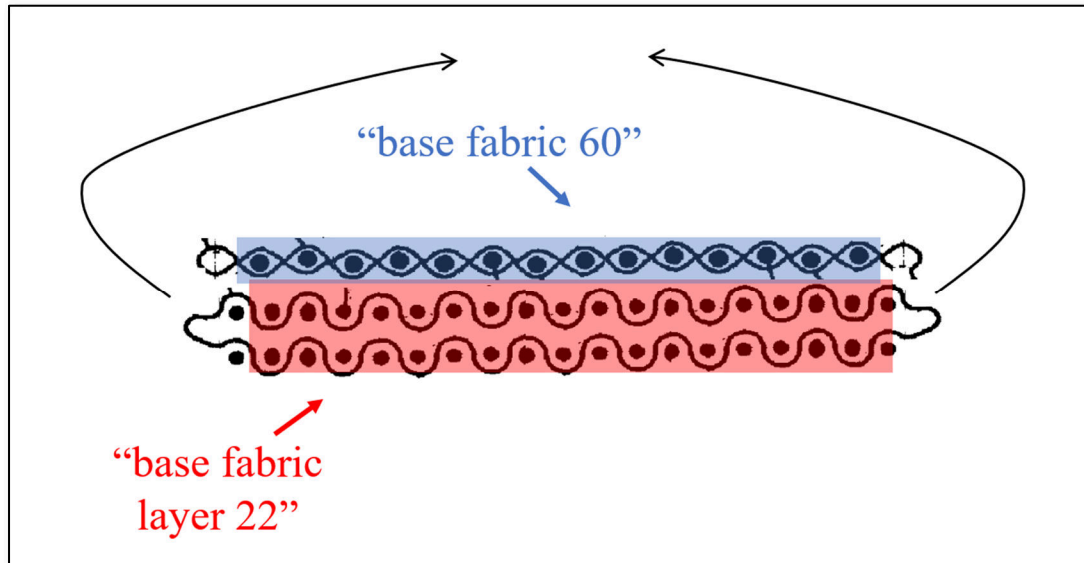


Application of Yook's laminated configuration to Ryan

99. The bottom illustration above is a composite of Ryan FIG. 1 and Yook FIG. 12.

100. The top illustration above is an adaptation of Yook FIG. 12. Ryan FIG. 1 shows Ryan's fabric with its folds and seam loops at opposite machine-direction (left-right) ends. Yook, however, does not provide an analogous view: Yook FIG. 12 shows Yook's fabric *after* the seam loops have been brought together. To promote better understanding of Yook's fabric and how its laminated configuration would be applied to Ryan, the adapted drawing shows the same FIG. 12 fabric *before* the seam loops are brought together. That is, to obtain the configuration of Yook FIG. 12, the left and right sides of the fabric (the seam loops

at the left and right edges) in the adapted drawing would be brought up and together, as shown below:

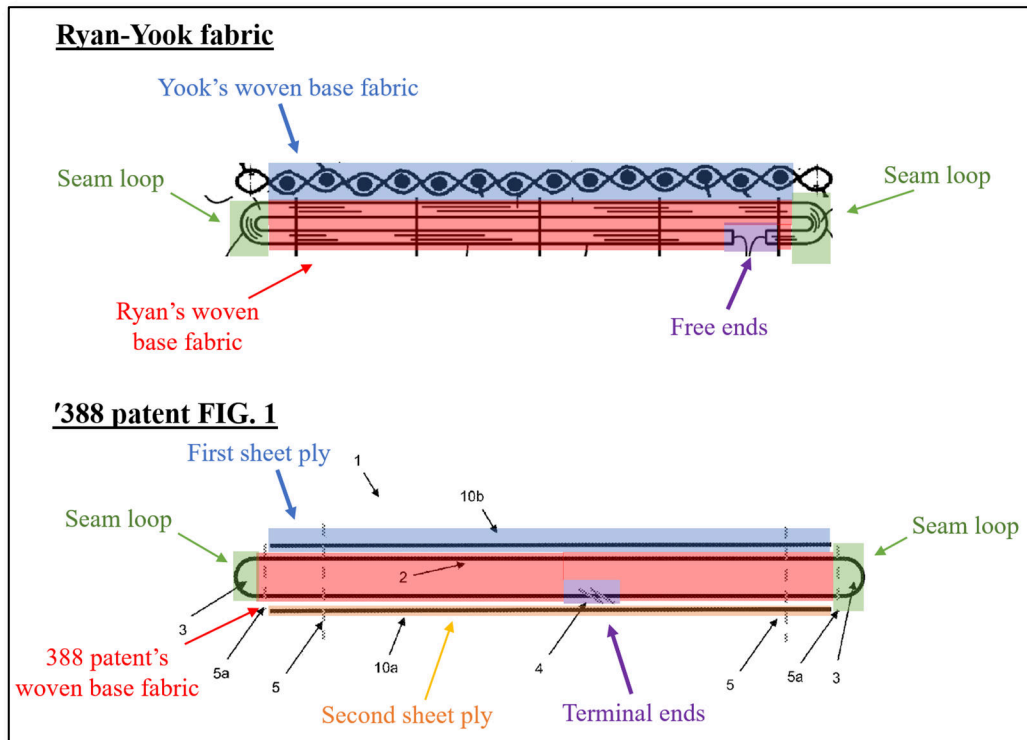


Bringing together seam loops to obtain FIG. 12 view

101. To obtain the Ryan-Yook fabric, a POSITA would have had to simply attach Yook's woven fabric 60 to Ryan's woven fabric 10, a process well within the skill of a POSITA in fabric manufacture. For example, Yook describes that base fabric 60 is "joined" to the underlying base fabric layer 22 "by one or more layers of staple fiber batt material 80 needled into and through the superimposed base fabric layer 22 and base fabric 60." EX1006, 10:22-28. In my opinion, it would have been obvious for a POSITA to use this same method to join Ryan's two-layer base fabric 10 to Yook's one-layer base fabric 60 by needling a batt material through both base fabrics.

102. While Yook's base fabric 60 is selected for attachment to Ryan's fabric 10 here, Yook describes that either base fabric 22 or 60 can be laminated to the outside. *See* claim 2 (§VII.A.4(b)); EX1006, 10:16-21.

103. An illustration of the Ryan-Yook fabric and the matching FIG. 1 fabric of the '388 Patent are shown below. In the Ryan-Yook fabric, Yook's base fabric is "one or more sheet plies," satisfying [1d] and [1e]. As shown below, the Ryan-Yook fabric and the FIG. 1 fabric are substantially identical, except that the Ryan-Yook fabric does not have an analogous element to sheet ply 10a of the FIG. 1 fabric.



Top: Ryan-Yook fabric³

Bottom: '388 Patent FIG. 1

104. My understanding is that the mere application of a known technique, to a piece of prior art ready for the improvement, is generally obvious. It is my opinion that this assessment applies to adding Yook's woven base fabric to Ryan's woven base fabric. The "known technique" is base fabric lamination, or the joining of multiple base fabrics to one another, as taught by Yook and corroborated widely in the art (for example, by Adanur, Virtanen, and Hyvonen, as cited above). The

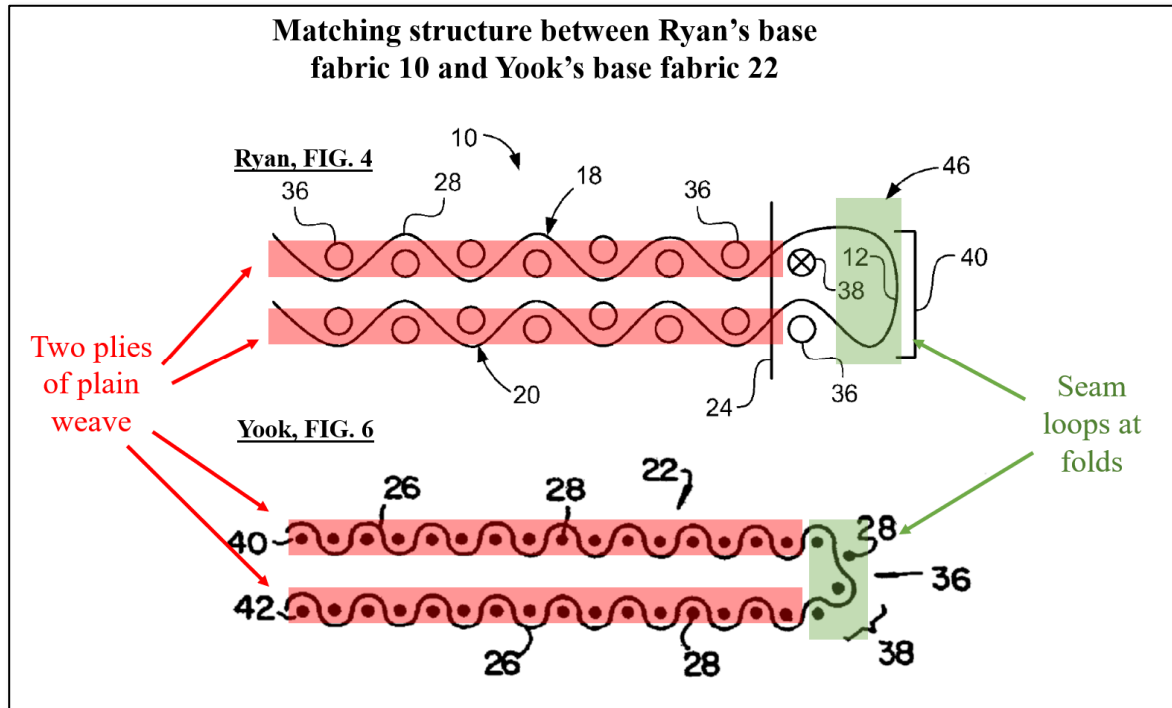
³ For clarity of illustration, batt material "needled" through both base fabrics of the Ryan-Yook fabric is not illustrated.

“improvement” is the increased void volume and other advantages that the art widely recognized as being provided by laminated fabrics. And the “piece of prior art ready for the improvement” is Ryan’s two-layer folded base fabric, which, as a base fabric for a press fabric, is the very type of fabric that Yook and other art teach should be made into a laminated structure.

105. It is my opinion that a POSITA would have had a reasonable expectation of success in obtaining the Ryan-Yook laminated structure. The means for joining Ryan’s and Yook’s base fabrics—needling with batt—was a standard technique for press fabrics, as attested to, for example, by its discussion in the Adanur textbook. EX1011, 165-66. And, as a practical matter, a POSITA would have understood that, although Ryan does not *explicitly* disclose a needled batt layer, a batt layer would have been needled into Ryan’s base fabric to obtain a final press fabric, given that batt was almost universally included in press fabrics. For example, Adanur explains that “[p]ress fabrics, in general, consist of two components []: base fabric and batt.” EX1011, 159. Ryan explicitly teaches the first component; the addition of the second component would have been expected by a POSITA. Further, “[t]he process in which the batt is locked to the base fabric is called *needling*,” the same process by which Yook teaches to laminate base fabrics to one another. EX1011, 160. Accordingly, attaching Yook’s base fabric to Ryan’s would have involved no more than a well-established, widely-known

process that, from a practical perspective, would have been performed on Ryan's base fabric *anyway*.

106. In addition, the base fabrics receiving the attached base fabric 60 are similar between Yook and the Ryan-Cook combination. That is, Ryan's two-layer base fabric 10 is similar to Yook's two-layer base fabric layer 22, which, in my opinion, would have provided a POSITA with a reasonable expectation that the lamination of Yook's base fabric 60 to Ryan's base fabric would have been successful. For example, as shown below, both Ryan's base fabric 10 and Yook's base fabric layer 22 are a folded, two-layer structure, and both have seam loops at their folds.



Top: Ryan, FIG. 4
Bottom: Yook, FIG. 6

107. Ryan's base fabric and Yook's base fabric layer 22, moreover, are similar not only in their overall structure (as shown in the figure immediately above) but also in their microstructure. Ryan's base fabric 10 is "flat-woven" and has a plain-weave structure, as discussed in more detail with respect to claim 6 below. EX1007, [0029], FIG. 2. Similarly, Yook's base fabric layer 22, although processed using a spiral-winding method, is ultimately formed from a flat-woven, plain-weave fabric strip. EX1006, 2:60-62, 8:13-16. So, on the small scale, Ryan's base fabric 10 and Yook's base fabric layer 22 would have been similar if not identical, and attaching Yook's base fabric 60 to the former rather than the latter would not have presented difficulties.

108. Ryan's base fabric 10 and Yook's base fabric layer 22 differ in that Yook's fabric is multiaxial (spiral-wound) whereas Ryan's is not. This difference, however, would not have impeded a POSITA in making the combination. In fact, lamination to Ryan's fabric would likely have been *easier* than lamination to Yook's fabric. Yook's base fabric layer 22, due to its multiaxial construction, has yarn systems that "lie in directions at oblique angles to the machine and cross-machine directions." EX1006, 4:8-11. This would likely complicate lamination of Yook's base fabric layer 22, because, for example, forming a straight line of seam loops in Yook's base fabric layer 22 might have to compensate for the oblique angles of the yarn systems. Yook (EX1006) describes this process at 8:59-9:8.

109. However, because Ryan's fabric presents square edges with CD yarns extending parallel to the fold, compared to angled CD yarns in Yook's multiaxial fabric, a POSITA forming the Ryan-Yook fabric would not have encountered this complication.

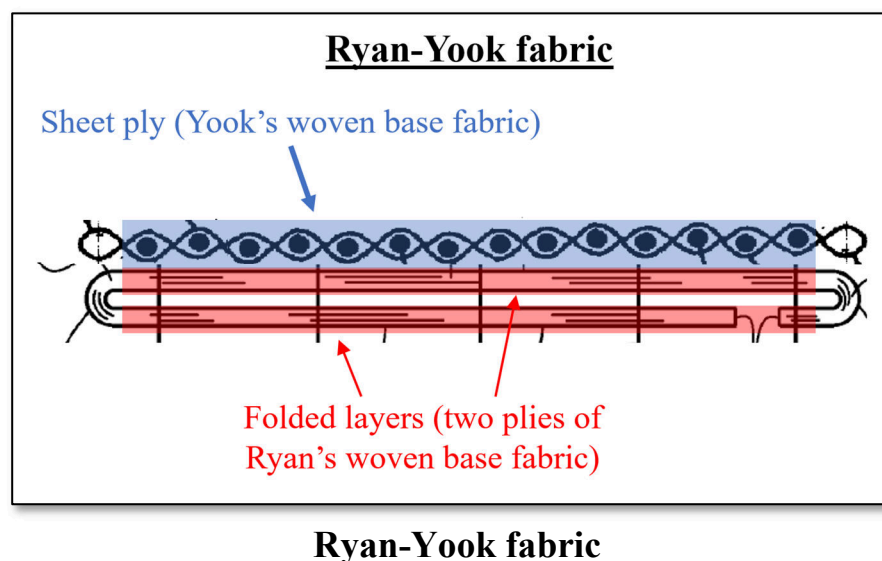
110. Therefore, lamination of Yook's base fabric 60 to Ryan's base fabric 10 would have involved only substituting one base fabric for another, very similar base fabric. In my opinion, this similarity between the fabrics, in conjunction with the predictable nature of the proposed modification and the simple methods associated with the attachment of the fabrics, would have given a POSITA a reasonable expectation of success in manufacturing the Ryan-Yook fabric.

111. In obtaining the Ryan-Yook fabric, a POSITA would also have been aided by Yook's extensive guidance on how seam loops of each base fabric in the laminated structure can be positioned or aligned to aid pintle insertion. Both Ryan's base fabric 10 and Yook's base fabric 60 include seam loops at opposite ends in the machine direction, and details on how the seam loops should be handled in a laminated structure would have been helpful to a POSITA forming the Ryan-Yook fabric.

112. To that end, Yook illustrates four different seam loop configurations suitable for use in a laminated fabric including two base fabrics, as for Yook's FIG. 12 fabric and the Ryan-Yook fabric. EX1006, FIGS. 13-16. For example, the

seam loops from each fabric can be “vertically stacked” (FIG. 13), arranged at opposite sides with respect to their corresponding base fabric (FIGS. 14 and 15), or fully aligned to form a single seam (FIG. 16). EX1006, 10:31-11:10. Yook’s detailed teachings in this respect further reinforce my opinion that a POSITA would have had a reasonable expectation of success in attaching Yook’s base fabric 60 to Ryan’s base fabric 10. For example, in my opinion, it would have been obvious for a POSITA to align Yook’s seam loops 66 with Ryan’s seam loops 12 to facilitate the seam loop configurations shown in Yook FIGS. 13-16.

113. As a result of the foregoing combination of Ryan and Yook, a POSITA would have arrived at the Ryan-Yook fabric illustrated below. The Ryan-Yook fabric has one or more sheet plies disposed outside the folded layers, thereby satisfying [1d] and [1e]. Specifically, as shown below, Yook’s base fabric (blue) is a sheet ply that is outside the two layers of Ryan’s base fabric (red).



[1f]: one, some or all of the sheet plies consist of or comprise a woven material or a non-woven component selected from the group consisting of a polymer film, a foam layer, a knitted structure and a warp-knit structure.

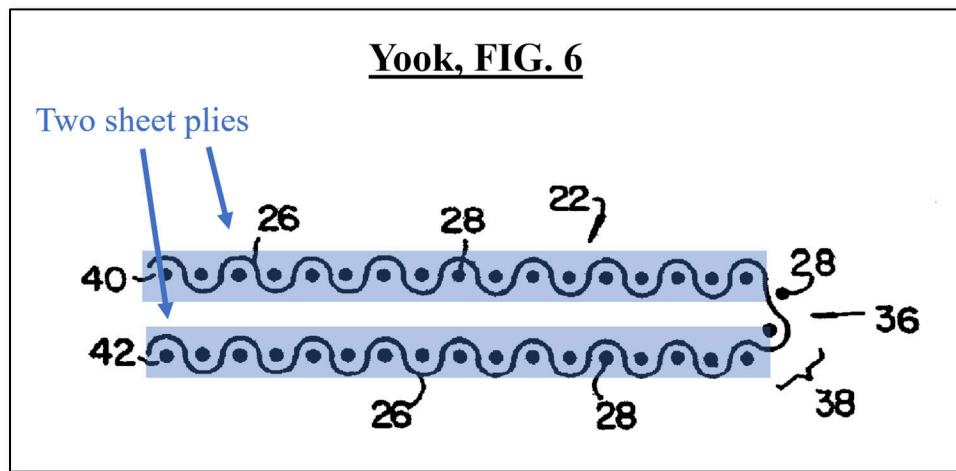
114. Yook's base fabric 60 (the "sheet ply" in the Ryan-Yook fabric) is a woven material (e.g., "either single- or multi-layer, and may be **woven** from monofilament, plied monofilament or multifilament yarns"), satisfying [1f]. EX1006, 10:9-13. This is similar to the '388 Patent's description that "[i]n a preferred embodiment of the invention, one, some or all of the sheet-like plies consist of or comprise a woven material, preferably a one-layer weave." EX1001, 3:9-12.

(b) **Claim 2**

[2]: The fabric according to claim 1, wherein said one or more sheet plies are two or more sheet plies.

115. The discussion of claim 1 was directed to a Ryan-Yook combination in which Yook's base fabric 60 was attached to Ryan's base fabric 10. Yook, however, describes that base fabric layer 22 can be used instead of the base fabric 60 in the FIG. 12 laminated fabric. EX1006, 10:19-21. Base fabric layer 22 has **two plies**. In my opinion, it would have been obvious to follow Yook's direct teachings and use base fabric layer 22 in the Ryan-Yook fabric, such that the two plies of base fabric layer 22 are "two or more sheet plies," satisfying claim 2.

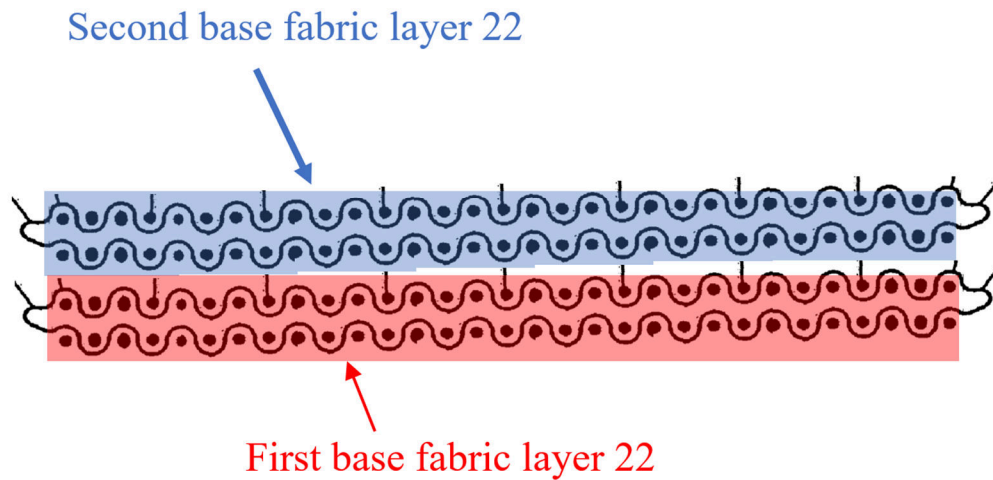
116. Specifically, Yook describes that “[a]lternatively, a second on-machine seamable base fabric layer 22 may be used instead of an on-machine-seamable base fabric 60.” EX1006, 10:19-21. The base fabric layer 22 is “a *two-ply fabric*.” EX1006, 8:40-46. For example, the base fabric layer 22 includes “a first fabric ply 40 and a second fabric ply 42,” shown below in blue. EX1006, 8:53-58.



Yook, FIG. 6

117. Yook’s alternative laminated structure includes two base fabric layers 22 and is shown below as an adaptation of Yook FIGS. 6 and 12.

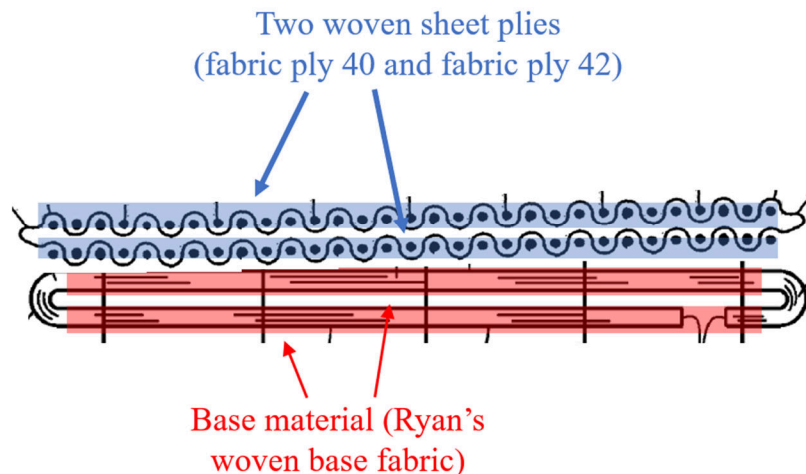
Yook, alternative FIG. 12 laminated fabric



Yook, alternative FIG. 12 laminated fabric

118. Laminating Yook's two-ply fabric layer 22 to Ryan's base fabric 10, to achieve the advantages of lamination as discussed with respect to claim 1, would result in two sheet plies in the Ryan-Yook fabric, as shown below. The two sheet plies are first fabric ply 40 and second fabric ply 42 in base fabric layer 22.

Alternative embodiment of Ryan-Yook fabric



Ryan-Yook fabric (alternate embodiment)

(c) **Claim 3**

[3]: *The fabric according to claim 1, configured for producing a fiber web selected from the group consisting of a paper web, a cardboard web, a tissue web and a pulp web.*

119. Each of Ryan and Yook discloses that their fabric is configured for producing a paper web, i.e., a fibrous web that is used to make paper. EX1006, 1:11-26; EX1007, [0006], [0029]. For example, Yook describes that forming fabrics and press fabrics are used for producing a paper web, explaining that “[d]uring the **papermaking** process, **a cellulosic fibrous web is formed** by depositing a fibrous slurry...onto a moving **forming fabric** in the forming section of a paper machine....The cellulosic fibrous web passes through the press nips **supported by a press fabric...to turn the cellulosic fibrous web into a paper sheet.**” EX1006, 1:11-26. All of these references to papermaking, web processing, forming, pressing, and the like teach the use of the fabric for producing a paper web. Ryan similarly describes that press fabrics carry a “fibrous web” or a “web of fibrous material “in a paper making machine.” EX1007, [0006], [0029]. Moreover, both Yook and Ryan teach the efficacy of their fabrics for use in or as press fabrics, matching the ’388 Patent’s description that “[t]he fabric according to the invention can be used as a press fabric, especially as a press felt.” EX1007, [0015]; EX1006, 10:22-28; EX1001, 2:56-58.

(d) **Claim 4**

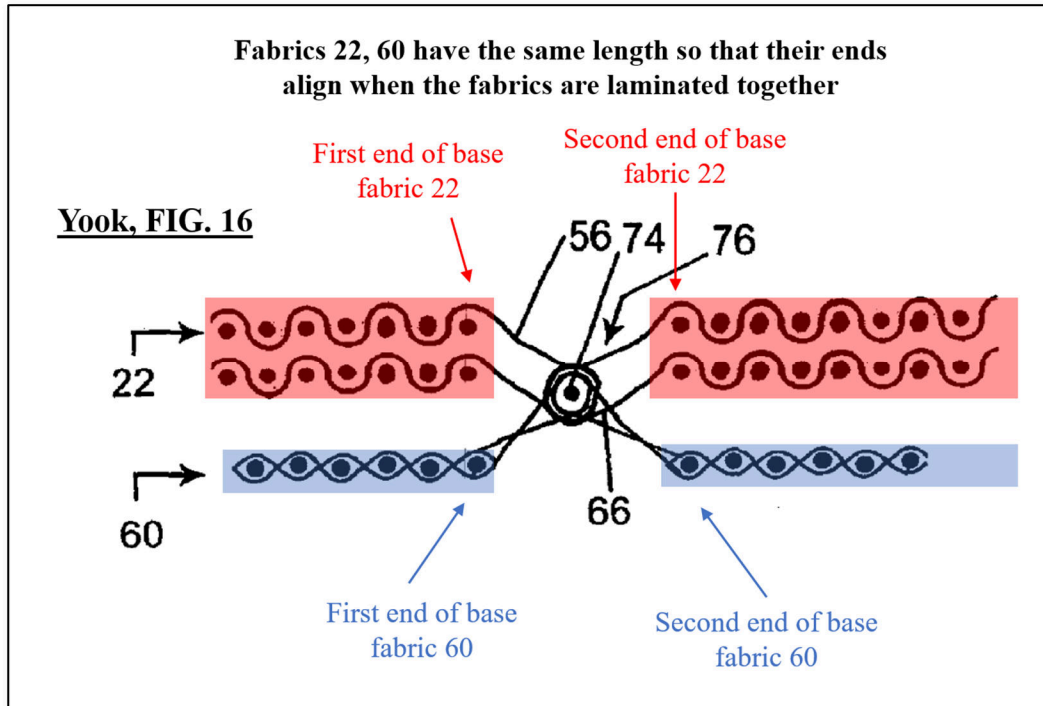
[4]: The fabric according to claim 1, wherein said sheet plies have a width substantially equal to a width in cross machine direction as the fabric and/or said sheet plies have a length substantially equal to a length in the machine direction as the fabric.

120. It is my opinion that Ryan and Yook disclose or render obvious both the substantially equal width and the substantially equal length. EX1006, 6:5-8, 2:52-57. For purposes of identifying “substantially equal,” I note that the ’388 Patent defines “essentially the same width” or “essentially the same length” as being within 10% (“not less than 90% and not more than 110% of the width in cross machine direction [or length in machine direction] of the fabric”). EX1001, 2:59-3:4. The ’388 Patent does not describe any particular benefits to this configuration, merely referring briefly to this configuration as a “preferred embodiment of the invention. *Id.* “Substantially equal” is not defined, but the art cited herein satisfies or renders obvious this “essentially the same” relationship, that is, lengths and widths within 10%.

121. With respect to the length, Yook discloses that, in a laminated base fabric, “[t]he second base fabric is an on-machine-seamable base fabric of substantially the same length as the first base fabric.” EX1006, 6:5-8. “Length” here refers to the machine direction. EX1006, 2:57-58 (“[t]he base fabric is endless

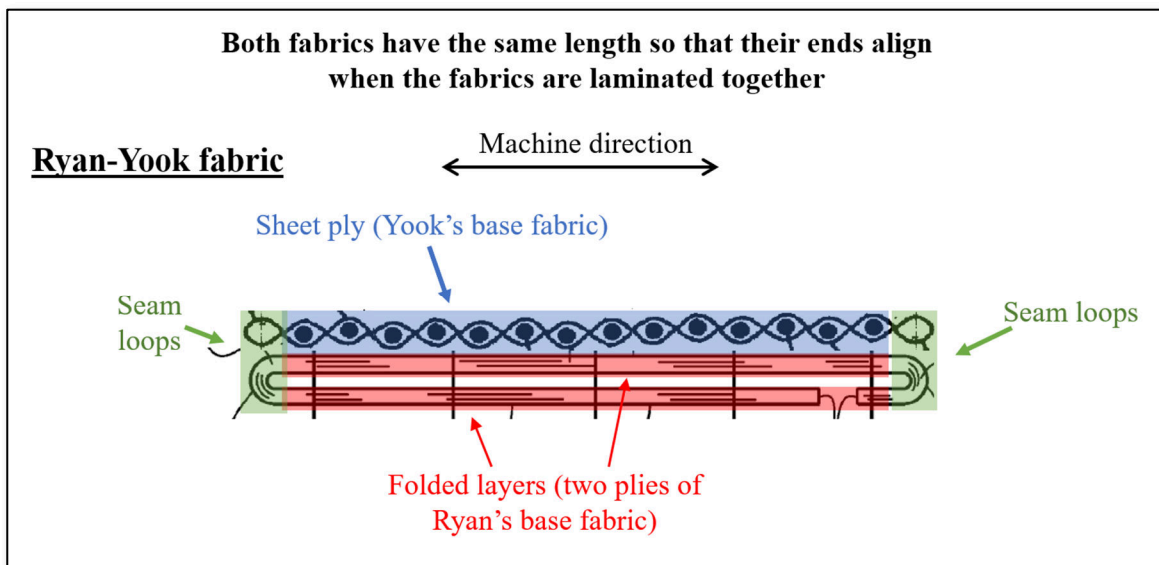
in the longitudinal, or machine, direction”) and 8:48-51 (describing that the folds 38 “align with the transverse, or crossmachine, direction,” meaning that the orthogonal, lengthwise direction would be the machine direction). Applied to the laminated base fabrics of the Ryan-Yook fabric, this configuration satisfies claim 4. EX1006, 6:5-8.

122. Matching lengths of the two laminated-together base fabrics advantageously permits alignment between the seam loops of the fabrics, so that the seam loops can be configured as Yook describes with respect to FIGS. 13 to 16. Each of the FIGS. 13 to 16 configurations has full or substantial alignment between the seam loops in the machine direction. EX1006, 10:31-11:9. For example, FIG. 16, shown below, has the seam loops of the two base fabrics 22 and 60 fully aligned to receive a “common pintle 74.” EX1006, 11:4-9. To facilitate this alignment, it would have been obvious—and consistent with Yook’s explicit disclosure—for Ryan’s base fabric 10 and Yook’s base fabric 60 to have the same length in the Ryan-Yook fabric.



Yook, FIG. 16

123. That is, in the laminated Ryan-Yook fabric, it would have been obvious for the fabric's sheet ply (Yook's base fabric 60) to have a length substantially equal to that of "the fabric" (Ryan's base fabric 10), as shown below.



Ryan-Yook fabric

124. It is my opinion that it would also have been obvious for a POSITA to provide Yook's base fabric with a cross-machine direction width substantially matching that of Ryan's base fabric. The cross-machine direction is the direction in and out of the page in this Declaration's illustrations of the Ryan-Yook fabric. Yook teaches that "press fabrics are designed to have smooth surfaces...so that...a smooth, mark-free surface is imparted to the paper." EX1006, 1:52-55. This is because surface features in press fabrics may be imprinted into the paper carried by the press fabrics, due in part to the high pressures with which water is pressed out of the paper.

125. A POSITA would have recognized that having the width of the laminated-on base fabric (Yook's base fabric 60 in the Ryan-Yook fabric) match the width of the underlying base fabric (Ryan's base fabric 10), so as to fully cover the underlying base fabric, would avoid forming "steps" in the fabric surface where one fabric is absent. This configuration would increase the surface uniformity that Yook teaches is desirable. Therefore, it would have been obvious for a POSITA to provide this advantageous configuration.

(e) ***Claims 5, 6***

[5]: The fabric according to claim 1, wherein said woven base material is a one-layer weave.

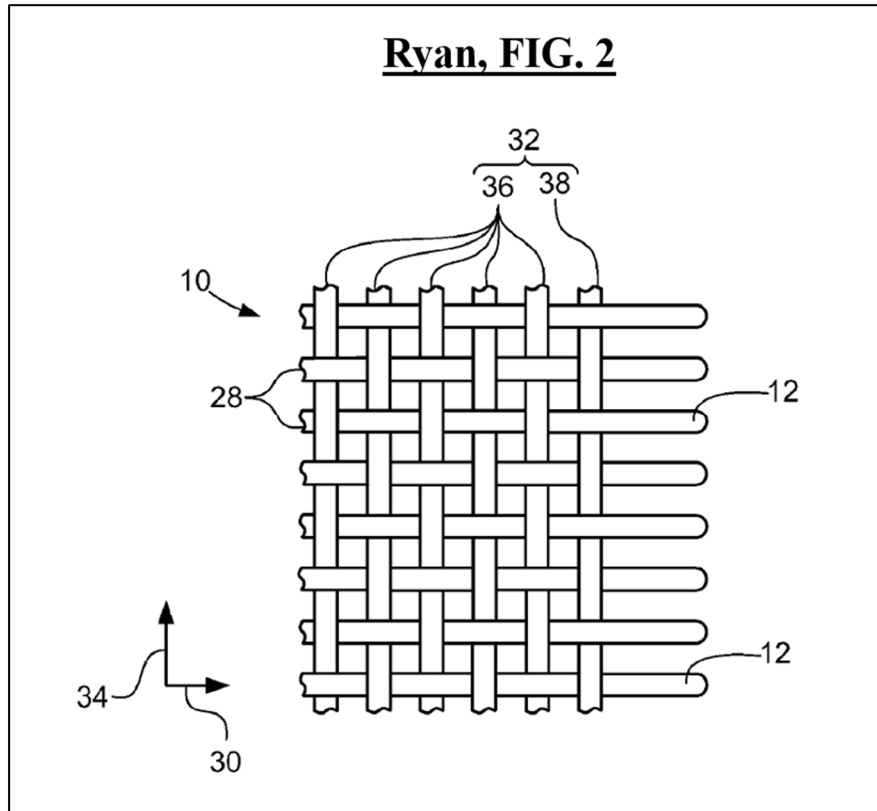
[6]: The fabric according to claim 5, wherein said woven base material is a

plain weave.

126. Each of Ryan and Yook discloses a one-layer plain weave as the woven base material. EX1007, [0034], FIGS. 2-8; EX1006, 2:4-7, 8:9-14, FIG. 6.⁴ For clarity, the “woven base material” of the claims is the base structure on which the sheet plies are provided. EX1001, 4:40-5:3. The base structure of the ’388 Patent is, as a whole, a two-layer structure, due to its folding; that two-layer structure, however, is composed of two layers of a one-layer weave, as claim 5 requires.

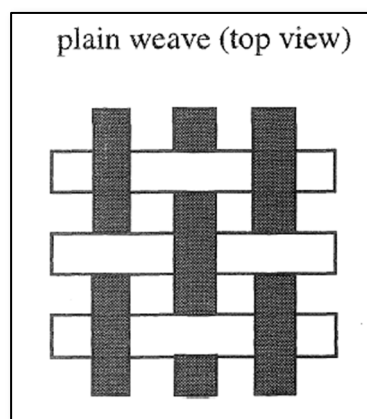
127. In the Ryan-Yook fabric, the woven base material is Ryan’s “base fabric 10.” Ryan describes that the “fabric 10” “can be a *single-layered fabric*.” EX1007, [0034]. Further, FIGS. 2-8 of Ryan illustrate a one-layer plain weave of the fabric 10. For example, FIG. 2 shows MD yarns 28 and CD yarns 32 arranged in a simple, right-angled crisscross pattern that a POSITA would have recognized as a plain weave. EX1007, FIG. 2.

⁴ The woven base material forms the base structure on which the sheet plies are provided. EX1001, 4:40-5:3.



Plain weave of Ryan’s base fabric (FIG. 2)

128. That FIG. 2 illustrates a plain weave is made clear, for example, by comparison with Adanur’s matching illustration of a “plain weave.” EX1011, 36:



Adanur, FIG. 2.2

129. Yook agrees with Ryan that base fabrics may be, or are, single-layer plain weaves. Specifically, Yook describes that “base fabrics...may be ***single-layered***” and describes a “***single-layer weave***” and “***plain weave***” for the base fabric layer 22 to which base fabric 60 is laminated. EX1006, 2:4-6, 8:9-14, FIG. 6.

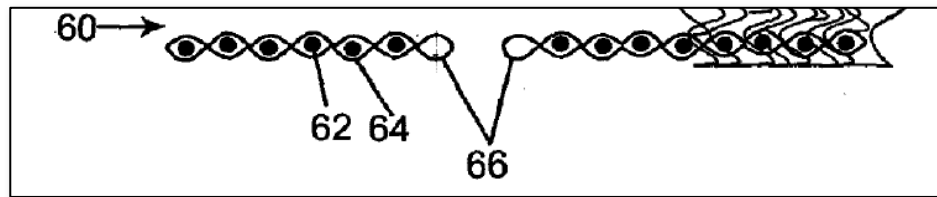
(f) ***Claims 7, 8***

[7]: The fabric according to claim 1, wherein said woven material is a one-layer weave.

[8]: The fabric according to claim 7, wherein said one-layer weave is a plain weave.

130. The “woven material” of the sheet ply (Yook’s base fabric 60) in the Ryan-Yook fabric is a “one-layer” “plain” weave. EX1006, 9:56-61, FIGS. 11-12. This is shown, for example, in Yook FIG. 12, where the base fabric 60 has one layer of crosswise yarns 62 and lengthwise yarns 64 crossing at right angles, with the lengthwise yarns 64 following an over/under/over/under pattern with respect to the crosswise yarns 62. EX1006, 9:56-61, 10:16-18, FIG. 12. A POSITA would have recognized this as a single-layer plain weave. For example, this is the weave pattern of Adanur’s FIG. 2.2 “plain weave” discussed for claims 5 and 6. This is also consistent with the definition of “plain weave” provided by *The Primary Structures of Fabrics*: “[t]he simplest possible interlacing of warp and weft

elements produces *plain weave*...The principle of the interlacing is unvarying alternation. Each weft unit passes alternately over and under successive warp units.” EX1025, 6.



Plain weave of Yook's base fabric 60 (FIG. 12)

131. Yook also describes that the base fabric “may be either *single-* or multi-*layer*.” EX1006, 10:9-13.

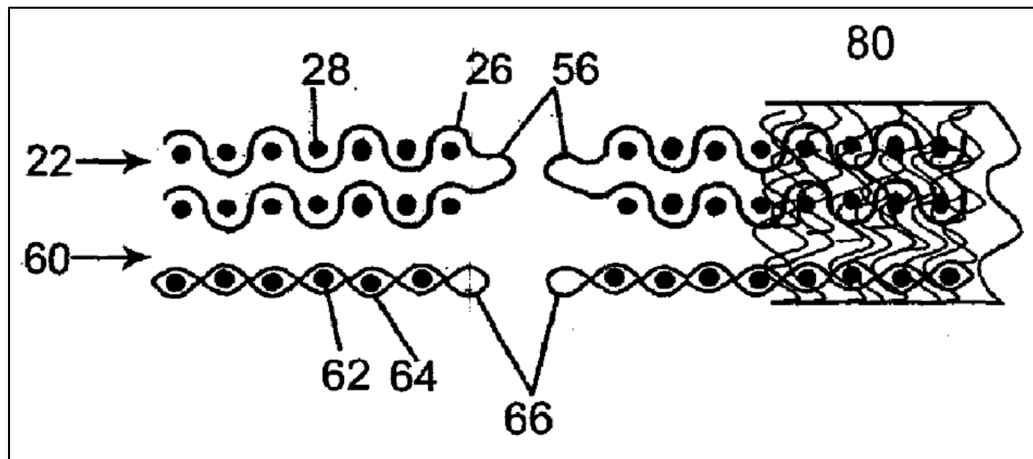
(g) ***Claim 9***

[9]: The fabric according to claim 1, wherein said woven base material and one, some or all of said sheet plies are formed of a same woven material.

132. Yook's base fabric 60 is formed, or, in my opinion, would have been obvious to form, of the same woven material as Ryan's base fabric 10. The base fabric 60 is the “sheet plies” of the Ryan-Yook fabric, and the base fabric 10 is the “woven base material” of the Ryan-Yook fabric, so, with these fabrics formed of the same woven material, claim 9 is satisfied.

133. As discussed above for claims 5-8, both Ryan's base fabric (before being folded into the two-layer base fabric 10) and Yook's base fabric 60 are composed of a one-layer plain weave. FIG. 12 shows that the base fabric 60

includes two “lengthwise yarns 64” that are in the same common, single layer having the simple, alternating structure of a plain weave. EX1025, 6.



Yook, FIG. 12

134. Not only Yook’s base fabric 60 but also Yook’s base fabric layer 22 includes a one-layer plain weave structure. That is, each of the two folded layers of the base fabric layer 22 has a one-layer plain weave structure. For example, Yook describes that the base fabric layer 22 is derived from a “strip 16” that has a “single-layer” “plain weave;” the strip is spiral-wound to obtain the two layers of base fabric layer 22. EX1006, 8:13-16, FIG. 1.

135. Ryan’s and Yook’s fabrics also use the same yarn compositions. Ryan’s yarns “may include *any manmade material*, such as nylon, *polyester*, or other types of poly-yarns,” and can specifically include “monofilament yarns 36.” EX1007, [0030]-[0031]. Similarly, Yook’s yarns may be “monofilament, plied monofilament multifilament or plied multifilament yarns” and “are typically extruded from any one of several synthetic polymeric resins, such as polyamide

and *polyester* resins.” EX1006, 2:4-10, 10:9-15. In addition, like Ryan’s yarns, Yook’s “yarns...are preferably monofilament yarns.” EX1006, 10:13-15.

136. Given these overlapping and broad descriptions of yarn composition, it would have been obvious for a POSITA to use the same yarns for both base fabrics of the Ryan-Yook fabric, to simplify manufacture by permitting the same yarn supply (e.g., the same machine-direction and cross-machine-direction yarns) and weaving tools, or weaving tool configurations, to be used for the weaving of both base fabrics. The use of the same yarns for both base fabrics would also advantageously result in both base fabrics having the same mechanical and hydrothermal responses, so that one would not deform significantly more or less than the other. Rather, each fabric’s fundamental response to temperature changes, pressure, moisture, etc., would be similar or the same.

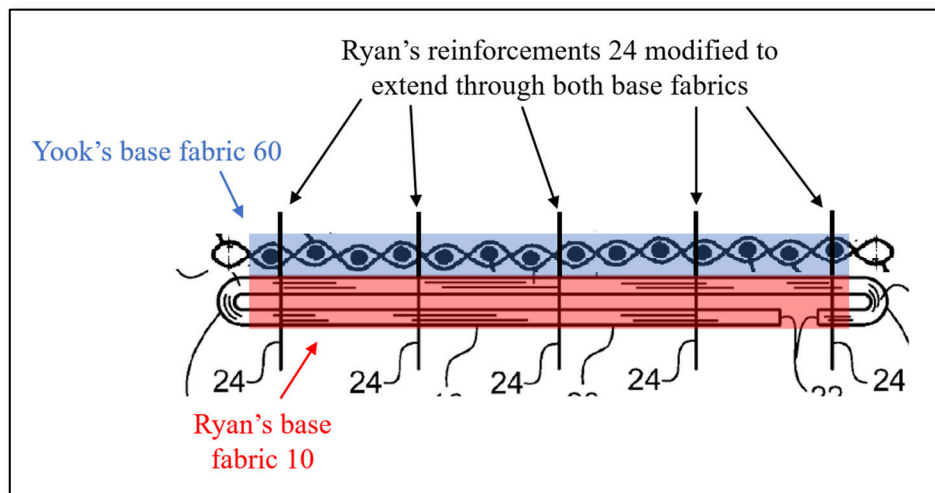
137. Indeed, as an alternative to the combination of base fabric 60 and base fabric layer 22 shown in Yook FIG. 12, Yook describes that a laminated fabric can include two *identical* base fabrics 22, which would naturally be formed of the same woven material. EX1006, 10:19-21.

138. Therefore, it would have been obvious to form the Ryan-Yook fabric with Ryan’s fabric 10 and Yook’s fabric 60 having the same yarn composition and same weave structure, satisfying claim 9’s requirement that the sheet plies and base material are “*formed of a same woven material.*”

(h) **Claim 10**

[10]: *The fabric according to claim 1, which comprises one or more stitchings for securing said sheet plies to said woven base material.*

139. It is my opinion that it would have been obvious to join Yook's base fabric 60 (sheet ply) to Ryan's folded base fabric 10 (woven base material) using the stitchings that are already present in Ryan. EX1007, [0029], [0031], [0040], [0042]. Specifically, Ryan's base fabric 10 includes "reinforcements 24," which are "seam stitching" that "assist[s] in securing bottom ply 20 to top ply [18]." EX1007, [0029], [0031]. It would have been obvious to provide the reinforcements 24 through **both** the base fabric 10 **and** the base fabric 60 in the laminated Ryan-Yook fabric to better secure the base fabrics to one another, as shown below.



Ryan-Yook fabric

140. Stitching together laminated base fabrics was well known in the art. Hyvonen describes that, in a "laminated base fabric" having "two or more separate

base fabric preforms [] woven in separate steps,” the preforms can be “stitched together” “to form one piece,” e.g., with “stitches passing through the first and the second layers.” EX1022, 5:36-40, 7:44-46. Hyvonen’s fabrics, like the Ryan-Yook fabric, also include needled batt. EX1022, 3:3-5. As another example, Lee discloses “one or more rows of stitches” that join together laminated fabric structures to “retain [a first fabric structure] in its desired position inside [a second fabric structure].” EX1015, [0062], [0104], FIG. 15.

141. In addition, a POSITA would have recognized that the reinforcements 24 would advantageously reduce drift of CD yarns adjacent to the seam loops of Yook’s base fabric, analogously to Virtanen’s “connecting portions,” as shown, e.g., in FIG. 5. EX1008, [0005], [0011]. Virtanen’s connecting portions “join together at least two superimposed fabric layers” having “independent yarn systems,” similar to the two base fabrics 10, 60 of the Ryan-Yook fabric. EX1008, [0009], [0016].

142. It is my opinion that a POSITA would have had a reasonable expectation of success in making this modification. Ryan’s overall process flow includes weaving of a flat-woven base fabric, followed by folding the base fabric into two layers. Therefore, Ryan’s reinforcements 24, which attach together the two folded layers, are stitched *after* the base fabric is folded into the two-layer base fabric 10, as opposed to during weaving of the base fabric 10. This method would

be highly compatible with stitching of the reinforcements through *both* base fabrics 10 and 60. To improve the joining of the base fabrics 10 and 60 to one another, a POSITA would have performed the stitching after placement of the base fabrics 10 and 60 against one another, without requiring any fundamental modifications to the reinforcements 24, the base fabrics, or their manufacture (e.g., modifications to the weaving of the base fabrics).

143. Moreover, Ryan makes clear that the reinforcements 24 may include a wide variety of stitch types, stitch patterns, and yarn materials, and may be located at various different locations. EX1007, [0040], [0042]. For example, Ryan states:

[S]titches/reinforcements 24 may be placed at alternative or additional locations. The sewing may be carried out using a lock stitch, chain stitch, bag stitch, back stitch, cable stitch, cover stitch, overcast stitch, an over seam stitch, or any other suitable stitch. The sewing may be applied as a straight stitch, zig-zag stitch, double needle stitch, or multi-needle stitch, for example. The yarn used for the stitches may be a cabled yarn, multifilament yarn, monofilament yarn, knitted yarn, spun fiber yarn, texturized yarn, thermal bonded yarn, low twisted yarn, plied yarn, twisted yarn, soluble yarn, thread or melting yarn. Other common types of yarn used for stitches are also possible

EX1007, [0040].

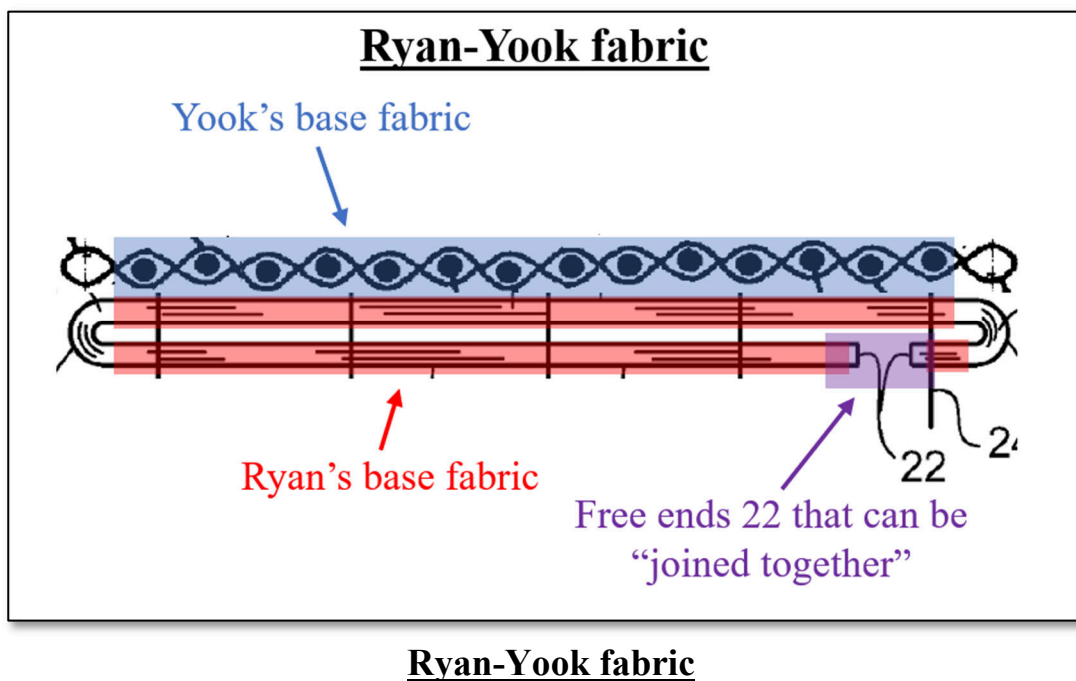
144. That is, the stitches 24 may be included in various different, flexible configurations that a POSITA would have had no trouble adapting to a stitch through multiple base fabrics in the Ryan-Yook fabric. EX1007, [0040], [0042].

145. The stitched reinforcements 24 of this modified Ryan-Yook fabric would join Yook's one-layer base fabric 60 (sheet ply) to Ryan's two-layer folded base fabric 10 (woven base material), satisfying claim 10.

(i) ***Claim 11***

[11]: The fabric according to claim 1, wherein said two terminal ends are at least temporarily connected to one another.

146. Ryan describes that “free ends 22 can come together and ***be joined together***,” satisfying [11]. EX1007, [0029], [0042], FIG. 1.



(j) **Claim 12**

[12]: The fabric according to claim 11, wherein said two terminal ends are connected to one another by a process selected from the group consisting of welded, stitching, and gluing.

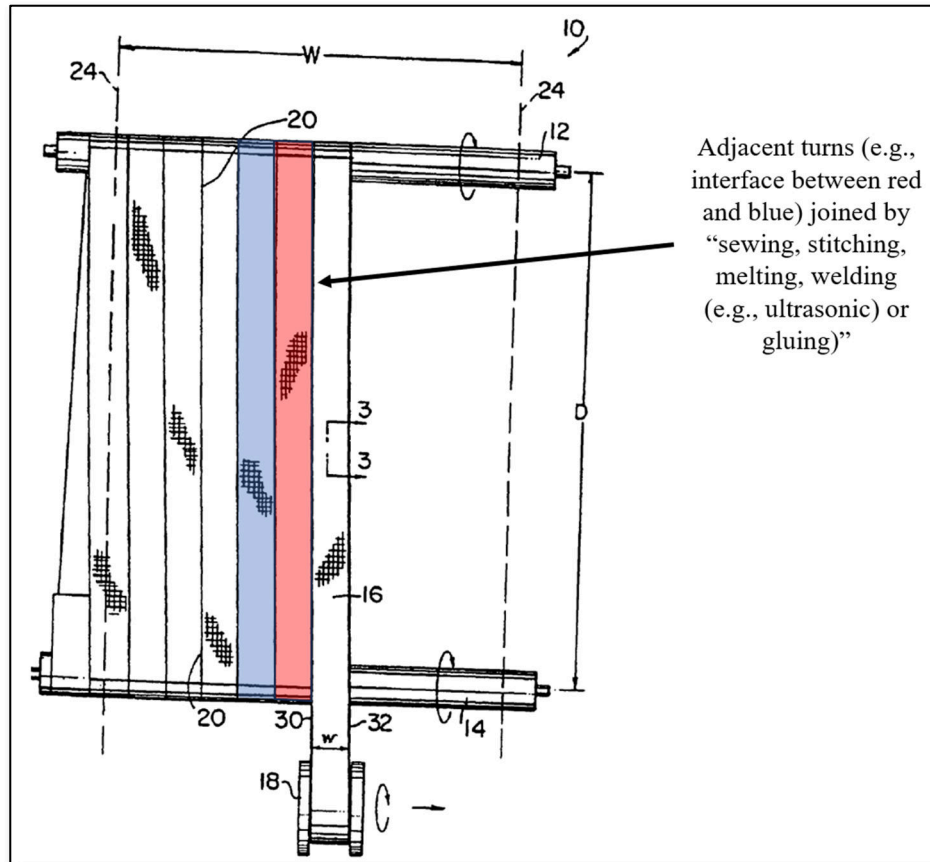
147. Although Ryan does not explicitly disclose a method by which the free ends 22 are “joined together,” it is my opinion that it would have been obvious for a POSITA to use welding, stitching, or gluing to secure the free ends 22 together. EX1007, [0039]; EX1006, 2:63-3:3.

148. First, each of welding, stitching, and gluing was a well-known method, and the '388 Patent does not disclose any particular advantages or unexpected effects associated with any of them. This claim appears to merely reflect the most common methods that a POSITA would have been aware of for attaching two yarns together.

149. For example, Ryan describes that “stitching,” “ultrasonic welding,” or “gluing” can be used to bond together the top and bottom ply of the fabric. EX1007, [0039].

150. Yook describes that “stitching,” “welding (e.g., ultrasonic) or gluing” can be used to bond together successive turns of the fabric strip 16 that forms Yook’s spiral-wound base fabric. EX1006, 2:63-3:3, 7:43-46. As shown in Yook FIG. 1 below, bonding together abutting turns (or “windings”) is practically

identical to bonding together the free ends 22, because both processes involve attaching laterally-adjacent fabric edges to one another.



Yook, FIG. 1

151. The use of any of these methods would have constituted no more than a selection of one of a small number of known methods to achieve the predictable result of joining the free ends 22 together.

(k) ***Claim 13***

[13]: The fabric according to claim 1, which further comprises at least one layer of batt fibers.

152. As discussed for claim 1 above, the Ryan-Yook fabric includes “one or more layers of staple fiber batt material 80 needled into and through” Ryan’s base fabric and Yook’s base fabric, to secure the base fabrics together. EX1006, 10:24-25. This configuration directly follows Yook’s teaching that multiple base fabrics in a laminated fabric can be attached together “by one or more layers of staple fiber batt material 80 needled into and through the superimposed [base fabrics].” EX1006, 10:24-27.

153. In addition, as further discussed for claim 1 above, the inclusion of at least one layer of batt fibers was a conventional, near-universal feature of press fabrics. For example, Adanur explains that “[p]ress fabrics, in general, consist of two components []: base fabric and batt.” EX1011, 159. It would have been obvious (and, indeed, expected as a matter of course) to add such a layer to the Ryan-Yook fabric, even if one were not already present.

(l) ***Claim 14***

[14]: The fabric according to claim 1, wherein the fabric is configured to be on-machine seamable and comprises only one seam.

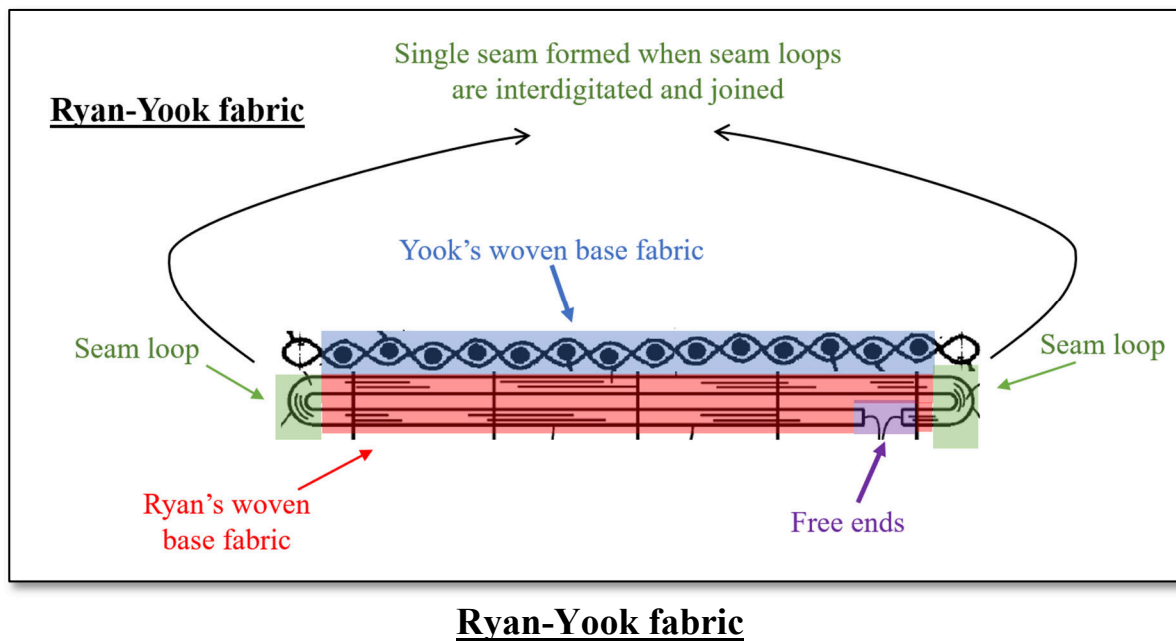
154. The Ryan-Yook fabric is on-machine seamable. EX1007, [0006]; EX1006, 10:16-11:9, FIGS. 12-16. Ryan describes that “[i]t is known to manufacture a woven press fabric having a flat-woven base fabric with a plurality of warp yarns forming seam loops... For installation in a paper machine [], the two

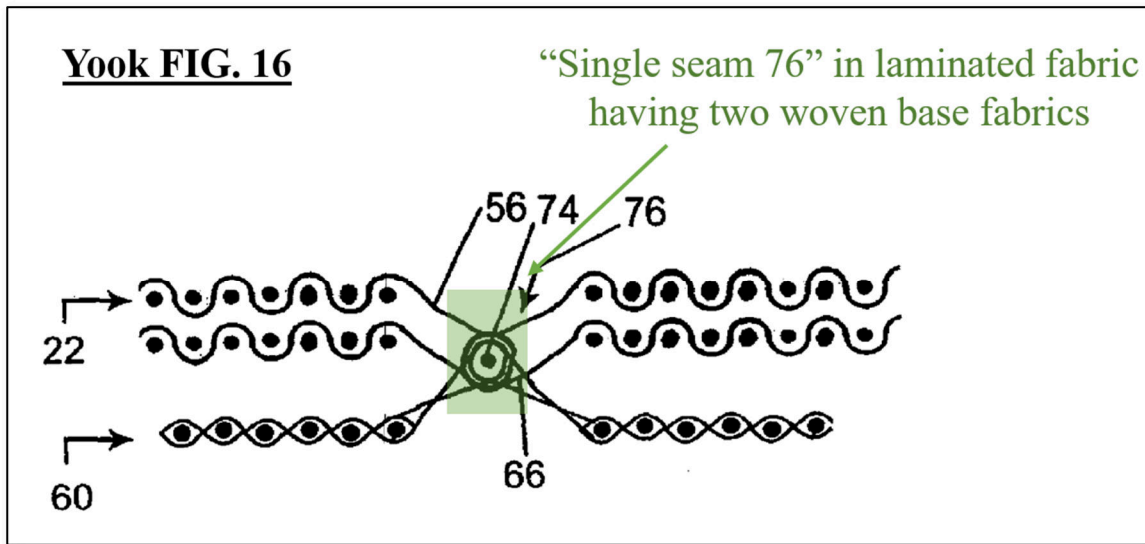
ends are separated such that the fabric can be pulled in its direction of movement into the machine, after which the two belt longitudinal ends can then be joined together again.” EX1007, [0006]. A POSITA would have recognized this as a description of on-machine seaming, which, as I discussed above in §V.A.3, is often easier than seaming prior to installation on a papermaking machine.

155. Similarly, Yook discloses that the base fabric 60 (integrated into the Ryan-Yook fabric) is “on-machine seamable.” EX1006, 10:16-18. Yook also provides detailed guidance as to how the seam loops in laminated fabrics can be arranged with respect to one another (e.g., aligned, overlapped, etc.), the purpose of which is to provide for on-machine seaming of the fabric. EX1006, 10:16-11:9, FIGS. 12-16. This accords with Adanur’s guidance that “pin seaming is used which makes installation of the fabric on paper machine a lot easier.” EX1011, 165.

156. Further, the Ryan-Yook fabric includes only one seam. This claim limitation appears to refer to the single seam formed by interdigitating the ’388 Patent’s seam loops. EX1001, 2:32-34. Although the seam is not yet formed when the fabric is in the form of FIG. 1 of the ’388 Patent, it would have been common for POSITAs to refer to the seam even before interdigitation and pintle insertion. The Ryan-Yook fabric similarly can include one seam formed by the seam loops 12, in Ryan’s fabric 10, when interdigitated with a pintle inserted. EX1007, [0006].

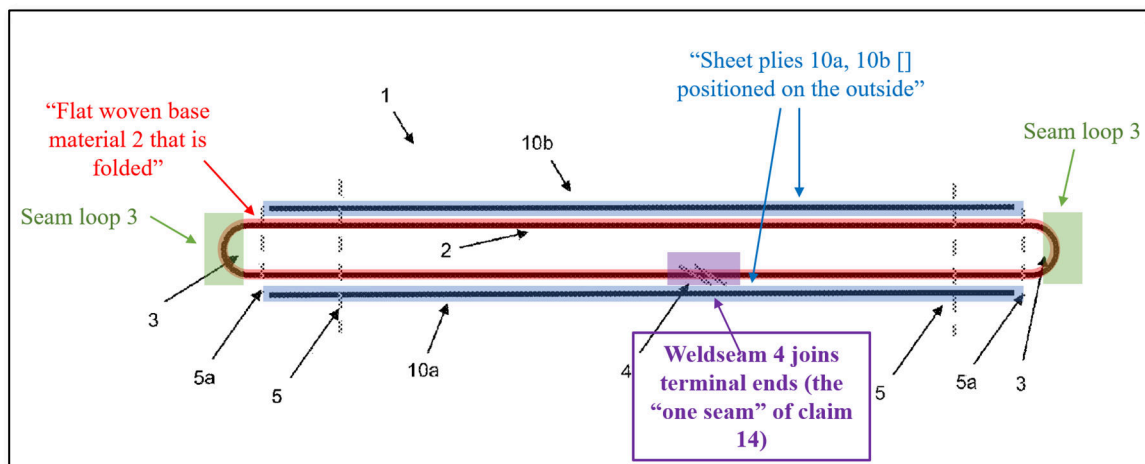
Yook's base fabric 60 is attached to the fabric 10 with batt and need not be attached using seam loops. In addition, like the '388 Patent's fabric, the Ryan-Yook fabric can be joined with a "single seam" as described for Yook FIG. 16. EX1006, 11:4-9, FIG. 16. This "single seam" is formed by seam loops 56, 66 of the two laminated-together woven base fabrics 22, 60, which are overlapped and interdigitated together such that a "common pintle" can be inserted through them. *Id.* The Ryan-Yook fabric likewise includes two attached woven base fabrics and has the same single-seam configuration.





Yook, FIG. 16

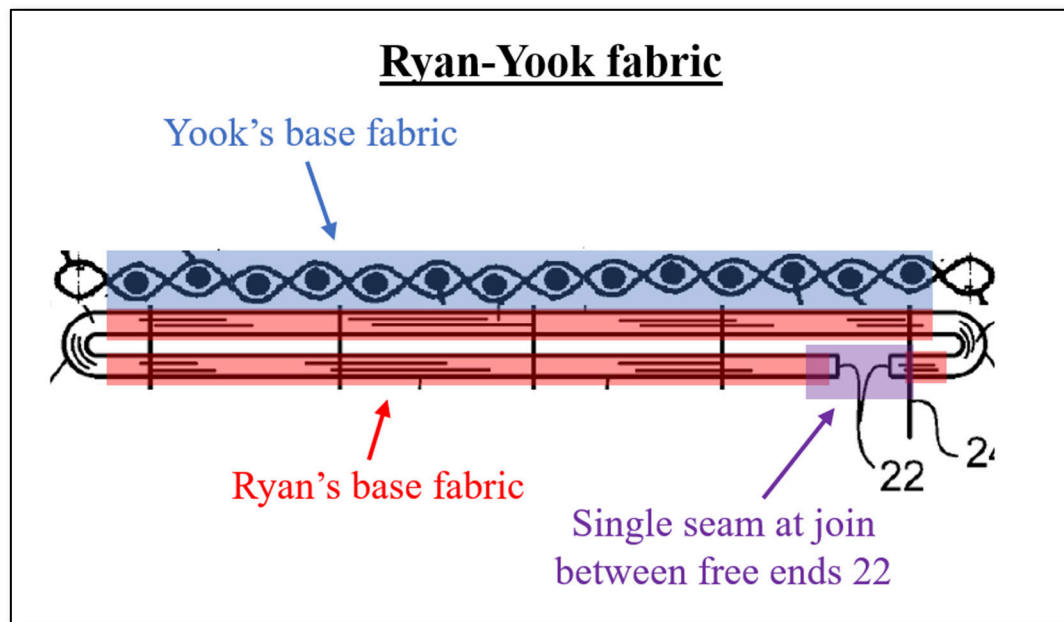
157. As an alternative, to the extent it may be argued that this claim limitation refers to the '388 Patent's "weldseam 4," which joins the terminal ends and is the only seam in the fabric of FIG. 1, the Ryan-Yook fabric also satisfies claim 14.



'388 Patent, FIG. 1

158. The Ryan-Yook fabric has the same configuration as the '388 Patent's FIG. 1 fabric, including having “only one seam” under this alternative

interpretation of claim 14. Specifically, the one seam in the Ryan-Yook fabric is the “join” between the free ends 22, analogous to the “weldseam 4” between the terminal ends of the ’388 Patent’s fabric.



Yook-Ryan fabric

(m) **Claim 15**

[15]: *A method for producing a fiber web, providing a web-producing machine with at least one fabric according to claim 1.*

159. Each of Ryan and Yook discloses the recited method. EX1007, [0006], [0029]; EX1006, 1:18-28, 1:46-55; 1:67-2:1; EX1003, 159. As discussed for claim 1, Ryan and Yook render obvious “at least fabric according to claim 1.” See §VII.A.4(a). Ryan and Yook also describe “a method for producing a fiber web” that includes “providing a web-producing machine” with the fabric. For example, Ryan describes “install[ing]” a press fabric (such as the Ryan-Yook

fabric) “in a paper machine” with “the fabric [] pulled in its direction of movement into the machine.” EX1007, [0006]. This “installation” is “providing” the machine with the fabric, and the machine is a “web-producing machine” because it is a paper making machine.

160. Ryan also describes processing a “web of fibrous material (or a nascent such web) when [the fabric] is used in a paper making machine,” for example, by performing “dewatering.” EX1007, [0006], [0029]. This reinforces that the paper making machine is used for “producing a fiber web” and is a “web-producing machine.”

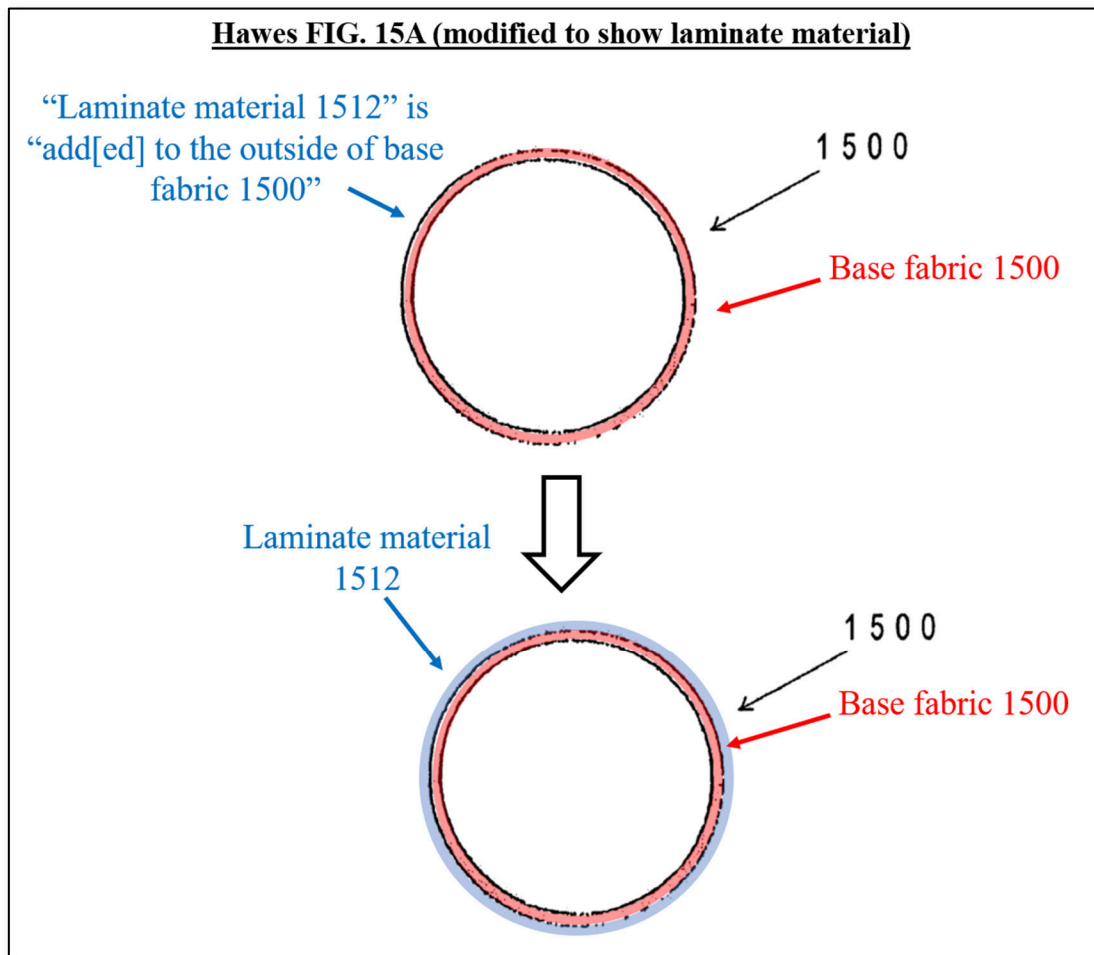
161. Similarly, Yook describes “install[ing]” press fabrics on “paper machines,” “support[ing]” and “carry[ing]” a “cellulosic fibrous web” on the press fabrics, and thereby “turn[ing] the cellulosic fibrous web into a paper sheet.” EX1006, 1:18-28, 1:46-55; 1:67-2:1. So, the “paper machines” described by Yook are “web-producing machine[s],” are “for producing a fiber web,” and are provided with the claim 1 fabric.

B. [GROUND 2A] – Hawes-Crook Renders Claims 1-15 unpatentable

1. Hawes

162. Hawes describes “multilayer” or “laminated” fabrics “for a paper machine.” EX1004, 3:36-4:57. Among other embodiments, Hawes describes an embodiment that “involves a laminate material which becomes part of a multilayer

fabric with a multiaxial base.” EX1004, 4:47-49. Specifically, a “multilayer fabric 1510” is obtained by first “adding a laminate material 1512” (shown in blue, below) “to the outside of base fabric 1500” (shown in red, below) “and needling the fabric with laminate to attach the same.” EX1004, 11:39-42; FIG. 15A.

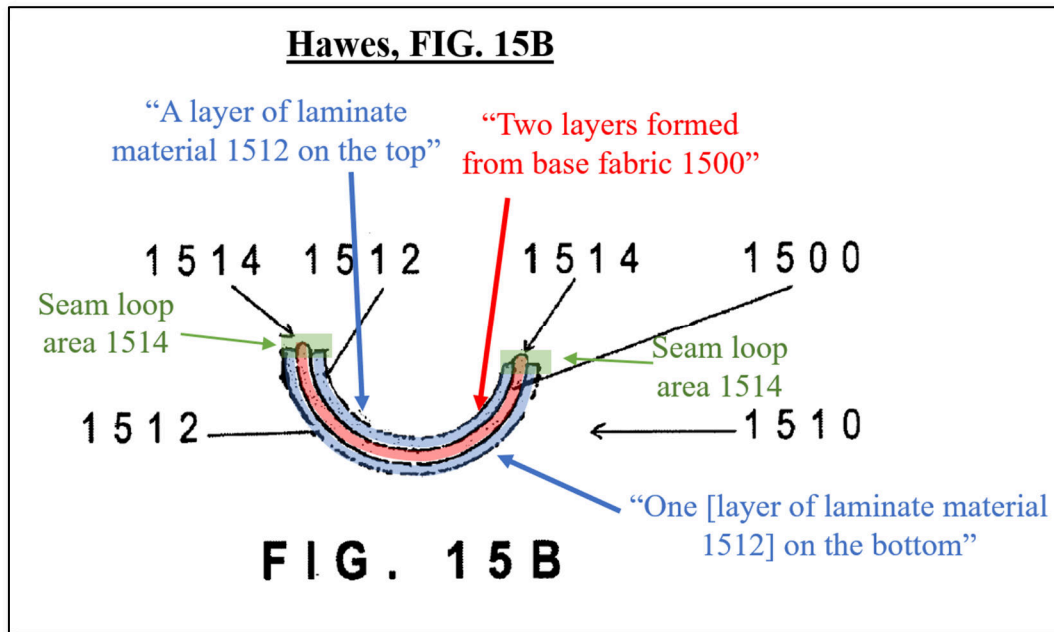


Hawes, FIG. 15A (modified to show laminate material)

163. The laminate material can be “any material suitable for the purpose, such as that described with regard to the second embodiment or even batt.” EX1004, 11:42-44. The mention that the laminate material can “even [be] batt” makes clear that it can also be (and perhaps primarily is) *not* batt.

164. Additionally, Hawes describes that the laminate material can be a “nonwoven layer [that] may include materials such as knitted, extruded mesh, MD or CD yarn arrays, and full width or spiral wound strips of nonwoven fibrous[sic] material.” EX1004, 9:34-37. For example, the laminate material “typically comprises a sheet or web structure bonded together by entangling fiber or filaments mechanically, thermally, or chemically. It may be made of any suitable material, such as polyamide and polyester resins, used for this purpose by those of ordinary skill in the paper machine clothing arts.” EX1004, 9:45-50.

165. After removal of a portion of the laminate material 1512 and seaming of the base fabric 1500 (discussed in more detail below), the “multilayer fabric 1510” fabric is obtained, as shown in FIG. 15B below. EX1004, 11:40-52. This fabric 1510 has “two layers formed from base fabric 1500 and a layer of laminate material 1512 on the top and one on the bottom.” *Id.*, 11:49-52 The fabric 1510 also has seam loop areas 1514 (“loop area 1514”), which include the seam loops discussed throughout this Declaration.



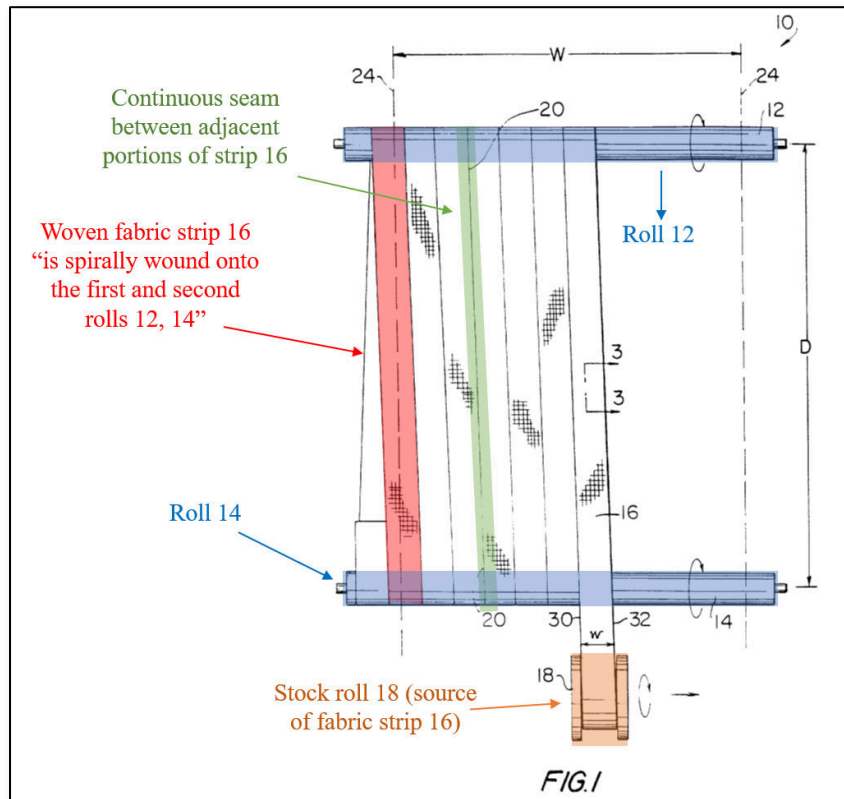
Hawes, FIG. 15B

166. The base fabric 1500 is “two layers” because the base fabric 1500 is an “endless single layer multiaxial base fabric” as described in “the ’176 patent,” (U.S. Pat. No. 5,939,176). U.S. 5,939,176 is referred to herein as “Yook ’176” to distinguish it from Yook applied in Ground 1, with which Yook ’176 shares the same single inventor. Yook ’176 is discussed repeatedly in Hawes and provides much of the background for understanding Hawes’ description. EX1004, 4:20-27, 6:3-44 11:32-37. Hawes also refers to “the ’656 patent” (U.S. Pat. No. 5,360,656), which provides similar description to Yook ’176 (e.g., spiral winding, as discussed below). EX1026, FIG. 1. For clarity, in the below explanation, I will refer only to Yook ’176.

167. Yook ’176 describes a process for forming an “endless base fabric layer” “by spirally winding a fabric strip in a plurality of continuous turns, each of

which abuts against and is attached to those adjacent thereto.” EX1016, Abstract. For example, the base fabric layer 22 of Yook, discussed above, is formed in this same process. EX1006, FIGS. 1-2.

168. In the “spiral winding” process used to form Hawes’ base fabric 1500, successive turns of a fabric strip 16 are wound around two spaced-apart rolls, 12 and 14, “which are parallel to one another.” Adjacent turns are “joined” to one another “by sewing, stitching, melting or welding” to produce a single layer loop. EX1016, 2:62-65, 6:9-12. Because of this configuration, the loop (also referred to by Yook ’176 as a “base fabric”) is “multi-axial”, meaning that its yarn systems “lie in directions at oblique angles to the machine and cross-machine directions.” EX1016, 4:8-11. Hawes describes this same process more briefly in its Background. EX1004, 2:57-3:16. Thus, Hawes’ fabric is not “endless-woven,” but it is manufactured directly in endless form using a spiral-winding method, resulting in an endless fabric analogous to endless-woven fabrics.

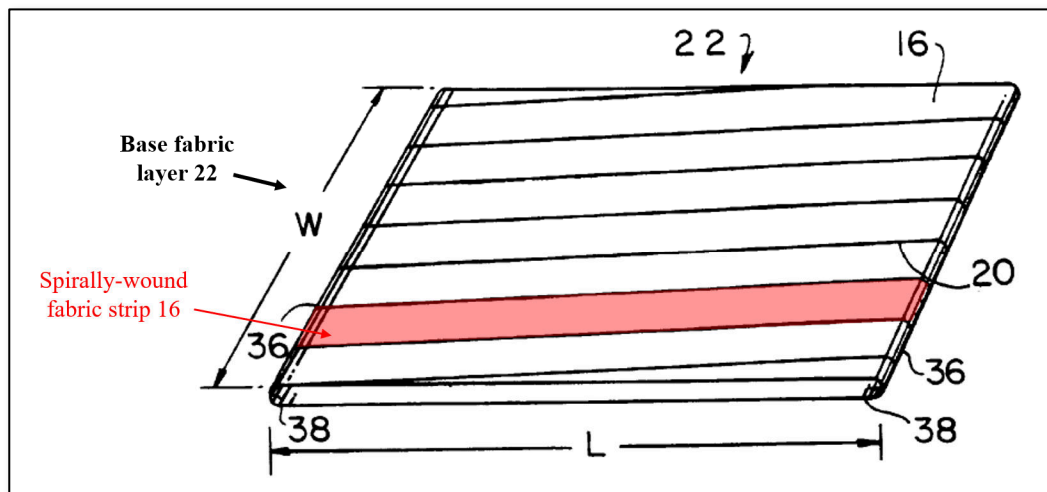


Yook '176, FIG. 1

169. That Hawes' "base fabric 1500" is obtained from this process is apparent from Hawes' repeated references to Yook '176 both generally and specifically in reference to the FIG. 15B embodiment of interest. For example, Hawes refers to "an endless multiaxial fabric folded upon itself along first and second fold lines such as that described in the '176 patent," describes that "multiaxial fabric 100...may be rendered into endless form with a seam as shown, for example, in the '176 patent," and, in reference to FIG. 15B, discloses that "[t]he fabric 1510 is folded on itself as shown and then seamed in a manner as taught in the '176 patent." EX1004, 6:6-9, 6:36-38, 11:47-49. These folding and

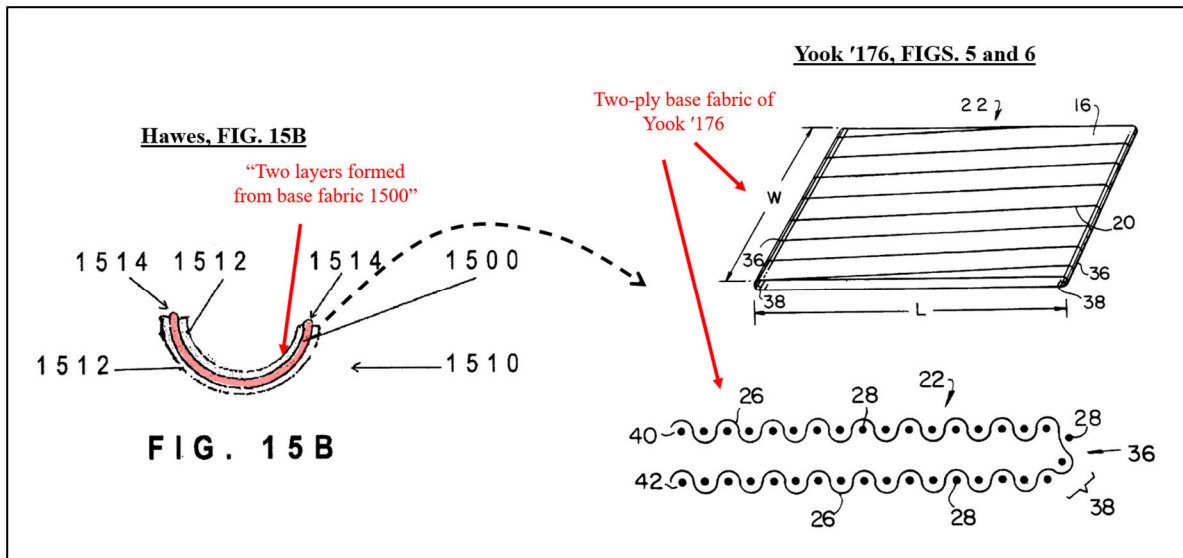
seaming steps exactly mirror the steps that Yook '176 describes as performing on a base fabric layer 22. EX1016, 7:13-45.

170. Yook '176's process provides a base fabric layer 22 (or, as referred-to by Hawes, a base fabric 1500), shown below. Note that, in the form shown in FIG. 5, the base fabric layer 22 has also been flattened and folded, operations that will also be performed on Hawes' base fabric 1500. EX1016, 7:13-16.



Yook '176, FIG. 5

171. This fabric is a “two-ply” fabric that constitutes the “two layers” of Hawes’ base fabric 1500, as shown below. As shown in the schematic below, this base fabric is the same as Yook’s “base fabric layer 22” discussed in the previous ground. See §§VII.A.2 and VII.A.4(a).



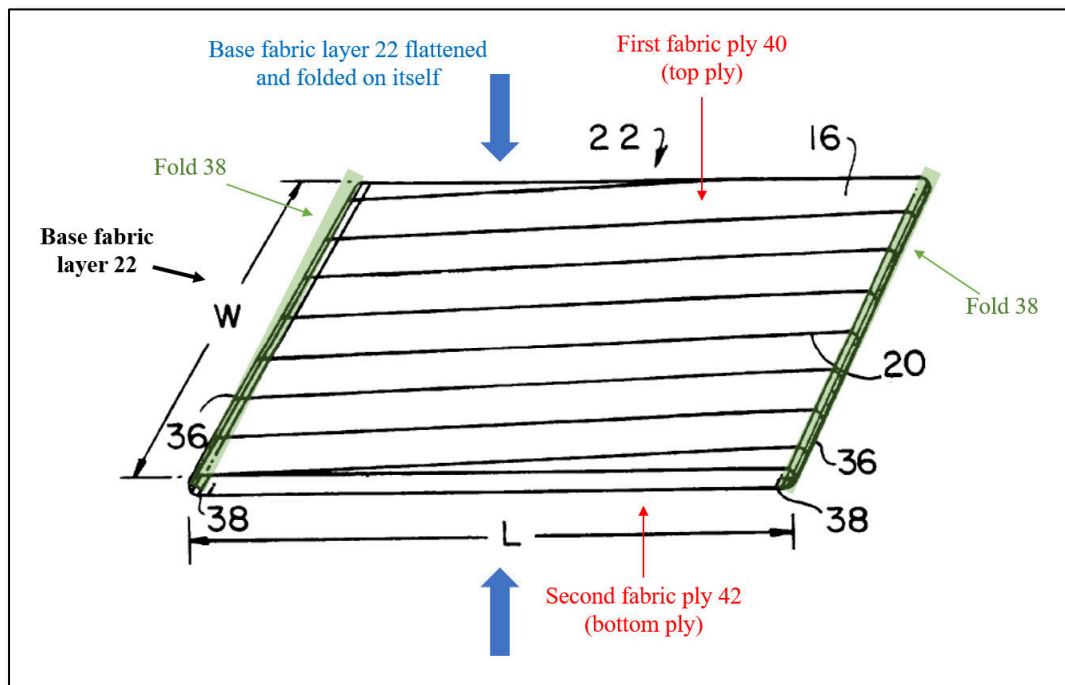
Left: Hawes, FIG. 15B
Right: Yook '176, FIGS. 5, 6

172. Referring again to Hawes, after Hawes' laminate material 1512 is needed to the outside of the base fabric 1500, “[t]he fabric would then be removed from the needle loom with the laminate material cut away in the loop area 1514.” “[R]emoved from the needle loom” here refers to the machine that needles the two-layer base fabric 1500 to the laminate material 1512, for example, needles with batt. *See, e.g.*, EX1020, 2:30-44 (Zehle’s description that “press felts are assembled in the following manner...The base fabric is then installed on a needle loom...Batt fibers are applied to the top side or paper contacting surface...The fibers are anchored to the base fabric assembly by one or more needling operations.”).

173. Hawes next describes that “[t]he fabric 1510 is folded on itself as shown and then seamed in a manner as taught in the '176 patent.” EX1004, 11:46-49. Hawes describes this process only briefly, perhaps because it is explained at

much greater length in Yook '176. “Folded on itself” refers to Yook '176’s description that “[t]he endless base fabric layer is flattened to produce the first and second fabric plies. The plies are joined to one another at their two widthwise edges at the folds produced when the endless base fabric layer is flattened.”

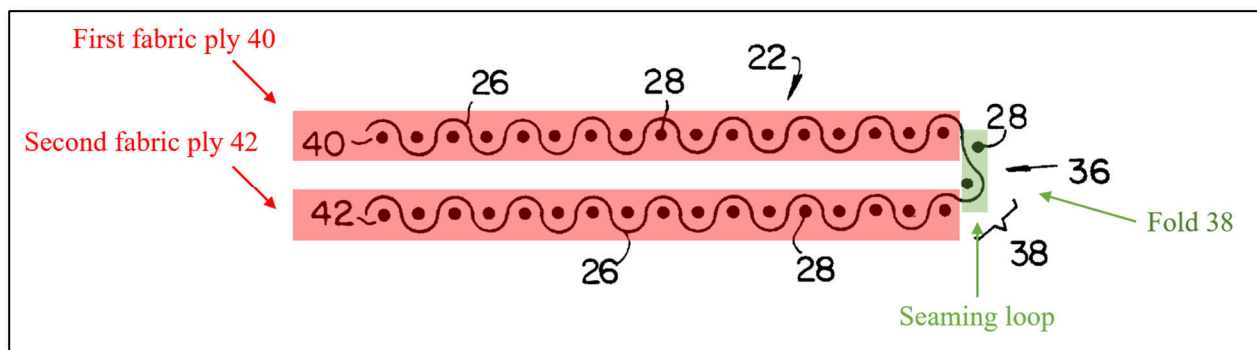
EX1016, 4:61-64. For example, FIG. 5 shows “folds 38” at “the two widthwise edges 36 of the flattened base fabric layer 22.” EX1016, 7:13-16.



Yook '176, FIG. 5

174. This is simply the well-known procedure for forming a two-layer fabric by folding (e.g., as described by Ryan, Crook, Zehle, Sudre, and other references), applied to a spiral-wound endless base fabric. EX1007, [0029], FIG. 1; EX1018, 5:38-48, 5:63-65, 7:36-41; EX1019, 4:1-6, 6:1-11; EX1020, 6:7-29, FIGS. 7A-7C; EX1013, [0025]-[0027], FIG. 3.

175. “[S]eamed in a manner as taught in the ’176 patent” refers to Yook ’176’s description that “[a]t least one crosswise yarn [] is removed from the fold at each widthwise edge of the flattened endless base fabric layer. This provides unbound sections . . . [that] are used as seaming loops.” EX1016, 4:61-5:4. Yook ’176 provides a “cross-sectional view” showing the fabric plies 40, 42 “joined...by unbound sections of lengthwise yarns 26 [that] form seaming loops.” EX1016, 7:17-27.

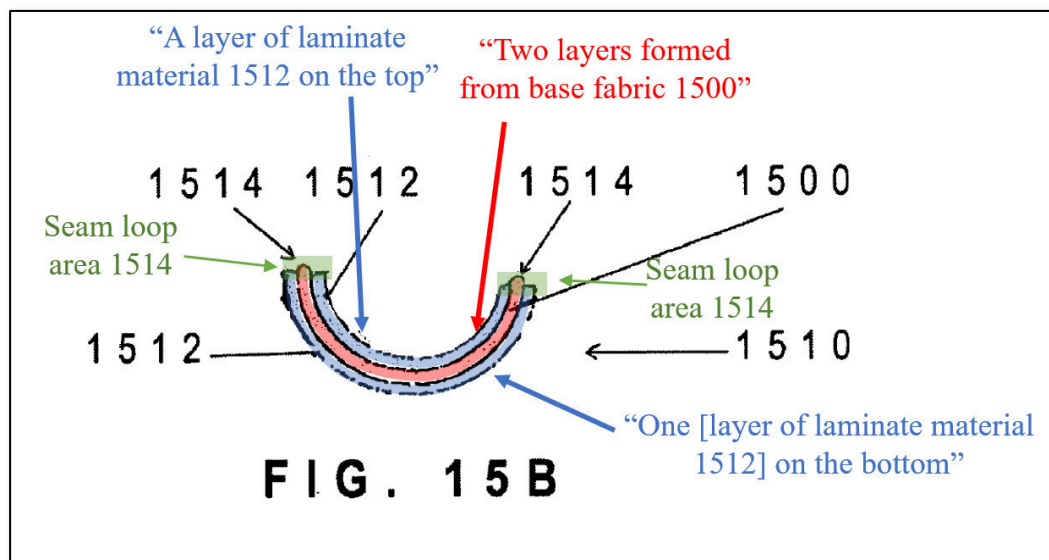


Yook ’176, FIG. 6

176. Hawes’ fabric has the same structure, except that the laminate material 1512 was added on the outside before folding. Therefore, in Hawes, “the laminate material [is] cut away from the loop area 1514” before folding, to ensure that the underlying yarn is accessible to form seaming loops. EX1004, 11:46-47.

177. As shown in FIG. 15B, “[t]he resulting fabric 1510 would have two layers formed from base fabric 1500 and a layer of laminate material 1512 on the top and one on the bottom.” EX1004, 11:49-52. Seam loops are located at “loop areas 1514” where the fabric 1510 is folded. This is exactly the structure of claim 1

of the '388 Patent, except that the base fabric 1500 is spiral-wound into endless form instead of having terminal ends separated in the machine direction.

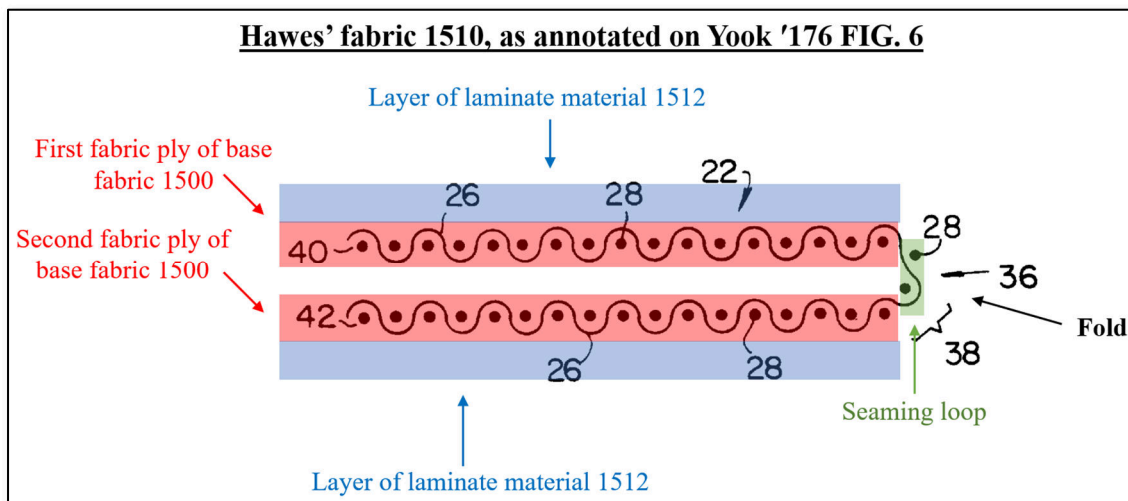


Hawes, FIG. 15B

178. Hawes FIG. 15B may be presented in the above curved form to emphasize that, for on-machine seaming, the opposite seam loop areas 1514 will be brought together and joined with a pintle, such that the fabric will be curved around rolls of a papermaking machine.

179. To clearly illustrate Hawes' fabric 1510, one edge of the fabric is shown below as an adaptation of Yook '176's base fabric layer 22, following Hawes' description that folding and seaming are performed as described in Yook '176. As described by Hawes, the laminate material 1512 has been removed from the right-most fold area, and a seam loop is positioned at the fold. EX1004, 11:46-47. Respective layers of the laminate material 1512 are at the top and bottom, as

described by Hawes. EX1004, 11:49-52. A second edge, opposite to the illustrated edge along the machine direction (left-right), would have the same structure.

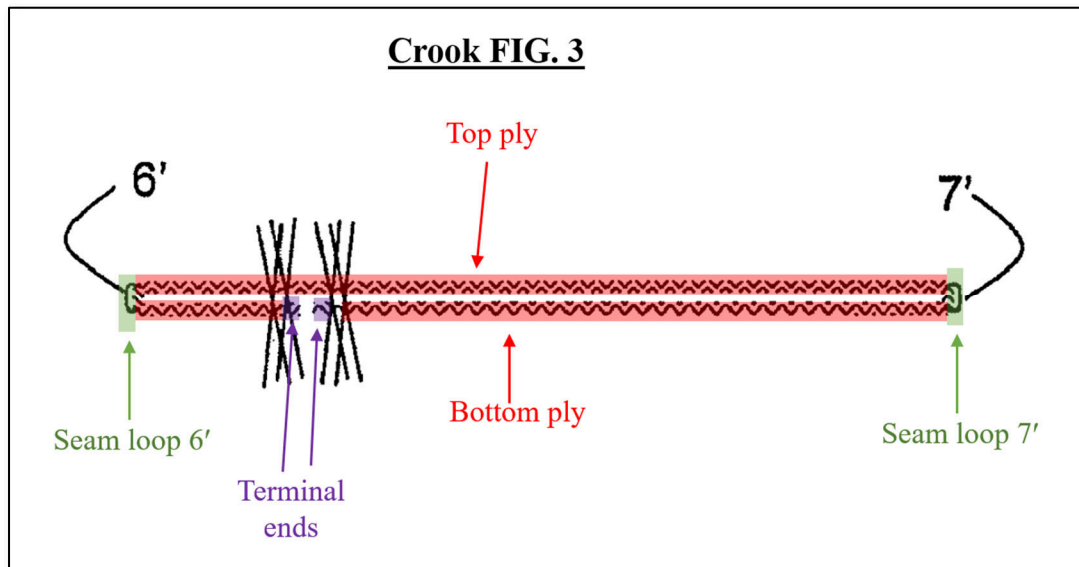


Hawes' fabric 1510, as annotated on Yook '176 FIG. 6

2. Crook

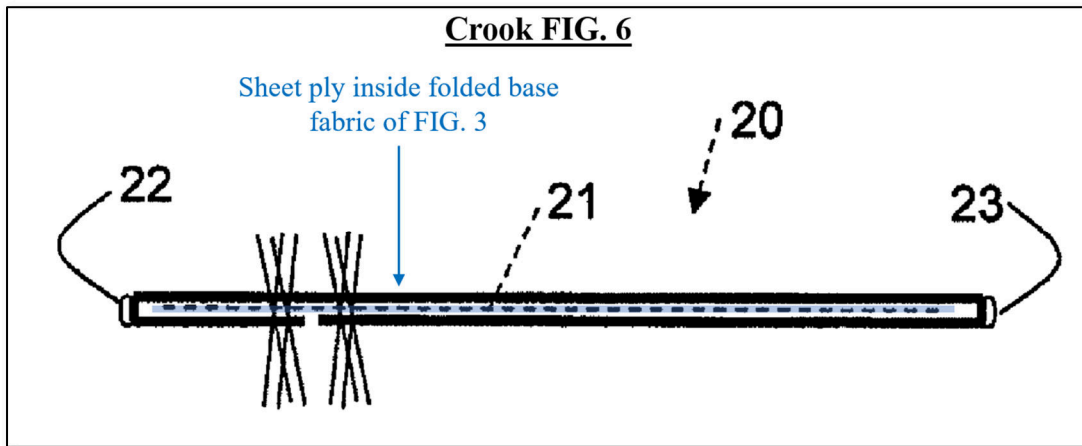
180. Instead of being spiral-wound in endless form like Hawes' base fabric 1500, Crook's fabric (like the '388 Patent's fabric and Ryan's fabric) has two terminal ends that are brought together by folding the fabric. Crook describes "a belt for a paper making machine that includes a flat woven material having a top side surface and a bottom side surface and two terminal ends separated in a machine direction. Folds formed in the flat woven material are separated in the machine direction, so that the two terminal ends are located under the bottom side surface. Seam loops are located at the folds. The two terminal ends [] are arranged adjacent each other and overlap each other." EX1005, 2:10-18. Crook's belt

(which is “for a paper making machine” and is therefore PMC) is shown in Figure 3, reproduced and annotated below. EX1005, 1:44-45.



Crook, FIG. 3

181. Crook also describes attaching sheet plies to this base fabric. For example, Crook FIG. 6 illustrates the base fabric with a sheet ply (an “insert 21”, shown in blue) *inside* the folded layers, as opposed to *outside* as recited in claim 1 of the ’388 Patent. EX1005, 6:16-34. This embodiment was cited during prosecution. EX1002, 61. In response, Applicant argued that Crook discloses a “woven insert” as opposed to a woven ply on the outside. EX1002, 49. Applicant argued that, in Crook, “[o]nly batt layers are considered for placement on the outside of the belt.” *Id.* Crook was overcome on this basis. EX1002, 38.



182. Based on the presence of this insert 21 in conjunction with Crook's base fabric having seam loops and terminal ends separated in the machine direction, Crook's PMC has essentially the same configuration as claim 1 of the '388 Patent, except that it is missing that "all of said sheet plies are disposed *outside* said folded layers." But, as I discuss below, it is my opinion that it would have been obvious for a POSITA to provide sheet plies disposed outside Crook's folded layers, for example, in view of Hawes and knowledge about the benefits of lamination in the art.

183. In addition to the FIG. 6 embodiment which includes an inner sheet ply, Crook also describes laminates and multi-component PMCs that are based on the foregoing flat-woven structure. For example, Crook discloses that "the folded fabric belt or belt base formed in accordance with the features of the present invention can be coupled to, e.g., laminated with, another belt, such as a single ply fabric belt or belt base." EX1005, 6:58-62. Crook further describes (i) the above-

discussed use of an “insert 21” (such as a “polyurethane composite nonwoven membrane... [a] non-folded flat woven fabric, [or a] knit material) between the folds of the folded fabric, (ii) “a non-woven parallel array of MD yarns [] laminated onto the bottom side of the flat woven seam base,” and (iii) that “other fabric laminates may be used without departing from the spirit and scope of the invention.” EX1005, 2:32-34, 6:15-57. Therefore, Crook makes clear that a broad range of layers, fabrics, and the like can be attached on and/or in Crook’s base fabric, including laminate belt structures.

3. Hawes-Crook combination

184. Hawes discloses all elements of claim 1, except that Hawes’ fabric lacks terminal ends separated in the machine direction. Hawes’ fabric, for example, is based on, and includes, a flat-woven fabric strip. EX1004, 2:64-67. As discussed in the claim analysis below, in my opinion, it would have been obvious to substitute Crook’s flat-woven fabric, with terminal ends, for Hawes’ base fabric, thereby arriving at the fabric of claim 1. This modification would have represented a predictable, simple substitution of a first type of base fabric for a second type of base fabric that was widely recognized as being substitutable with the first base fabric.

4. Analysis of Claims

185. It is my opinion that claims 1-15 are unpatentable as obvious over Hawes and Crook.

(a) *Claim 1*

[Ipre]: A fabric for a machine for producing a fiber web, comprising:

186. Hawes and Crook each disclose a “fabric for a machine for producing a fiber web.” EX1004, 1:9-19, 1:44-49; EX1005, 1:7-20. Hawes describes that “[d]uring the papermaking process, a cellulosic *fibrous web is formed* by depositing a fibrous slurry, that is, an aqueous dispersion of cellulose fibers, *onto a moving forming fabric* in the forming section of a paper machine...The cellulosic fibrous web passes through the press nips supported by a press fabric.” EX1004, 1:9-. A POSITA would have understood this process as “producing a fiber web.” Then, relating this fiber web production to the disclosed fabrics, Hawes describes that “[t]he present invention relates primarily to the fabrics used in the press section, generally known as *press fabrics*, but it may also find application in the fabrics used in the forming and dryer sections.” EX1004, 1:44-49. This is similar to the ’388 Patent’s description that “[t]he fabric according to the invention can be used as a press fabric, especially as a press felt. But other uses, for example as a forming fabric are also possible.” EX1001, 2:56-58.

187. Crook similarly describes “a seamable belt base for a paper making machine” and that “[t]he base can be needled and finished in any conventional matter [sic] in order to form a normal press seam fabric.” EX1005, 1:7-20. Crook also explicitly mentions a “web,” noting that a “batt layer 10 can be needled onto the seamed base structure to cover seam 9 so as to prevent disadvantageous marking of the web due to a variance in the caliper at seam 9.” EX1005, 6:3-6.

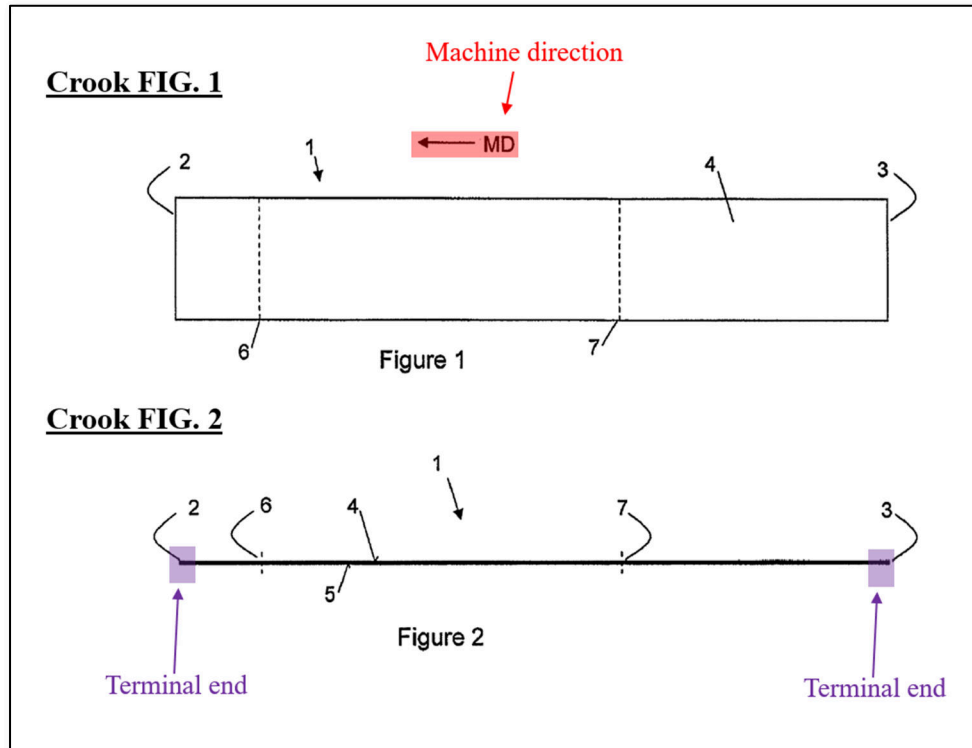
[1a]: a flat woven base material having a top side and a bottom side, two terminal ends separated from one another in a machine direction;

188. As I discussed above, because it is formed in a spiral-winding process, Hawes’ base fabric is an endless fabric that lacks the terminal ends, separated from each other in a machine direction, of claim 1. But Hawes describes—and a POSITA would have understood—that the “flat-woven with terminal ends” (Crook) and “endless” (Hawes) approaches were common alternatives to one another. On this point, Hawes teaches that “woven fabrics...may be **woven endless, or flat woven and subsequently rendered into endless form with a seam.**” EX1004, 2:13-15. Following this teaching, and as I further discuss below, in my opinion it would have been obvious for a POSITA to substitute Hawes’ base fabric with Crook’s base fabric.

189. That is, because endless and non-endless fabrics were widely recognized as substitutes for one another, it is my opinion that it would have been

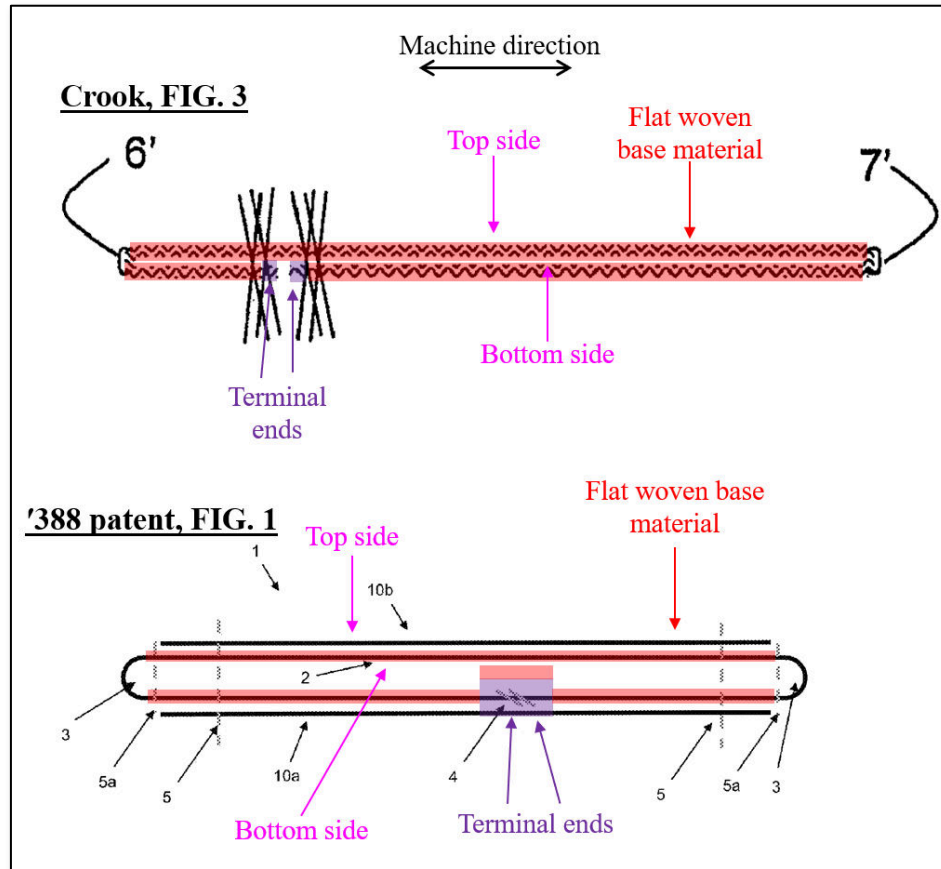
obvious to replace Hawes' endless base fabric with Crook's fabric having terminal ends separated from one another in the machine direction.

190. For clarity, I note here that Crook discloses claim 1's base structure using words almost identical to that of claim 1. Specifically, Crook discloses "a flat woven material having a top side surface and a bottom side surface and two terminal ends separated in a machine direction," whereas claim 1 recites "a flat woven base material having a top side and a bottom side, two terminal ends separated from one another in a machine direction." EX1005, 2:10-13. The machine direction (MD, left-right) is labeled in FIG. 1, and the terminal ends 2, 3 are labeled in FIG. 2. EX1005, 3:61-65.



Crook, FIGS. 1 and 2

191. As shown below, when this base fabric is folded, its structure matches that of the '388 Patent and satisfies [1a].



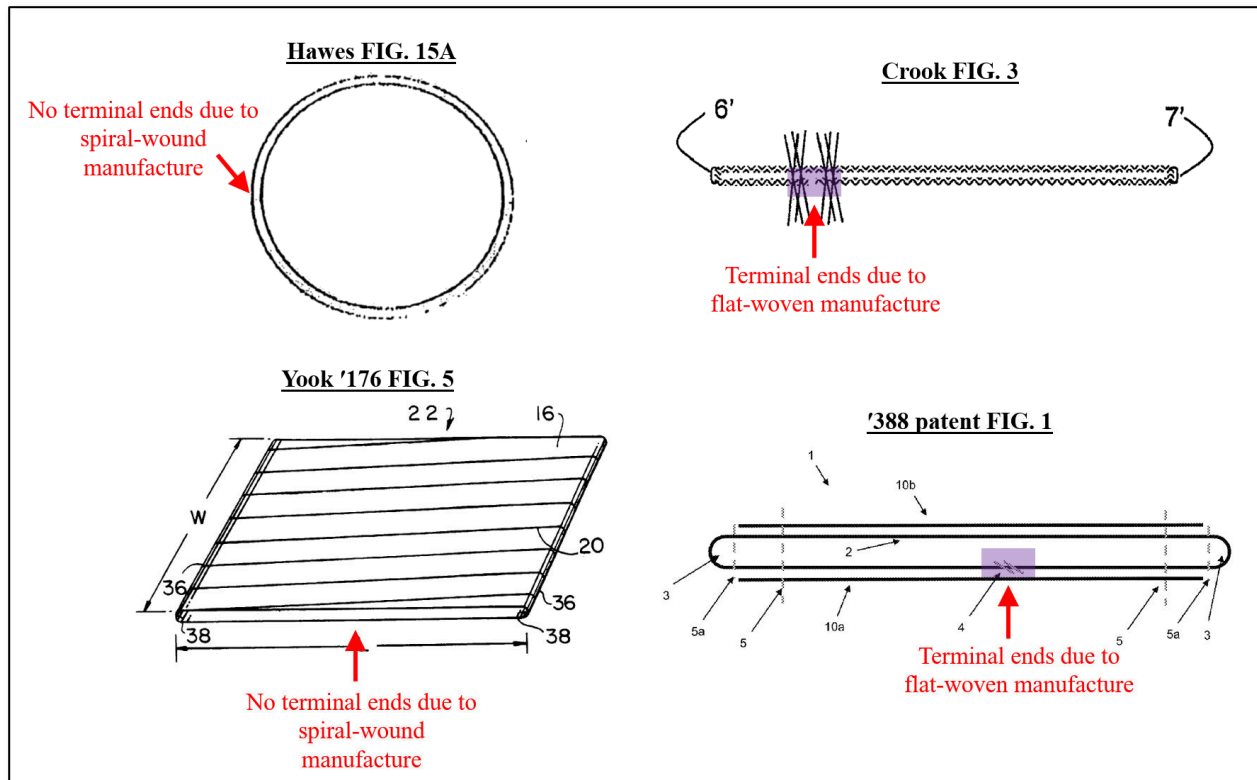
Top: Crook, FIG. 3
Bottom: '388 Patent, FIG. 1

192. A POSITA would have known that Crook's base structure and Hawes' base structure were valid, substitutable alternatives to one another. Specifically, Hawes' base fabric and Crook's base fabric represented two well-known and similar alternatives for providing base fabrics for papermaking fabrics. Substituting Crook's fabric for Hawes' would have involved nothing more than the

simple substitution of one of these base structures for the other, and the result of the substitution would have been predictable.

193. The difference between Hawes' base fabric (as represented by Hawes and Yook '176) and Crook's base fabric is shown below. EX1004, FIG. 15A; EX1016, FIG. 5; EX1005, FIG. 3. Hawes' fabric forms an endless closed loop, *without* terminal ends separated in the machine direction, because of its spiral-wound manufacture as discussed in §§VII.B.1 and V.3. The spiral winding directly results in two layers that are connected in a closed loop, without terminal ends separated in the machine direction.⁵ By contrast, because Crook's base fabric results from folding ends of a flat-woven fabric without spiral-winding, Crook's fabric, like the '388 Patent's, *has* terminal ends. These terminal ends are joined to one another to form a closed loop.

⁵ Hawes' fabric has terminal ends in the cross-machine direction, but these terminal ends are not "separated in the machine direction."



Top-left: Hawes, FIG. 15A;
Bottom-left: Yook '176, FIG. 5;
Top-right: Crook, FIG. 3;
Bottom-right: '388 Patent FIG. 1

194. The structures are otherwise identical to one another with respect to key fabric characteristics, e.g., those discussed by the '388 Patent. For example, Hawes' fabric is multiaxial whereas Crook's is not; however, this distinction is not discussed by the '388 Patent and would not have introduced any technical challenges for replacing Hawes' fabric with Crook's.

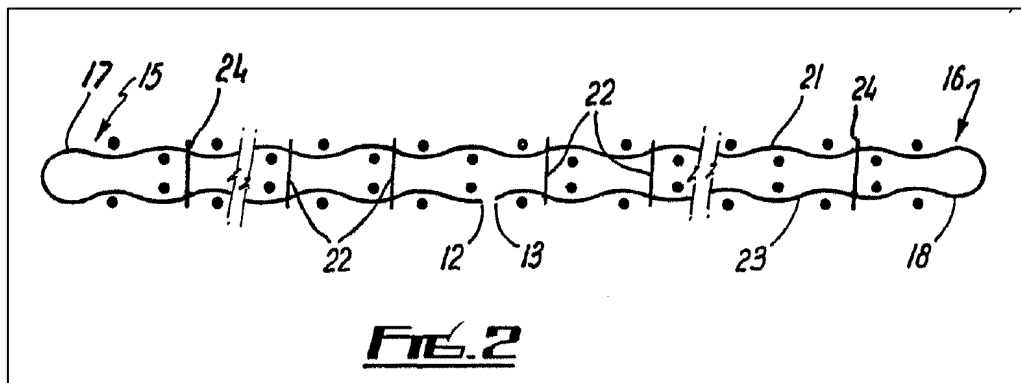
195. A POSITA would have understood that endless, without terminal ends, and flat-woven with terminal ends were common alternatives to one another. Hawes itself describes that "[w]oven fabrics take many different forms. For

example, they may be woven endless, or flat woven and subsequently rendered into endless form with a seam.” EX1004, 2:13-15 Hawes also discusses the “spiral winding technique” as a “recent” development “[i]n response to [a] need to produce press fabrics in a variety of lengths and widths more quickly,” indicating that other techniques were known. EX1004, 2:51-56.

196. A POSITA would have been well aware of Crook’s technique as one such valid alternative. In fact, the base fabric structure of Crooks and the ’388 Patent was typical. This is made clear from the Background of the ’388 Patent itself, which admits that “is known, for example from commonly assigned U.S. Pat. No. 8,043,477 B2 [Crook] and its counterpart WO 2009/106182 to use a simple, flat woven material and to fold it in order to produce a two ply base structure with seam loops for a seamable fabric.” EX1001, 1:41-45.

197. The prior art is replete with discussion of folded, flat-woven base fabrics having terminal ends separated in the machine direction. In addition to Crook, this structure is also found, for example, in Sudre, which discusses two alternatives: “[t]here are two basic methods whereby papermaker’s fabrics are produced, either the fabric is woven ‘flat’, and the free ends joined, or the fabric is woven ‘endless.’” EX1014, 1:6-9. “Woven ‘flat’” is Crook’s configuration, and “woven ‘endless’” is like Hawes’ configuration in that both lack terminal ends separated in the machine direction. Sudre’s illustrated structure, shown below, is

identical to that of Crook and the '388 Patent. Note, for example, the illustration of “[seam] loops 17, 18” at the “fold regions 15, 16,” the “two-ply structure” defined by folding, and the “free ends 12, 13” that are “brought into substantial abutment.” EX1014, 3:18-4:1.

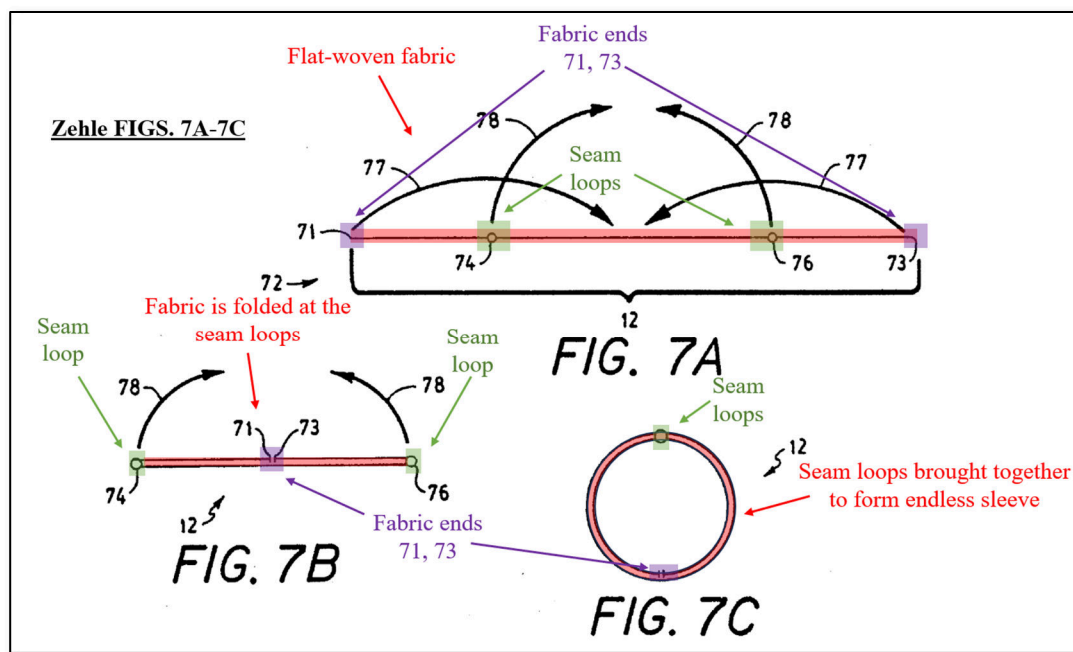


Sudre, FIG. 2

198. Similar or identical configurations are also disclosed, for example, in Hawes '402 (e.g., “the fabric is folded in the machine direction (‘MD’) upon itself...so that the common MD yarns form seaming loops on both widthwise edges”), Ryan (*applied in* Ground 1), Sarrazin (e.g., “The fabric is folded back on itself in the manner of a hem...Both ends of the fabric are made similar and when mated together, the loops forming yarns define a channel which receives the pin or pintle wire”), McGill (e.g., “The protruding sections 3, 4 are folded around the bottom side of the membrane structure so that the ends of the protruding sections 3, 4...The areas of the intermediate structure that have the seam loops are folded in the direction indicated by the arrows 8, 9, thus interdigitating and bringing the seam loops together”), and Zehle. EX1007, [0029], FIG. 1; EX1018, 5:38-65,

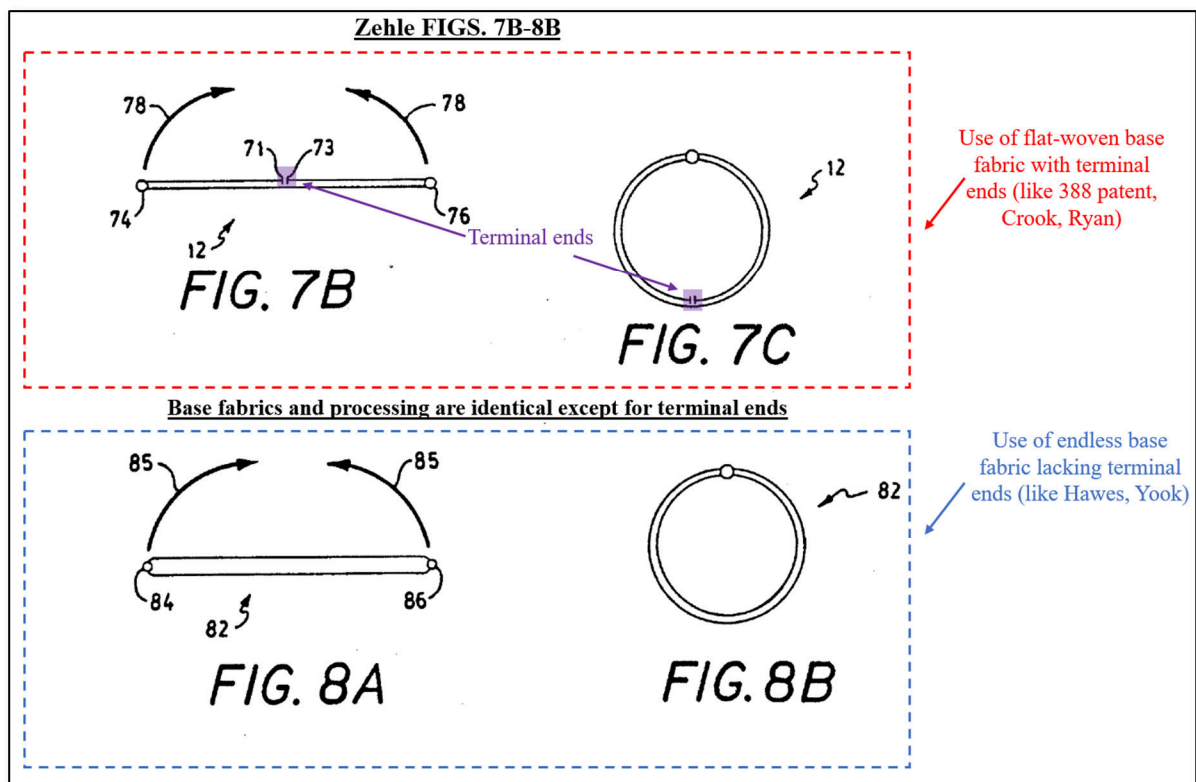
7:36-41; EX1019, 4:1-6, 6:1-11; EX1020, 6:7-29, FIGS. 7A-7C; EX1013, [0025], FIG. 3.

199. Zehle's clear description (relied on below in Grounds 3A and 3B) provides a useful illustration of the extent to which the art recognized Hawes' and Crook's base fabrics as exchangeable with one another. Zehle teaches a flat-woven, folded base fabric with terminal ends, similar to the base fabrics of Ryan, Crook, the '388 Patent, and other art noted above. For example, Zehle's FIGS. 7A-7C illustrate folding a "flat base fabric 72" with terminal ends 71 and 73. EX1020, 6:10-21. Zehle refers to the terminal ends as the "ends of the fabric." *Id.*



200. Immediately after describing the FIGS. 7A-7C flat-woven fabric (with terminal ends) discussed above, Zehle describes that "[a]lternatively, the base

fabric assembly may be formed from, as shown in FIGS. 8A-8B, an endless base fabric.” EX1020, 6:30-32. Zehle then illustrates how the first base fabric (which has terminal ends, like Crook’s) and the second base fabric (which is endless, similar to Hawes’) can be used to obtain essentially the same structure, differing only in that one includes terminal ends separated in the machine direction and one lacks terminal ends separated in the machine direction. EX1020, 6:30-40, FIGS. 7B-8B.



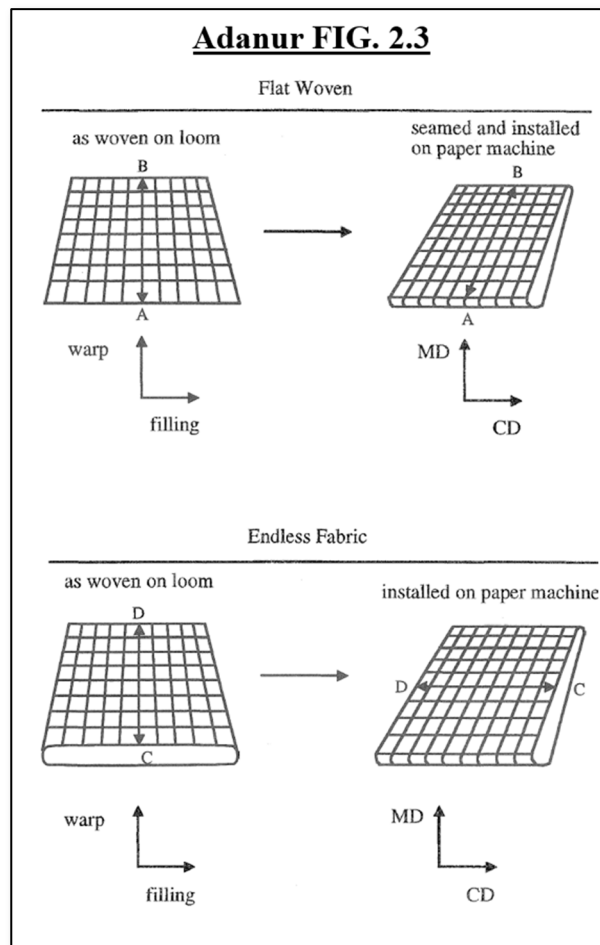
Zehle, FIGS. 7B-8B

201. Zehle makes clear that these two types of base fabric – the type disclosed by Hawes and the type disclosed by Crook – were being used in the same way, by the same POSITA, to obtain nearly identical end products. It is my

opinion, based on Zehle and the other references cited in this section, that it would have been obvious to substitute one for the other as proposed in this ground.

202. Similarly, in describing the “Manufacturing of Press Fabrics,” Adanur describes that “[b]ase fabrics...can be *woven as a flat or endless belt*,” suggesting that these two approaches were known substitutes for one another. EX1011, 165.

Figure 2.3 of Adanur illustrates the terminal end-including and endless configurations as straightforward alternatives. EX1011, 39.



Adanur, FIG. 2.3

203. And, the same inventors were known to work using both flat-woven fabrics having terminal ends separated in the machine direction, and endless fabrics. For example, Hawes '402, which shares inventor John M. Hawes with the Hawes reference applied in this declaration, describes a “flat woven piece of fabric” that is “folded upon itself...to form an endless loop” and “to form seaming loops,” after which the “two free ends” are “joined,” a configuration similar or identical to that of the '388 Patent and Crook. EX1018, 5:38-65, 7:36-47. The same inventor also, as reflected in Hawes, used endless, spiral-wound fabrics as base fabrics. This demonstrates that POSITAs in this field were aware of both types of base fabrics and able to apply either one as desired, rather than being limited to the use of one or the other.

204. In view of the above discussion, the substitution of Crook's well-known base fabric with terminal ends for Hawes' endless base fabric would have amounted to a simple substitution of one known structure for another. More concretely, the manufacture of Hawes' FIG. 15B fabric begins with “an endless single layer multiaxial base fabric 1500 [that] can be created *in any manner* heretofore discussed.” EX1004, 11:32-35. In my opinion, it would have been obvious to a POSITA to instead start with a closed loop formed by Crook's flat-woven fabric, e.g., with the terminal ends joined to one another. EX1005, 5:6-15. Indeed, although Crook's flat-woven fabric is not multiaxial, it was “heretofore

discussed” in Hawes: Hawes describes that woven fabrics in general “may be woven endless, or flat woven and subsequently rendered into endless form with a seam.” EX1004, 2:13-15. The substitution of Crook’s base fabric represents only a small departure from Hawes’ explicit description of FIG. 15B and is well within the bounds of fabrics contemplated by Hawes.

205. I am advised that subject matter is likely to have been obvious if the claimed subject matter does not involve more than the simple substitution of one known element for another. It is my opinion that the substitution of Crook’s fabric for Hawes’ is the simple substitution of one known element for another. The proposed modification is merely substituting a fabric that is looped by joining its opposite terminal ends, for a fabric that is manufactured already in a loop form, but which otherwise is identical in its key attributes. As a POSITA would have been aware, there are multiple ways to form a fabric, including Crook’s end-joining approach and Hawes’ spiral-wound approach. The resulting fabrics, however, look and operate fundamentally the same, and a POSITA would have had no technical difficulties in substituting one for another.

206. In my opinion, this substitution would have been achievable by a POSITA with a reasonable expectation of success. To realize the substitution (that is, obtain Hawes FIG. 15B fabric in which the base fabric 1500 is replaced by Crook’s base fabric), a POSITA would have used Hawes’ disclosed method of

“needling” to attach Hawes’ laminate material 1512 to Crook’s base fabric.

Specifically, Hawes describes that the “laminate material 1512” is “needl[ed]” to the “outside of base fabric 1500” on a “needle loom.” EX1004, 11:40-47. As I explained in §VII.A.4(a), “needling” refers to a needle-punching process in which barbed needles would be pushed through the laminate material and the base fabric to attach them together, for example, using batt. EX1011, 160-166, 169 (FIG.

3.21). Needling can be applied to many combinations of materials and is not reliant on any particular weave structure—or even a woven structure at all—to effectively attach materials to one another. Indeed, needling was conventionally used for attachment of batt layers and for attaching fabrics to one another in laminated fabrics. For example, Hawes describes that, generally, “woven base fabrics may be laminated by placing one base fabric within the endless loop formed by another, and by needling a staple fiber batting through both base fabrics to join them to one another. EX1004, 2:4-6, 2:35-38, 3:36-43; 6:31-34. Adanur describes that “[t]he process in which the batt is locked to the base fabric is called needling.” EX1011, 160. And Crook itself describes that “a batt layer can be needled onto at least one of the top side surface and a surface comprising the terminal ends,” where the batt can also extend into a sheet ply. EX1005, 2:42-44, 6:31-33.

207. So Crook and Hawes *already* describe using needling to attach material to their base fabrics. The needling process by which the laminate material

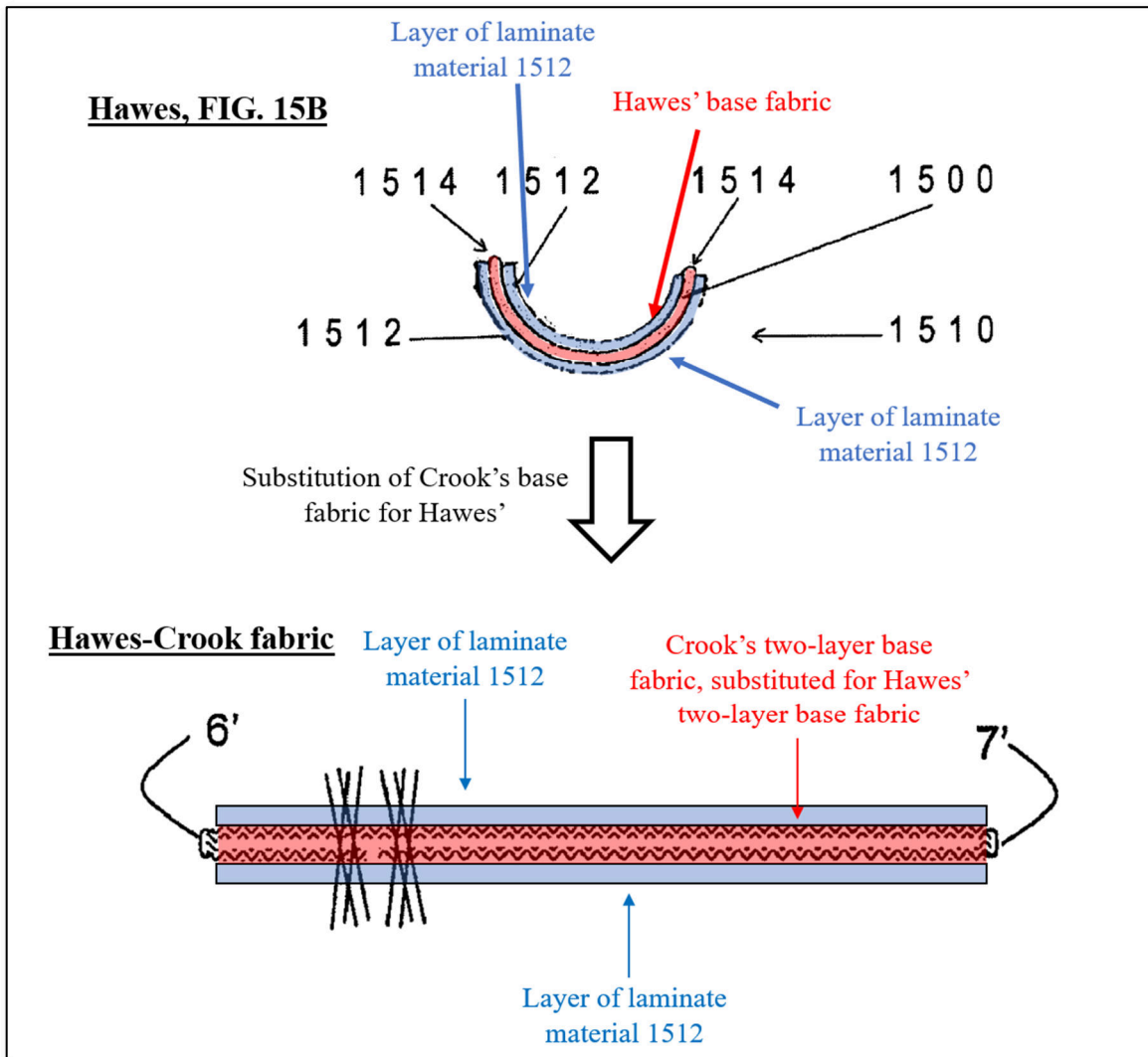
1512 is attached to Hawes' base fabric 1500 could equally have been applied to Crook's base fabric without a substantive difference except for the minor change in base structure. And the base structure of Crook, incorporated into the modified fabric, is already described as receiving needling, such that this modification also does not represent a significant departure from Crook's teachings.

208. In addition, the art recognized advantages provided by Crook's approach, and it is my opinion that it would have been obvious for a POSITA to pursue these advantages by incorporating Crook's base fabric. EX1014, 6:11-17; EX1001, 1:45-49. These advantages included manufacturing simplicity and efficiency. Sudre describes that Crook's configuration is "simple" because "in the case of a flat-woven structure requisite lengths of base fabric woven in any desired weave pattern[sic] may be cut from a stock supply thereof, and a papermaker's fabric meeting the particular requirements of its intended end use as regards performance characteristics can be produced from that base fabric." EX1014, 6:11-17. Similarly, the Background of the '388 Patent acknowledges that the advantages of Crook's configuration were known, stating that "[t]he use of a flat woven material is advantageous, since it can easily be produced on a comparably simple and cheap loom and the production time is much faster." EX1001, 1:45-49.

209. It is my opinion that, in order to improve the simplicity and efficiency of manufacture, and as a matter of simple substitution of one known alternative for

another, it would have been obvious for a POSITA to use Crook's base fabric, having terminal ends separated in the machine direction, instead of Hawes' endless fabric. The resulting "Hawes-Crook" fabric includes Crook's flat woven base material, which, as described by Crook, is "a flat woven material having a top side surface and a bottom side surface and two terminal ends separated in a machine direction," satisfying [1a] almost verbatim. EX1005, 2:10-13.

210. For clarity of illustration, the Hawes-Crook fabric is shown below as an adaptation of Crook FIG. 3, with Hawes' two layers of laminate material 1512 attached on the top and bottom.



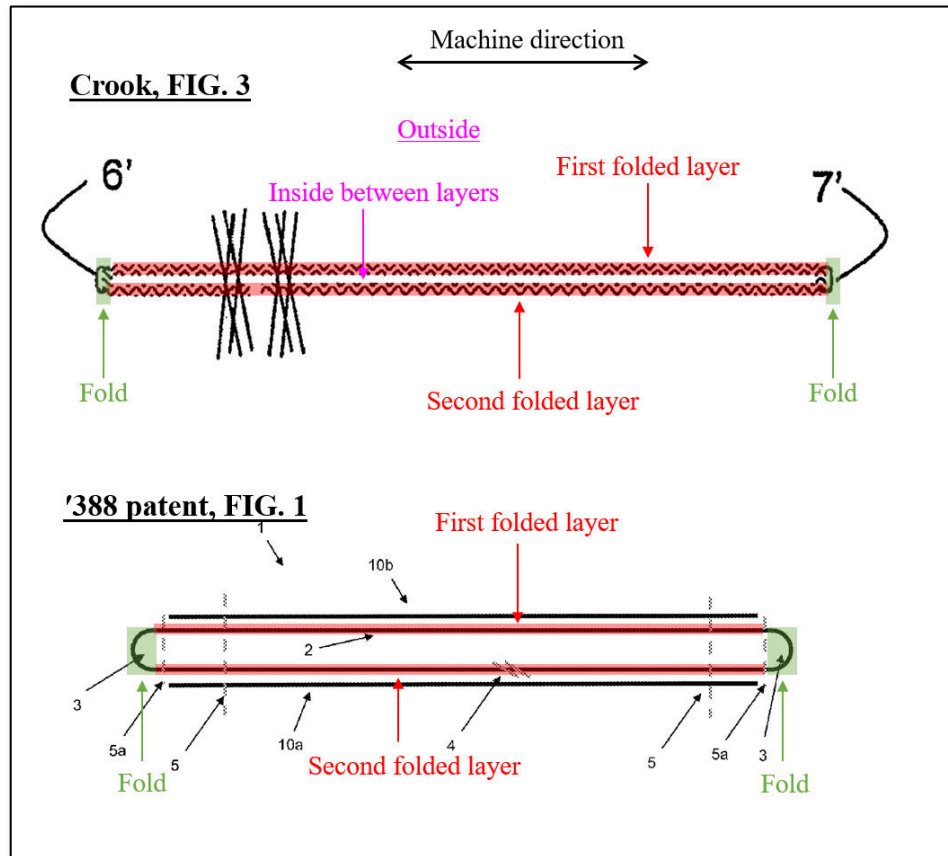
Top: Hawes, FIG. 15B

Bottom: Hawes-Crook fabric, adapted from Crook FIG. 3

[1b]: said flat woven base material being folded in two folded layers with folds being separated from one another in the machine direction and defining an inside between the two folded layers and an outside;

211. Crook's base structure, which is included in the Hawes-Crook fabric, is "folded over onto itself" to form two folded layers. EX1005, 4:38-39. "[F]old lines 6 and 7" are separated from one another in the machine direction and define

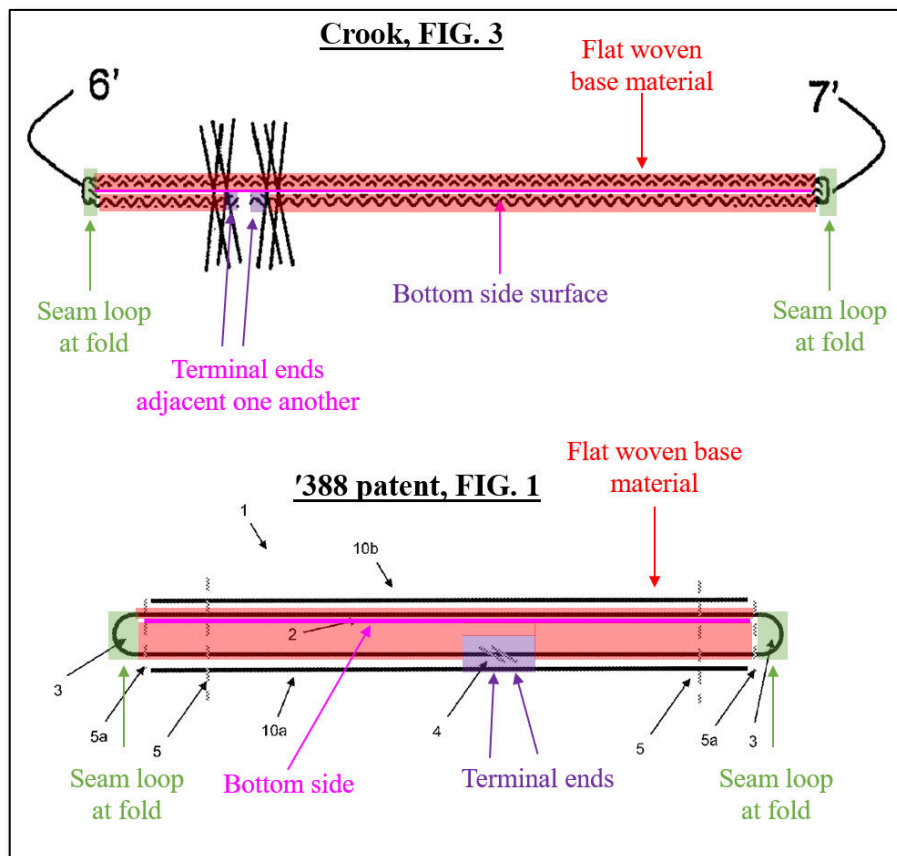
an inside (e.g., between Crook's two layers) and an outside (e.g., above Crook's upper layer and below Crook's lower layer). EX1005, 4:38-48, FIGS. 2-3. The presence of the "insert 21" in Crook FIG. 6 demonstrates the presence of the "inside" between Crook's two layers.



Top: Crook, FIG. 3
Bottom: '388 Patent, FIG. 1

[1c]: said two terminal ends being located under the bottom side surface and said two terminal ends being adjacent one another or overlapping one another, and wherein seam loops are located at said folds; and

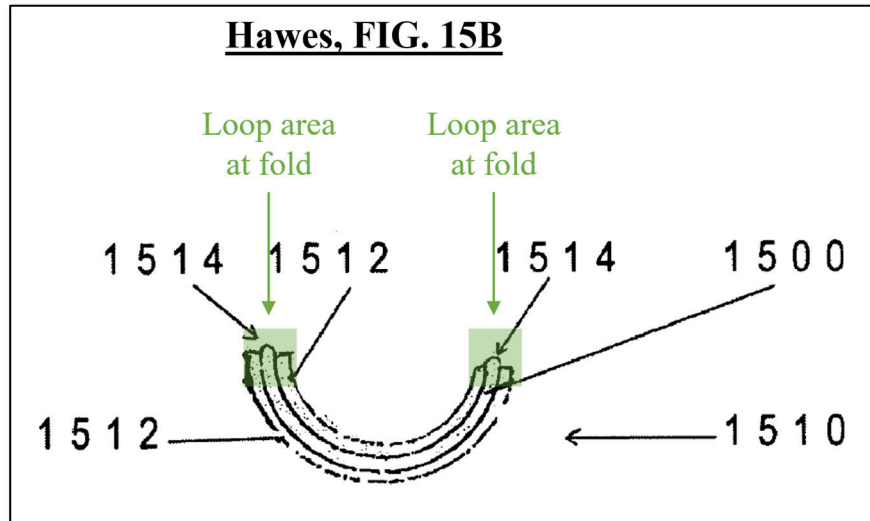
212. Crook's base structure, which is included in the Hawes-Crook fabric, includes "terminal ends 2 and 3" that are "positioned under the bottom side surface and one of adjacent each other and overlapping each other," matching almost verbatim the language of [1c]. EX1005, 3:61-65, 8:19-21 (cl. 13), FIG. 3. Further satisfying [1c], Crook's "seam loop ends 6' and 7'" (green) are "in the folds." EX1005, 4:45-52; 8:25-26, FIG. 3. For example, Crook claims "separating adjacent cross direction threads in the folds to form seam loops." EX1005, 8:25-26 (cl. 13).



Top: Crook, FIG. 3
Bottom: '388 Patent, FIG. 1

213. Hawes' fabric also has seam loops at its folds, as shown below.

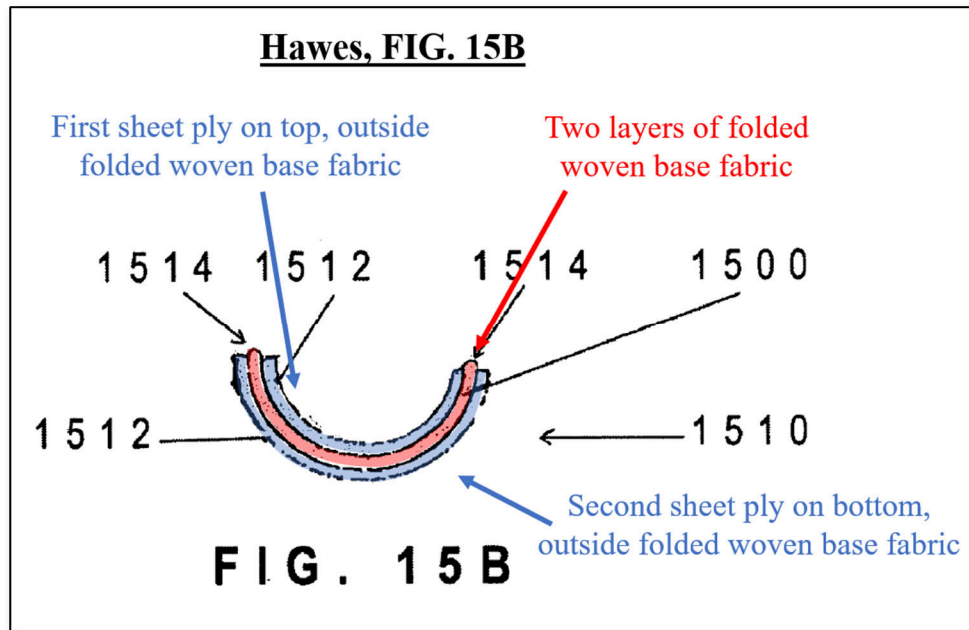
EX1004, 11:46-49.



Hawes, FIG. 15B

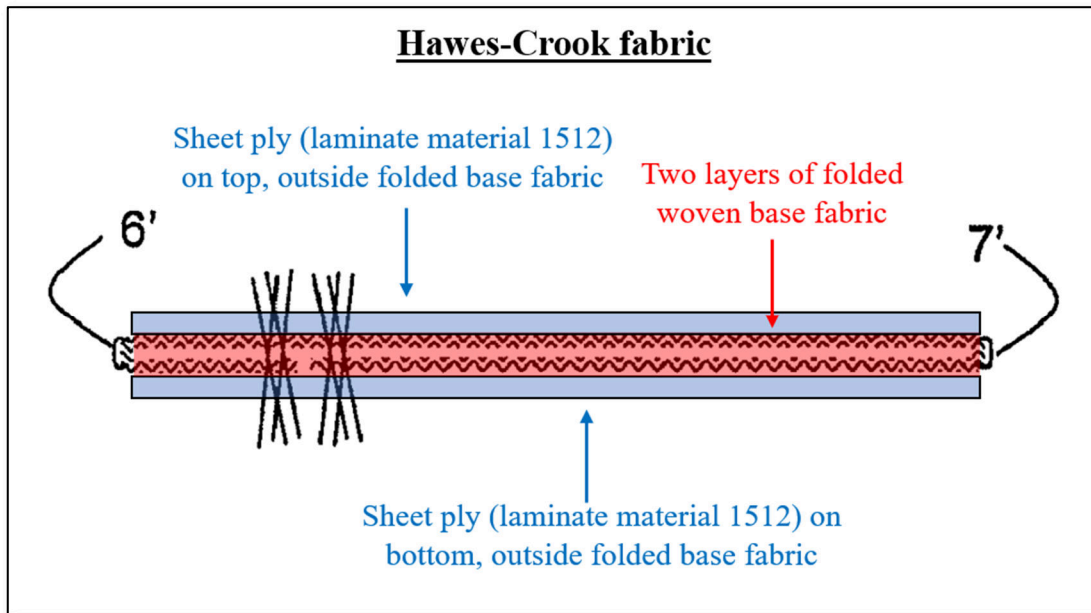
[1d], [1e]: one or more sheet plies, wherein: all of said sheet plies are disposed outside said folded layers; and

214. Hawes discloses one or more sheet plies, where all of the sheet plies are disposed outside the folded layers. EX1004, 11:49-52, FIG. 15B. Hawes' FIG. 15B illustrates a "fabric 1510 [having] two layers formed from base fabric 1500 and ***a layer of laminate material 1512 on the top and one on the bottom.***" EX1004, 11:49-52. The layers of laminate material 1512 (blue) on the top and bottom of the "two layers formed from base fabric 1500" (red) are sheet plies that are "outside" the two-layer structure of the base fabric 1500.



Hawes, FIG. 15B

215. When the folded, flat-woven base structure of Crook is used in place of the endless base fabric of Hawes, the layers of laminate material 1512 are on the top and bottom, respectively, of the two folded layers of Crook's base fabric, as shown below. That is, the sheet plies of the Hawes-Crook fabric (the layers of laminate material 1512) are "outside" the folded layers of the Hawes-Crook fabric.



216. As discussed above for [1a], in my opinion, it would have been obvious for a POSITA to obtain this Hawes-Crook fabric by substituting Crook's base fabric for Hawes' base fabric, and the POSITA would have had a reasonable expectation of success in making the substitution because the two fabric types are well-known alternatives. See §VII.B.4(a).

[1f]: one, some or all of the sheet plies consist of or comprise a woven material or a non-woven component selected from the group consisting of a polymer film, a foam layer, a knitted structure and a warp-knit structure.

217. The laminate material 1512 of Hawes (the "sheet plies") can be a polymer film or a knitted structure, two classes of materials within the scope of [1f]. EX1004, 9:34-50, 11:42-44. Specifically, Hawes describes that "the laminate may be any material suitable for the purpose, such as that described with regard to

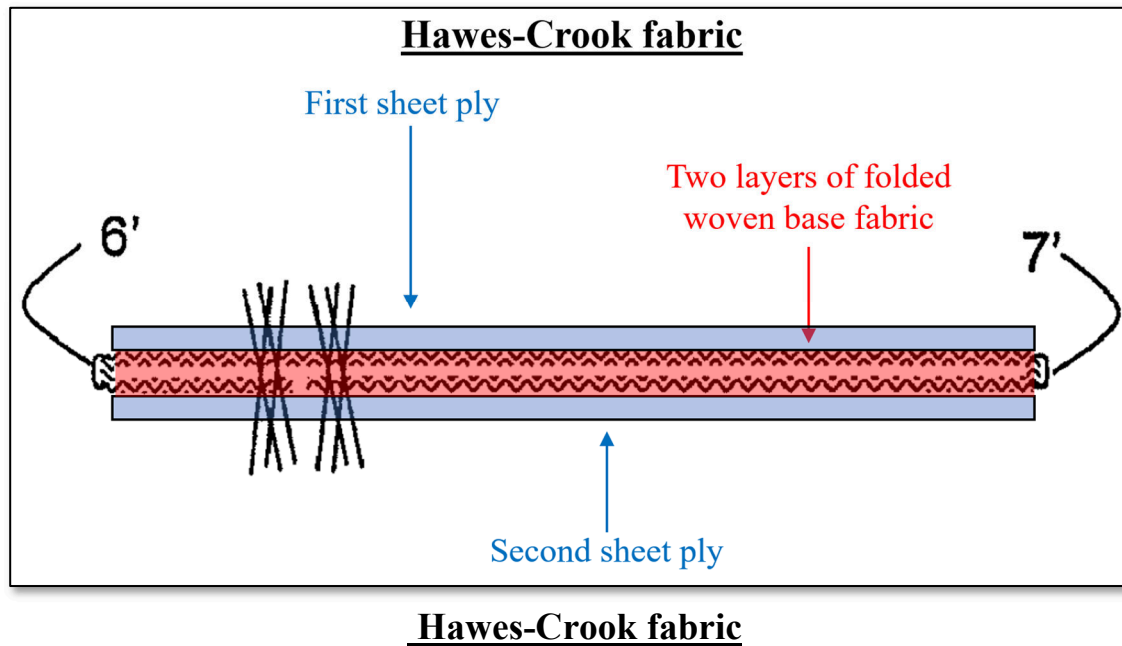
the second embodiment.” EX1004, 11:42-44. The “second embodiment” is the fabric described in reference to FIG. 12, a “multilayer multiaxial fabric” in which a “nonwoven layer 1230” is provided “between the multiaxial layers 1210 and 1220 which serves to create void volume and preserve fabric openness.” EX1004, 9:26-30. In connection to that layer 120 (and, correspondingly, in connection to the laminate material 1512), Hawes describes that the “nonwoven layer may include materials such as *knitted, extruded mesh*” or “a *sheet* or web structure...made of any suitable material, such as *polyamide and polyester resins*.” EX1004, 9:34-50. The “knitted, extruded mesh” is a “knitted structure” as recited in claim 1. “Polyamide” and “polyester” are polymers and, in this context, refer to “polymer film[s],” as in claim 1.

(b) ***Claim 2***

[2]: The fabric according to claim 1, wherein said one or more sheet plies are two or more sheet plies.

218. Hawes’ fabric 1510 includes two sheet plies: “a layer of laminate material 1512 on the top and one on the bottom.” EX1004, 11:49-52. That is, the layer of laminate material “on the top” is a first sheet ply, and the layer of laminate material “on the bottom” is a second sheet ply.

219. As discussed for claim 1, the Hawes-Crook fabric similarly includes two sheet plies (one on the top, and one on the bottom) having the same configuration.



(c) **Claim 3**

[3]: The fabric according to claim 1, configured for producing a fiber web selected from the group consisting of a paper web, a cardboard web, a tissue web and a pulp web.

220. The fabrics of Hawes and Crook are configured for producing paper webs, i.e., fibrous webs that are used to make paper. EX1004, 1:9-24; EX1005, 3:61-65, 6:3-6. For example, Hawes describes that “[d]uring the papermaking process, **a cellulosic fibrous web** is formed by depositing a fibrous slurry, that is, an aqueous dispersion of cellulose fibers, onto a moving forming fabric in the

forming section of a paper machine...The cellulosic fibrous web passes through the press nips supported by a press fabric, or, as is often the case, between two such press fabrics. In the press nips, the cellulosic fibrous web is subjected to compressive forces which squeeze water therefrom, and which adhere the cellulosic fibers in the web to one another *to turn the cellulosic fibrous web into a paper sheet.*” EX1004, 1:9-24. A POSITA would have understood that this description refers to producing a paper web.

221. Further, Hawes describes that “[t]he present invention relates primarily to the fabrics used in the press section, generally known as press fabrics, but it may also find application in the fabrics used in the forming and dryer sections.” EX1004, 1:44-49. This is similar to the ’388 Patent’s description that “[t]he fabric according to the invention can be used as a press fabric, especially as a press felt. But other uses, for example as a forming fabric are also possible.” EX1001, 2:56-58. Thus, to the extent the ’388 Patent’s fabrics satisfy claim 2, Hawes’ fabrics also do.

222. Crook similarly describes a “a base structure for a belt of a paper making machine” and refers to a “web” (e.g., a paper web) that would be produced using the base structure. EX1005, 3:61-65, 6:3-6.

(d) ***Claim 4***

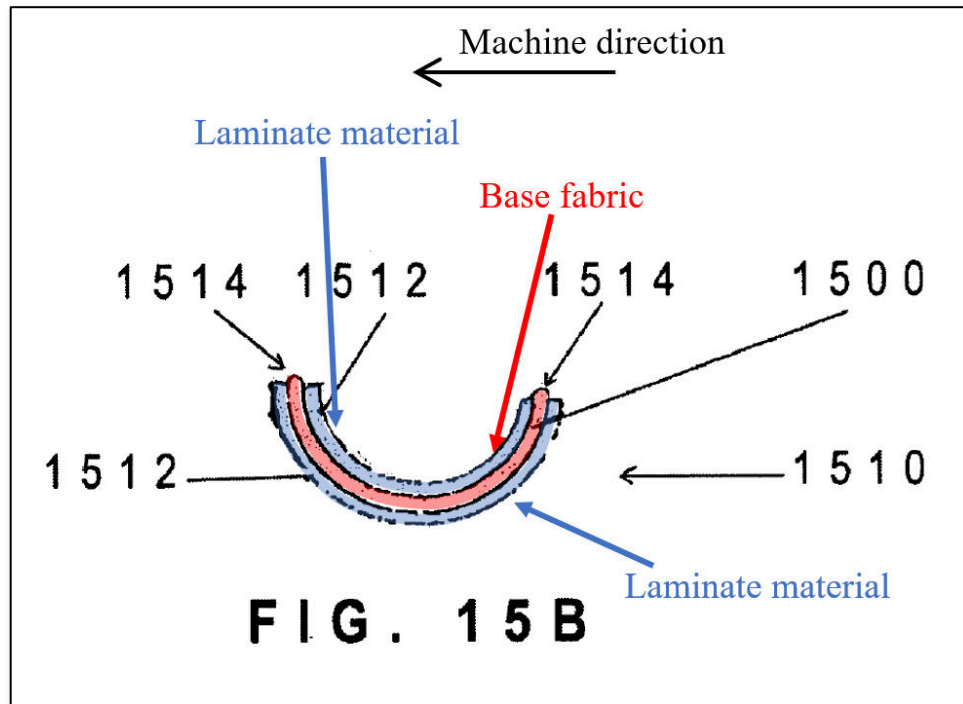
[4]: The fabric according to claim 1, wherein said sheet plies have a width

substantially equal to a width in cross machine direction as the fabric and/or said sheet plies have a length substantially equal to a length in the machine direction as the fabric.

223. It is my opinion that Hawes discloses or renders obvious both the substantially equal width and the substantially equal length elements of claim 4.

224. First, as I noted above for Ground 1 in §VII.A.4(d), the '388 Patent defines “substantially equal” (more specifically, “essentially the same”) broadly. Although the width/length relationships are described as “preferred,” no reasoning is given for this label. EX1001, 1:59-64.

225. With respect to the length, FIG. 15B of Hawes illustrates that the laminate material 1512 (sheet plies) has substantially the same machine-direction length as the base fabric 1500. EX1004, FIG. 15B. In FIG. 15B below, the machine direction is generally left-right; the fabric is shown as curved, but would align with the machine direction when not depicted in this particular curved form. The drawing illustrates the length of the laminate material 1512 as differing less than 10% from the length of the base fabric 1500.

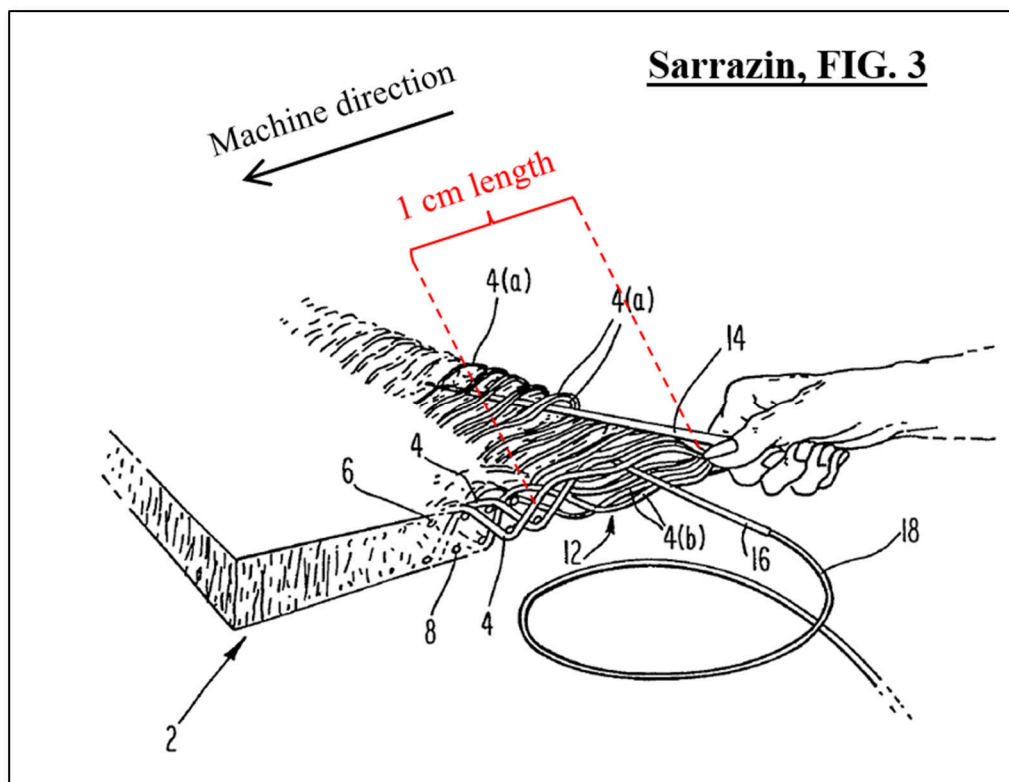


Hawes, FIG. 15B

226. Specifically, the laminate material entirely overlaps the base fabric except for a small portion of laminate material 1512 that is “cut away in the loop area 1514” to permit forming seam loops, as shown in FIG. 15B. EX1004, 11:46-47. Although Hawes does not provide a relative length of this “cut away” section, in my opinion, a POSITA would have understood that it would constitute much less than 10% of the entire machine-direction length of the base fabric.

227. A typical papermaking fabric 1510 would be tens of meters long in the machine direction. EX1011, 77; EX1007, [0037]. Seam loops, by contrast, are centimeter scale structures—they need only be large enough to receive a pin or pintle. Sarrazin provides specific dimensions for “constructing the seam loops.” EX1019, Abstract. These dimensions are directly relevant to the portion of

laminate material 1512 that is “cut away” in the Hawes and Hawes-Yook fabrics, because the length of laminate material 1512 cut away would be the length used for seam loop formation. Sarrazin describes that, to form seam loops, cross-machine direction yarns are removed over a length of about 1 cm in a fold area of a fabric. EX1019, 6:12-25, FIGS. 2-3. This indicates about a 1 cm difference between laminate material 1512 length (or sheet ply length in claim 4) and base fabric 1500 length (or “fabric” length in claim 4).



Sarrazin, FIG. 3

228. This is corroborated by FIGS. 3.16 and 3.17 of Adanur, which illustrate seam loops being similar in scale to several yarn diameters, or several millimeters, based on typical 0.3 - 0.5 mm yarns. *See, e.g.*, EX1005, 4:21-24;

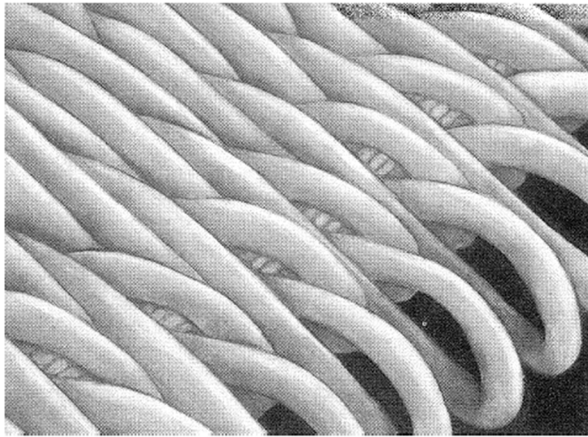


FIGURE 3.16. Pin seam press fabric.

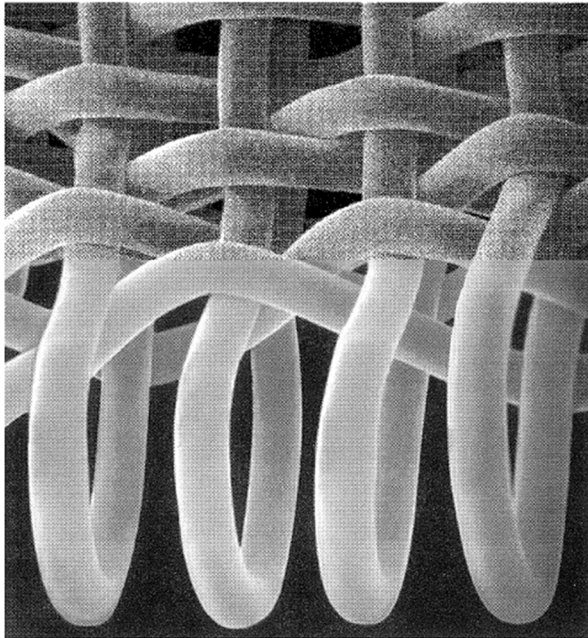


FIGURE 3.17. Woven loop seam fabric.

Adanur, FIGS. 3.16-3.17

229. Using a 1 cm length difference and (at least) a 10 m total length, a POSITA would have understood that the machine-direction length difference between Hawes' laminate material (sheet plies) and base fabric would be *less than* $(1\text{ cm})/(10\text{ m}) = 0.1\%$, well within the 10% limits specified by the '388 Patent.

230. Turning to the cross-machine direction width, it is my opinion that it would have been obvious for a POSITA to provide the laminate material 1512 with a cross-machine direction width substantially matching that of the base fabric 1500. Hawes emphasizes the desirability of having a “smooth” and “uniform” fabric surface in order to form a smooth, uniform paper surface. EX1004, 1:54-58; 3:44-61. Unequal widths would result in “steps” where one of the laminate material 1512 or base fabric 1500 failed to extend. Thus, following Hawes’ guidance, it would have been obvious for a POSITA to have the width of the laminate material match the width of the underlying base fabric, so as to fully cover the base fabric, thereby avoiding forming these “steps” in the fabric surface and improving the surface uniformity.

(e) ***Claims 5, 6***

[5]: The fabric according to claim 1, wherein said woven base material is a one-layer weave.

[6]: The fabric according to claim 5, wherein said woven base material is a plain weave.

231. Each of Hawes and Crook discloses a one-layer plain weave as the woven base material. EX1004, 2:6-9; EX1016, 6:41-48, FIGS. 3, 6; EX1005, 4:8-11, 4:21-24. With respect to “one-layer weave,” Hawes describes that “[t]he base fabrics may be **woven** from monofilament, plied monofilament, multifilament or

plied multifilament yarns, and may be *single-layered*, multi-layered or laminated.” EX1004, 2:6-9. Moreover, Yook ’176 (which Hawes cites for its base fabric 1500 as discussed in §VII.B.1) describes that the fabric strip from which the base fabric 1500 is derived is “interwoven in a *single-layer weave*.” EX1016, 6:41-45. Similarly, Crook describes that “the woven material 1 in the exemplary embodiment is identified as a *single layer woven structure*.” EX1005, 4:8-11.

232. In addition, each of Hawes and Crook discloses that the woven base material is a plain weave. The Yook ’176 fabric that is Hawes’ base fabric 1500 has “a *plain weave*.” EX1016, 6:45-48. This description is reflected in Yook ’176 FIGS. 3 and 6, which illustrate the simple, alternating over/under arrangement that a POSITA would have recognized as a plain weave. EX1016, FIGS. 3, 6; EX1011, 36; EX1025, 6.

233. The Hawes-Crook fabric itself uses Crook’s base fabric as the “woven base material.” Crook describes that “the fabric can be formed with...MD yarns and...the same yarns in the CD direction *using a single layer plain weave*,” satisfying claims 5 and 6. EX1005, 4:21-24.

(f) ***Claims 7, 8***

[7]: *The fabric according to claim 1, wherein said woven material is a one-layer weave.*

[8]: *The fabric according to claim 7, wherein said one-layer weave is a*

plain weave.

234. Claims 7 and 8 further narrow the composition of the “one or more sheet plies” in the case where the sheet plies “consist of or comprise a woven material.” Based on my understanding of the claim language, however, the claims do not require that the sheet plies necessarily include the woven material. That is, sheet plies that “consist of or comprise...a ***non-woven*** component selected from the group consisting of a polymer film, a foam layer, a knitted structure and a warp-knit structure” are also within the scope of claims 7 and 8, as is evident from rewriting claims 7 and 8 in independent form. For example, rewritten in independent form, claim 7 recites:

A fabric for a machine for producing a fiber web, comprising:
a flat woven base material having a top side and a bottom side,
two terminal ends separated from one another in a machine direction;
said flat woven base material being folded in two folded layers
with folds being separated from one another in the machine direction
and defining an inside between the two folded layers and an outside;
said two terminal ends being located under the bottom side
surface and said two terminal ends being adjacent one another or
overlapping one another, and wherein seam loops are located at said
folds; and
one or more sheet plies, wherein:
all of said sheet plies are disposed outside said folded layers; and
one, some or all of the sheet plies consist of or comprise a woven
material or a non-woven component selected from the group consisting
of a polymer film, a foam layer, a knitted structure and a warp-knit
structure,
wherein said woven material is a one-layer weave.

235. Thus, claims 7 and 8 are rendered obvious by Hawes-Crook for the reasons discussed with respect to claim 1 (with the “one or more sheet plies” being composed of the non-woven polymer film or non-woven knitted structure of Hawes’ laminate material 1512), even absent an analysis of whether the Hawes-Crook fabric includes “one or more sheet plies” that “consist of or comprise a woven material.” *See* §VII.B.4(a).

236. Claims 7 and 8 would have *also* been obvious over Hawes-Crook because, in my opinion, it would have been obvious to a POSITA to use at least one ply of one-layer, plain-woven material as the “laminate material 1512,” which Hawes describes can be “any material suitable for the purpose.” EX1004, 11:40-44.

237. Hawes recognizes woven fabrics as suitable for the purpose, describing that “woven base fabrics may be laminated” to one another. EX1004, 2:35-36. Crook similarly describes that a “folded fabric belt or belt base...can be coupled to, e.g., laminated with, another belt, such as a *single ply fabric belt* or belt base...[I]t is understood that the belt or belt base of the invention can be joined with or to other belts or belt bases without departing from the spirit and scope of the invention.” EX1005, 6:57-7:3. And these teachings comport with the widespread recognition in the art that laminated press fabrics composed of multiple base fabrics were advantageous, as discussed at length for Ground 1 at

§VII.A.4(a). It would have been obvious for a POSITA to form the Hawes-Crook fabric with a woven material as the laminate material to obtain this advantageous structure.

238. Moreover, Hawes' laminate material 1512 is joined to the underlying woven base fabric by needling, the same method that the art widely described as being used for laminating multiple woven base fabrics to one another, as discussed for Ground 1 at §VII.A.4(a). EX1004, 11:40-42. A POSITA would have applied this attachment method to attach the woven base fabric to Crook's base fabric, thereby having a reasonable expectation of success in using a woven base fabric as the laminate material 1512.

239. In my opinion, it would have been obvious for a POSITA to select, as the laminate material, the base fabric that Crook describes as suitable for the role of one of multiple base fabrics in a laminated fabric: a "single ply fabric belt or belt base." EX1005, 6:57-62. For example, it would have been obvious to use the "single layer plain weave" that Crook describes as being suitable for use as a belt or belt base. EX1005, 4:21-24.

240. The resulting laminated structure in which the laminate material 1512 is Crook's "single layer plain weave" fabric belt satisfies claims 7 and 8, because the single layer plain weave fabric belt is the "woven material" of the "one or more sheet plies" in that fabric.

(g) **Claim 9**

[9]: The fabric according to claim 1, wherein said woven base material and one, some or all of said sheet plies are formed of a same woven material.

241. As discussed for claims 7-8, it would have been obvious to use Crook's "single ply fabric belt or belt base" as the laminate material 1512 in the Hawes-Crook fabric. In this fabric, it is my opinion that the woven base material and the sheet plies would have been obvious to form of the same woven material, that is, the "single layer plain weave" with "nylon 6" yarns that Crook describes using for belt fabric. EX1005, 4:15-24. This is because, first, the use of that woven material would merely follow Crook's teachings as to belt fabric material. Second, the use of the same woven material for both sheet plies and woven base material would have simplified manufacture and provided favorable fabric responses, as discussed for claim 9 in Ground 1. *See* §VII.A.4(g).

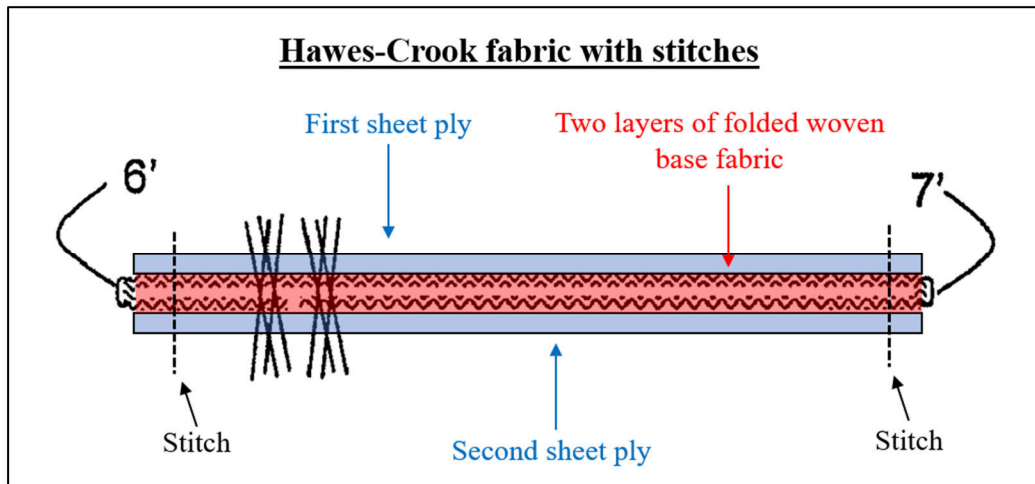
(h) **Claim 10**

[10]: The fabric according to claim 1, which comprises one or more stitchings for securing said sheet plies to said woven base material.

242. Crook describes "stitch[es]" that extend between Crook's two folded base fabric layers near the seam loops 6' and 7', to attach the fabric layers to one another. EX1005, 5:1-5. It is my opinion that it would have been obvious to sew

these stitches through the additional layers of the laminate material 1512 of the Hawes-Crook fabric, thereby satisfying claim 10.

243. As an initial matter, Crook describes that the stitches are “sewn” “once the MD thread loops are formed,” which in Hawes’ process happens *after* the laminate material 1512 has been applied. EX1004, 11:46-49; EX1005, 5:1-5. Specifically, Hawes describes that first “a laminate material” is “add[ed]...to the outside of base fabric 1500” and “attach[ed].” EX1004, 11:40-42. Then, “the laminate material [is] cutaway in the loop area 1514 [and] [t]he fabric 1510 is folded on itself as shown and then seamed.” EX1004, 11:46-49. Based on Crook’s description, this is the point at which the stitches would be sewn into the fabric. It follows that simply following Hawes’ and Crook’s teachings to manufacture the Hawes-Crook fabric would result in the stitches naturally extending through the laminate material 1512 as well, as shown in the drawing below. That is, the sewn stitching would naturally extend through each layer present, including the laminate material 1512.



Hawes-Crook fabric with stitches

244. A POSITA would have also found it advantageous to provide the stitches in this configuration. For example, in my opinion, a POSITA would have recognized that the stitches would help to secure the laminate material 1512 to the base fabric, as discussed for claim 10 in Ground 1 at §VII.A.4(h). *See* EX1022, 5:36-40, 7:44-46; EX1015, [0062], [0104], FIG. 15.

245. These stitches in the Hawes-Crook fabric would secure the sheet plies (laminate material 1512) to the base fabric, satisfying claim 10.

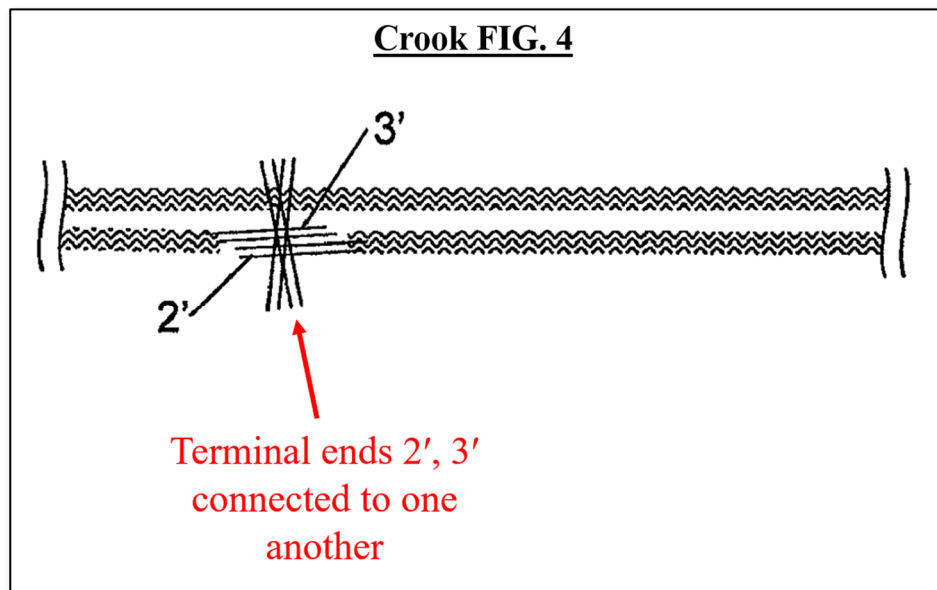
(i) ***Claim 11***

[11]: The fabric according to claim 1, wherein said two terminal ends are at least temporarily connected to one another.

246. Crook FIG. 3 shows the terminal ends 2 and 3 “attached to the bottom side surface 5 of...woven fabric 1.” EX1005, 5:8-10. Crook, however, also describes that “[a]dditionally or alternatively, terminal ends 2 and 3 can be sewn

across the join,” that is, sewn (or stitched) to one another. EX1005, 5:13-14.

Further, Crook’s FIG. 4 configuration (an “advantageous alternative embodiment” that is otherwise identical to the FIG. 3 embodiment shown above) includes terminal ends connected to one another. EX1005, 5:29-39, FIG. 4 (reproduced below). Specifically, the terminal ends 2’ and 3 are “overlapped, and stitched down” or “intermeshed and stitched.” *Id.*



Crook, FIG. 4

247. Based on the FIG. 3 or FIG. 4 configuration, the terminal ends 2 and 3 or 2’ and 3’ are connected to one another, satisfying claim 11 for the Hawes-Crook fabric.

(j) ***Claim 12***

[12]: The fabric according to claim 11, wherein said two terminal ends are connected to one another by a process selected from the group consisting of

welded, stitching, and gluing.

248. As discussed for claim 11, Crook discloses that the terminal ends 3', 4' can be "overlapped, and ***stitched down***" or "intermeshed and ***stitched.***" EX1005, 5:31-39. And the terminal ends 3, 4 "sewn across the join" would, a POSITA would have understood, be stitched to one another. EX1005, 5:13-15. Accordingly, the Hawes-Crook fabric satisfies claim 12.

(k) ***Claim 13***

[13]: The fabric according to claim 1, which further comprises at least one layer of batt fibers.

249. Hawes provides extensive description that Hawes' fabrics include batt layers, which Hawes treats as a conventional inclusion in PMC. Therefore, although Hawes does not explicitly illustrate a batt layer in the FIG. 15B embodiment, it is my opinion that a POSITA would have found the inclusion of such a layer obvious. For example, Hawes describes that "while only certain layers may be discussed, such layers may be part of a fabric having additional layers. For example, ***in a press fabric one or more layers of batt fiber would be added*** to either the paper contact side or machine side of the laminate by way of, for example, needling." EX1004, 4:54-57. Hawes further describes that "[i]n addition as to ***all of the embodiments discussed herein***, additional layers can be added ***such as fiber batt*** attached by needling." EX1004, 9:24-26.

250. Crook agrees, describing that “[a] batt layer 10 can be needled onto the seamed base structure.” EX1005, 6:3-6.

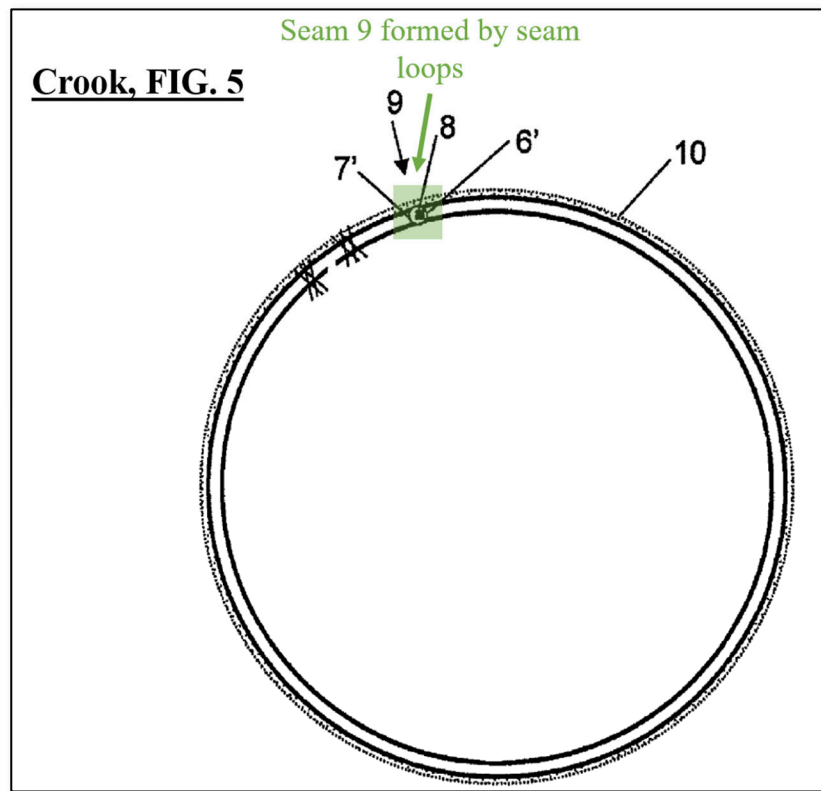
(1) ***Claim 14***

[14]: The fabric according to claim 1, wherein the fabric is configured to be on-machine seamable and comprises only one seam.

251. The Hawes-Crook fabric is on-machine seamable (like the fabrics of Hawes and Crook individually) and includes only one seam. EX1004, 11:48-49; EX1016, Abstract, 4:38-40; 7:17-27; EX1005, 5:46-51.

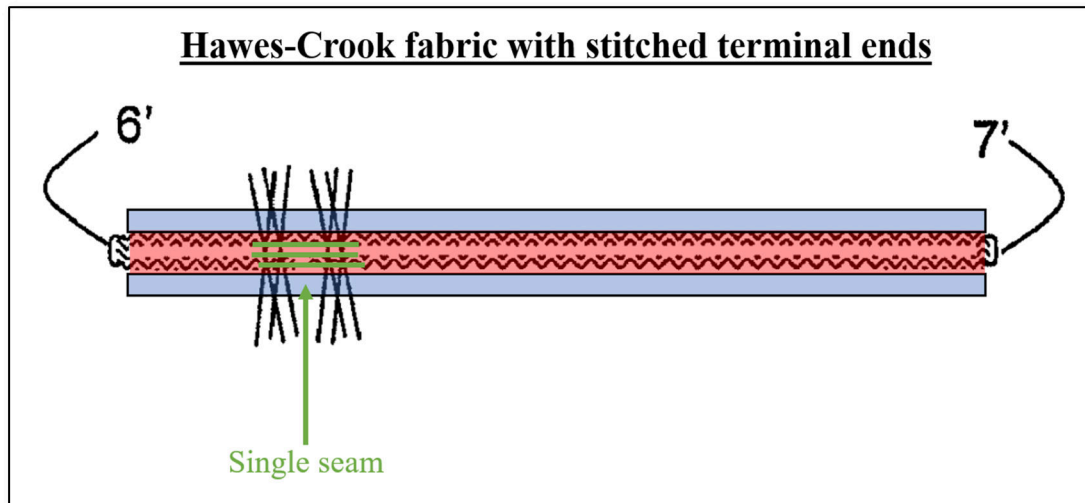
252. As would have been clear to a POSITA, the “seam[ing]” described for Hawes’ FIG. 15B fabric forms seam loops that are specifically designed to make the fabric on-machine seamable. For example, Hawes describes that the FIG. 15B fabric is “seamed in a manner as taught in the ’176 patent,” and Yook ’176’s fabric is expressly “on-machine-seamable.” EX1004, 11:48-49; EX1016, Abstract, 4:38-40; 7:17-27. The Hawes-Crook fabric, having Crook’s “seam loop ends 6’ and 7’” that “form an opening to receive a pintle 8,” is likewise on-machine seamable, because, as a POSITA would have understood, the “pintle” would be inserted during installation on a paper machine. EX1005, 5:46-51. For example, Adanur describes that a “monofilament pin passes through the loops connecting the two ends together after the installation of the fabric on the paper machine.” EX1011, 165.

253. Further, the Hawes-Crook fabric (illustrated below) includes only a single seam. As discussed for claim 14 in Ground 1, assuming the “single seam” refers to the single seam through interdigitated seam loops, the Hawes-Crook fabric includes only a single “seam 9,” formed by the seam loop ends 6’, 7’ when the seam loops are “aligned and connected with a pintle.” EX1005, 1:16-18, 5:49-51.



Crook, FIG. 5

254. Under an alternative interpretation, the Hawes-Crook fabric also includes only a single seam, where the terminal ends 2, 3 or 2’, 3’ are connected (e.g., “stitched”) to one another as discussed for claims 11 and 12. This is analogous to the weldseam 4 of the ’388 Patent’s FIG. 1 fabric.



Hawes-Crook fabric with stitched terminal ends

(m) **Claim 15**

[15]: A method for producing a fiber web, providing a web-producing machine with at least one fabric according to claim 1.

255. Each of Hawes and Crook disclose the recited method. EX1004, 1:16-26, 2:1-4, 2:22-25; EX1005, 1:11-20; 2:39-41, 6:4-6. First, as discussed for claim 1, Hawes and Crook render obvious “at least one fabric according to claim 1.” Hawes and Crook also describe “a method for producing a fiber web” that includes “providing a web-producing machine” with the fabric. For example, Hawes describes “install[ing]” “press fabrics” on “paper machines” and “plac[ing]” base fabrics “into endless form during installation on a paper machine.” EX1004, 2:1-4, 2:22-25. This “install[ing]” constitutes “providing a web-producing machine” with Hawes’ fabric. Then, with the press fabric installed on the paper machine, Hawes describes “support[ing]” a “cellulosic fibrous web” using the press fabric and

“subject[ing]” the web “to compressive forces which squeeze water therefrom...to turn the cellulosic fibrous web into a paper sheet.” EX1004, 1:16-26. These operations constitute “producing a fiber web.”

256. In addition, Crook describes “insert[ing]” “a pintle...through the seam loops,” which a POSITA would have understood would be performed during installation on a paper machine. EX1005, 1:11-20; 2:39-41. The installed fabric is then used to process a “web.” EX1005, 6:4-6.

257. Moreover, the '388 Patent describes that “[t]he fabric according to the invention can be used as a press fabric, especially as a press felt. But other uses, for example as a forming fabric are also possible.” EX1001, 2:56-58. Similarly, Hawes describes that “[t]he present invention relates primarily to the fabrics used in the press section, generally known as press fabrics, but it may also find application in the fabrics used in the forming and dryer sections,” and Crook discusses “fabric performance in the press nip” (i.e., performance as a press fabric). EX1004, 1:44-49; EX1005, 6:34-39. Hawes and Crook describe using PMC in the same way as the '388 Patent and, correspondingly, teach the same method of claim 15.

C. [GROUND 2B] – Hawes-Crook-Yook renders claims 7-9 unpatentable

1. Analysis of claims

(a) Claim 7

[7]: The fabric according to claim 1, wherein said woven material is a one-layer weave.

258. Hawes describes that the “laminate material 1512” “may be any material suitable for the purpose.” EX1004, 11:40-44. Yook describes laminating using a one-layer woven material. It is my opinion that, based on Yook, it would have been obvious to use this woven material, Yook’s base fabric 60, as the laminate material.

259. As I discussed for claim 1 in Ground 1 (§VII.A.4(a)), a POSITA would have been well aware of the advantages of laminated press fabrics having multiple layers of woven material. For example, Virtanen describes that “a laminated structure” has a “relatively large water retention capacity,” “good resistance against compression,” and “greater flexibility compared with a single-base structure,” EX1008, [0012]. More broadly, “multilayer or laminated fabrics” were known to provide “[h]igh void volume,” EX1011, 154. In addition, “[l]aminated fabrics” having “two or more base fabric structures” “allow a wider range of base fabric pressure uniformity and low batt-to-base ratio which is critical for open and clean operation.” EX1011, 163. Similarly, Hyvonen describes

advantages that include “space for water,” “an even surface,” and that such fabrics “remain longer unclogged.” EX1022, 3:15-24.

260. In view of this motivation, in my opinion, it would have been obvious for a POSITA to look to Yook’s teachings to learn how to modify the Hawes-Crook fabric to incorporate a woven laminate material, such as Yook’s base fabric 60. Yook’s base fabric 60 is a one-layer weave, as shown in FIG. 12 and as discussed above. EX1006, FIG. 12 (Substituted), 12:62-64; §VII.B.4(f).

261. The use of Yook’s woven base fabric 60 as the laminate material would have been well within the skill of a POSITA to implement predictably. As discussed for Ground 1, Yook discloses that, to form a laminate fabric having multiple woven base fabrics, the base fabrics can be “joined to one another by one or more layers of staple fiber batt material 80 needled into and through the superimposed base fabric layer 22 and base fabric 60.” EX1006, 10:21-28. Because Hawes already describes that the laminate material 1512 is “needl[ed]” to the base fabric 1500, the use of a woven material (such as the base fabric 60) as the laminate material 1512 would have been merely a modification of the laminate composition, with the method of joining the laminate to the base fabric being substantially unchanged from that described by Hawes. EX1004, 11:40-42. Only the material, not the method of joining, would be modified.

262. Indeed, both Hawes and Crook describe that their fabrics can be used in a laminate of multiple woven fabric layers, as proposed for the combination with Yook. Hawes describes that a “laminated” structure includes “two separate base fabrics, on top of the other” and “joined together” by “the needling of batt therethrough.” EX1004, 3:36-43. That is, Hawes describes a laminate of multiple woven fabric layers based on the same method of joining as described by Yook. Hawes discloses that this arrangement can advantageously allow for “each layer [to] be designed for a different functionality.” EX1004, 3:36-39.

263. Similarly, Crook describes that “[i]n a further embodiment of the invention, the folded fabric belt or belt base formed in accordance with the features of the present invention can be coupled to, e.g., laminated with, another belt, such as a *single ply* fabric belt or belt base, a double ply fabric belt or belt base, or a folded fabric belt or belt base.” EX1005, 6:57-64. “Single ply fabric” here refers to a one-layer woven material.

264. So, the use of a woven base fabric, such as Yook’s base fabric 60, as the laminate material would not have represented a departure from the teachings of Hawes and Crook. Rather, it would have aligned with the suggestions already provided by each of Hawes and Crook and provided advantages recognized widely in the art. In my opinion, a POSITA would have had a reasonable expectation of success in making this combination, and would have been motivated to do so.

265. Because Yook's base fabric 60 is a one-layer weave, the Hawes-Crook fabric, modified with Yook's base fabric 60 as the laminate material 1512, satisfies claim 7. EX1006, FIG. 12, 12:62-64.

(b) **Claim 8**

[8]: The fabric according to claim 7, wherein said one-layer weave is a plain weave.

266. As shown in FIG. 12 and as I discussed for claims 7-8 in Ground 1 (§VII.A.4(f)), Yook's base fabric 60 is a plain weave. Therefore, the Hawes-Crook fabric, modified with Yook's base fabric 60 as the laminate material 1512 (see discussion for claim 7), satisfies claim 8.

(c) **Claim 9**

[9]: The fabric according to claim 1, wherein said woven base material and one, some or all of said sheet plies are formed of a same woven material.

267. As I discussed for claim 7, it would have been obvious to use Yook's woven base fabric 60 as Hawes' laminate material 1512 in the Hawes-Crook fabric. In this fabric, the woven base material (Crook's base fabric) and the sheet plies (Yook's base fabric 60) are formed of a same woven material.

268. First, as discussed for claims 5 and 6, Crook's base fabric is a single-layer plain weave. EX1005, 4:8-11, 4:21-24. Moreover, the yarns of this weave are "nylon 6" yarns, that is, polyamide yarns. EX1005, 4:21-24; EX1023, 7-8;

EX1024. “The name ‘nylons’ refers to a group of plastics known as polyamides...[including] Nylon 6[.]” EX1024, 1.

269. Similarly, Yook’s base fabric 60 is a single-layer plain weave (see claims 5-6 of Ground 1 at §VII.A.4(e)) with “polyamide” yarns. EX1006, 2:4-10, 7:59-63, 8:9-16, FIG. 6.

270. Accordingly, both the woven base material and sheet plies of the Hawes-Crook-Yook fabric are single-layer plain weaves with polyamide yarns, thereby being “formed of a same woven material.”

D. [GROUND 3A] – Hawes-Zehle Renders Claims 1-8 and 11-15 Unpatentable

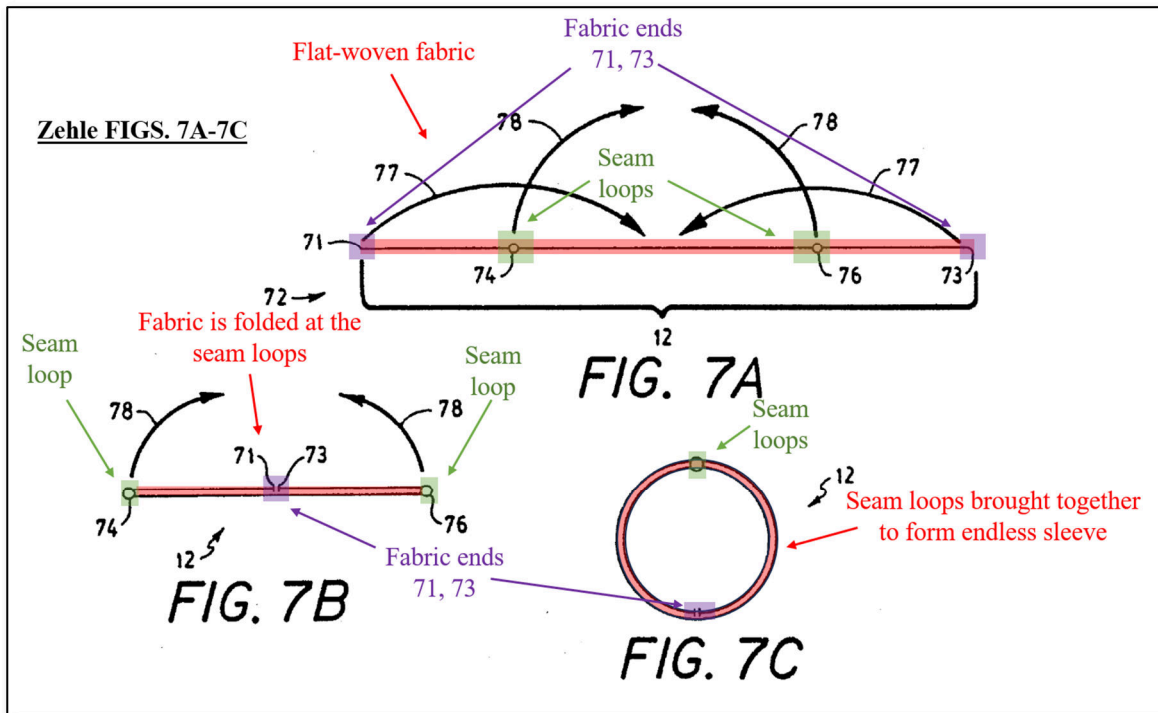
271. In Grounds 2A-2B, Crook was cited for its teaching of a flat-woven fabric with terminal ends separated in the machine direction. That fabric, however, did not originate from Crook. Rather, it long existed in the art and can be found throughout various other prior art documents.

272. For example, Zehle discloses the same fabric as Crook. Indeed, Zehle provides many of the same teachings as Crook (such as seam loops at folds, terminal ends separated in the machine direction, etc.) while further demonstrating the interchangeability of flat-woven, folded base fabrics with terminal ends and endless base fabrics. Thus, not only are the claims unpatentable for obviousness over the combination of Hawes and Crook, as detailed in Ground 2A (§VII.B), but

the claims are also equally unpatentable for obviousness over the combination of Hawes and Zehle.

1. **Zehle**

273. Zehle teaches a flat-woven, folded base fabric with terminal ends separated in the machine direction, similar to the teachings of Ryan, Crook, the '388 Patent, and other art noted above. For example, Zehle's FIGS. 7A-7C (reproduced and annotated below) illustrate folding a "flat base fabric 72" having CD yarns removed at its folds "to be used as a [seam] loop." EX1020, 6:12-29. In FIG. 7A, the base fabric 72 is initially flat along the machine direction (left-right). In FIG. 7B, fabric ends 71, 73 (or terminal ends) are folded together and separated in the machine direction, such that the base fabric 72 forms a two-layer folded fabric. The FIG. 7B configuration is analogous to the configuration of FIG. 1 of the '388 Patent. In FIG. 7C, the seam loops 74, 76, initially opposite to one another along the machine direction, are brought together. The FIG. 7C configuration illustrates on-machine seaming of the fabric.



Zehle, FIGS. 7A-7C

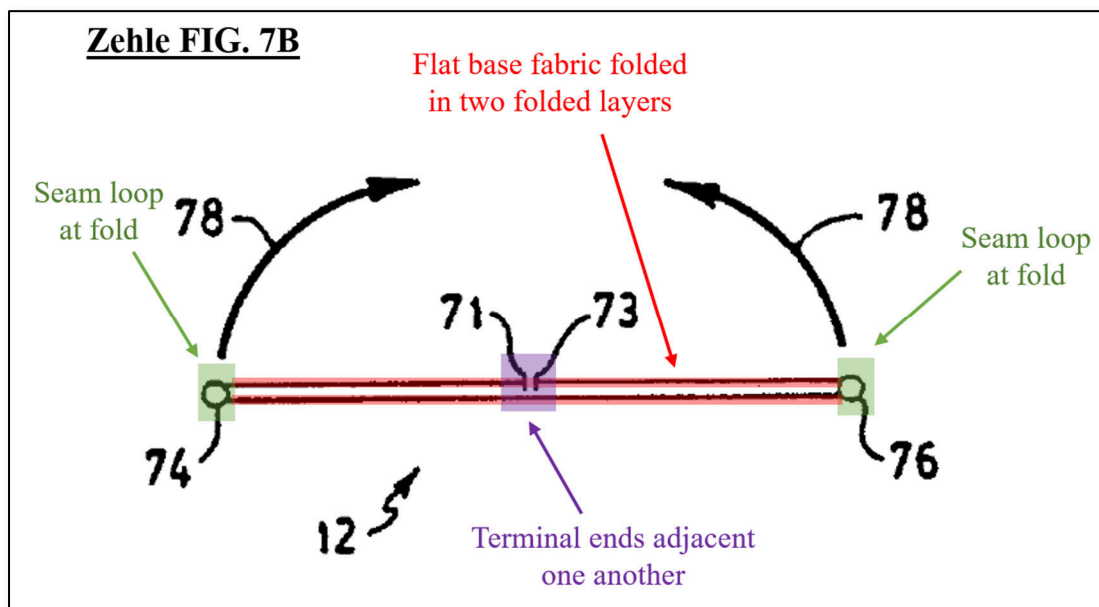
2. Analysis of claims

(a) *Claim 1*

274. The reasoning provided above for claim 1 of Ground 2A (§VII.B.4(a)) applies equally here. As shown below, Zehle’s fabric of FIG. 7B is a flat-woven base material having two terminal ends separated in the machine direction and folded into two layers, with seam loops located at its folds. EX1020, 6:7-29. That is, Zehle’s fabric satisfies all elements of claim 1 except for the arrangement of the “one or more sheet plies...[where] all of said sheet plies are disposed outside said folded layers.”

275. Zehle FIG. 7B illustrates the terminal ends as being on the top as opposed to the bottom (claim 1 recites that the terminal ends are “located under the

bottom side surface”). In the annotated version of Zehle Figure 7B below, the terminal ends are shown in purple. However, this arrangement of the terminal is merely a choice of illustration and does not reflect a substantive difference between Zehle’s fabric and that of claim 1. A POSITA would have understood that the same structure could equivalently be illustrated with the opposite orientation (i.e., rotated by 180°), so that the terminal ends—or “ends” 74 and 76—would be “located under the bottom side surface.”

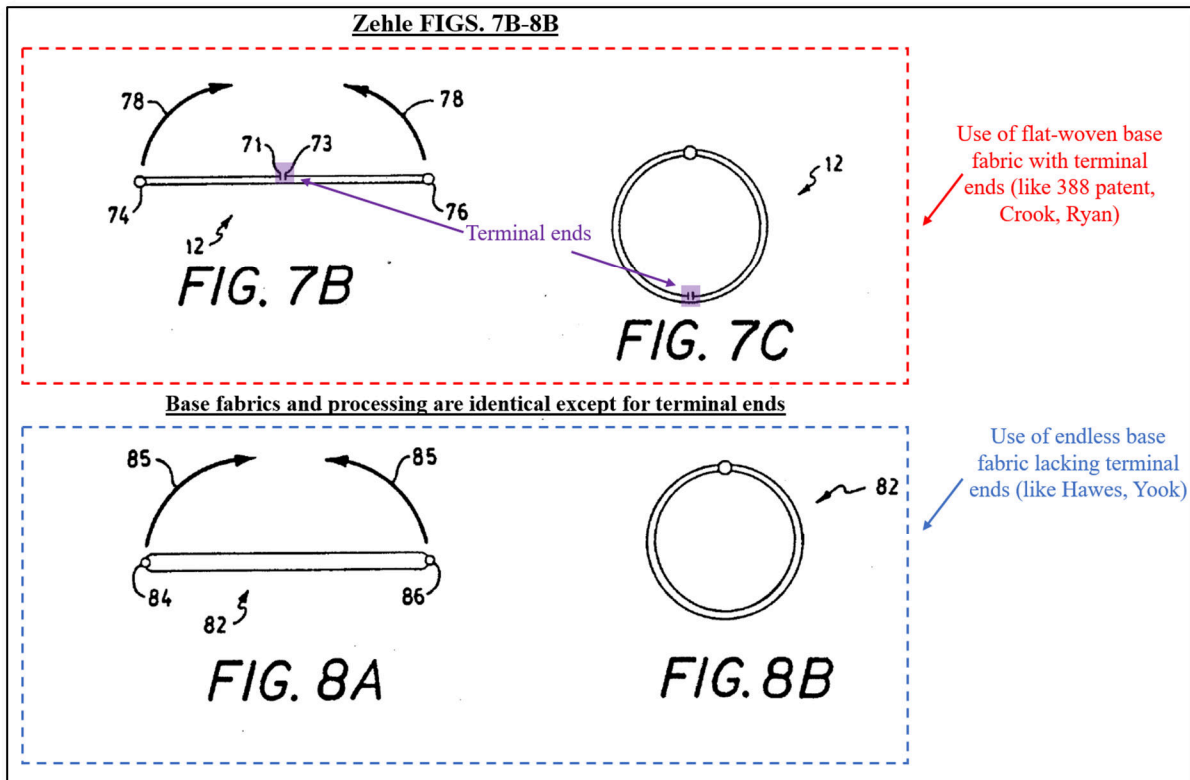


Zehle, FIG. 7B

276. It is my opinion that, for the reasons provided with respect to the Hawes-Crook combination in §VII.B.4(a), it would have been obvious to a POSITA to substitute Zehle’s fabric 72 for Hawes’ base fabric 1500 in Hawes’ FIG. 15B embodiment, thereby satisfying claim 1. Like Hawes’ and Crook’s fabrics, Zehle’s fabric is “needled,” such that a POSITA would have a reasonable

expectation of success in making the substitution by attaching Hawes' laminate material 1512 to Zehle's fabric 72 using Hawes' method of "needling." EX1020, 6:27-29; EX1004, 11:40-42.

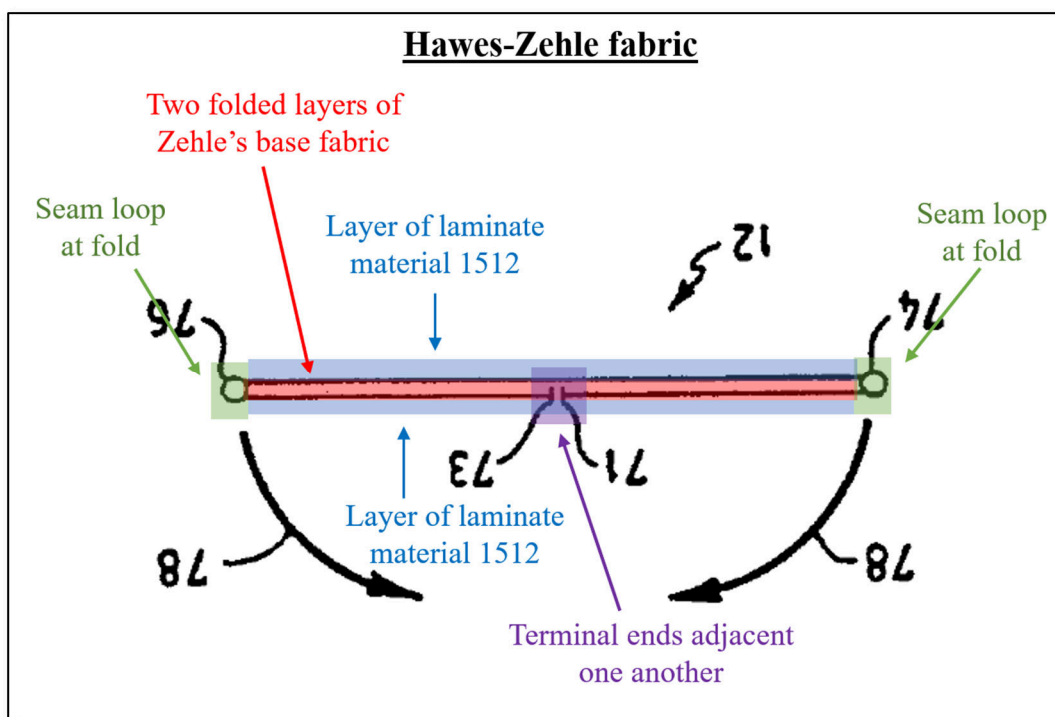
277. Indeed, in addition to the reasons provided for the Hawes-Crook combination, Zehle reinforces that (i) fabrics with terminal ends separated in the machine direction (like Zehle's FIG. 7B fabric) and (ii) fabrics manufactured in endless form (like Hawes' base fabric 1500) were understood as substitutable alternatives for one another. Immediately after describing the FIGS. 7A-7C fabric with terminal ends shown above, Zehle describes that "[a]lternatively, the base fabric assembly may be formed from, as shown in FIGS. 8A-8B, an endless base fabric." EX1020, 6:30-32. Zehle then illustrates how the fabric with terminal ends and the endless fabric without terminal ends can be used to obtain essentially the same structure, differing only in that one includes terminal ends separated in the machine direction and one lacks terminal ends separated in the machine direction. EX1020, 6:30-40, FIGS. 7B-8B.



278. Zehle then discusses these two approaches in conjunction with one another, describing that “[t]he advantage to a base fabric prepared according to the embodiments...*shown in FIGS. 7A-7C and 8A/-/8B* is that in the area of the seaming of the base fabric, the thickness of the base fabric is not increased from the pintle cable joining because a yarn has been removed from that area already.” EX1020, 6:41-46. That is, Zehle describes the two types of base fabrics in succession, illustrates them near-identically, and describes that they provide the same advantage. This is a clear demonstration of why, in my opinion it would have been obvious to substitute one type of base fabric (Zehle’s base fabric with

separated terminal ends) for the other (Hawes' endless base fabric) as described above in Ground 2A. *See* §VII.B.4(a).

279. The remainder of the discussion for claim 1 at §VII.B.4(a) applies equally with Zehle substituted for Crook as providing the base fabric for a Hawes-Zehle fabric. The Hawes-Zehle fabric, shown below satisfies claim 1. In this drawing, the Zehle fabric is rotated 180° to emphasize the similarity with FIG. 1 of the '388 Patent.



Hawes-Zehle fabric

(b) ***Claim 2***

280. *See* claim 2 at §VII.B.4(b). The Hawes-Zehle fabric includes two sheet plies: "a layer of laminate material 1512 on the top and one on the bottom." EX1004, 11:50-52.

(c) ***Claim 3***

281. See claim 3 at §VII.B.4(c). Like Hawes’ fabric, Zehle’s fabric is configured for producing a paper web. EX1020, 1:10-35, 2:40-44.

(d) ***Claim 4***

282. See claim 4 at §VII.B.4(d), which cites Hawes to demonstrate that the Hawes-Crook—and, correspondingly, the Hawes-Zehle—fabric satisfies claim 4.

(e) ***Claims 5, 6***

283. See claims 5, 6 at §VII.B.4(e), which demonstrates that Hawes’ base fabric 1500 has a one-layer plain weave. Zehle also describes use of a one-layer plain weave for the base fabric, i.e., the base fabric in the Hawes-Zehle fabric. Specifically, Zehle discloses the use of “a single layer plain weave monofilament fabric” and specifically describes that the folded fabric 72 is “now a double layer fabric,” meaning that it was a single layer fabric prior to folding. EX1020, 5:48-49. It would have been obvious to use Zehle’s “single layer plain weave monofilament fabric” as the fabric 72 in the Hawes-Zehle fabric, as Zehle discloses its suitability for this purpose.

(f) ***Claims 7, 8***

284. See claims 7, 8 at §VII.B.4(f). As discussed at §VII.B.4(f), the Hawes-Zehle fabric – which includes a non-woven polymer layer or knitted structure as the “one or more sheet plies” – satisfies these claims even without including a woven material as a sheet ply, because these claims only narrow the type of

“woven material” required for the sheet plies of claim 1, rather than requiring the woven material itself.

285. Hawes-Zehle also renders obvious the use of a one-layer, plain-woven material as Hawes’ laminate material 1512. Like Crook (discussed in VII.B.4(f)), Zehle describes that base fabrics can be attached to one another (in the form of a “dual base fabric”), which is advantageous because, in such a case, “two base fabrics with different characteristics can be used. A coarse base fabric with high void volume and a high degree of compaction resistance is desirable for the inside or wear surface of the press felt which contacts the machine and rollers. A finer fabric for the side of the press felt which faces the paper sheet will provide uniform pressure and prevent marking from the coarse machine side base fabric which reduces the quality of the paper sheet.” EX1020, 3:2, 5:14-23.

286. It would have been obvious for a POSITA to realize these advantages by using a woven material as the laminate material 1512, thereby obtaining a fabric having multiple base fabrics laminated to one another. This embodiment of the Hawes-Zehle fabric includes the woven laminate material attached to Zehle’s base fabric. For selection of the woven laminate material, Zehle discloses the use of a “single layer plain weave monofilament fabric” in the laminated structures of FIGS. 4 and 5. EX1020, 5:48-50. It would have been obvious to use this “fine” fabric as the laminate material 1512 in order to “provide uniform pressure and

prevent marking...which reduces the quality of the paper sheet.” EX1020, 5:19-23, 5:48-50.

(g) ***Claims 11, 12***

287. The Hawes-Zehle fabric includes free ends (terminal ends) 71, 73, which are “***stitched together*** loosely with brittle yarns which are subsequently destroyed in the needling operation.” EX1020, 6:21-23. This is similar to the ’388 Patent’s description that the connection between the terminal ends “may or may not be destroyed during the further processing of the fabric, e.g. by needle punching.” EX1001, 3:62-64.

288. Accordingly, the free ends of Zehle’s base fabric, which is included in the Hawes-Zehle fabric, are “at least temporarily [stitched]” to one another, satisfying claims 11 and 12.

(h) ***Claim 13***

289. See claim 13 at §VII.B.4(k). Hawes discloses or at least renders obvious at least one layer of batt.

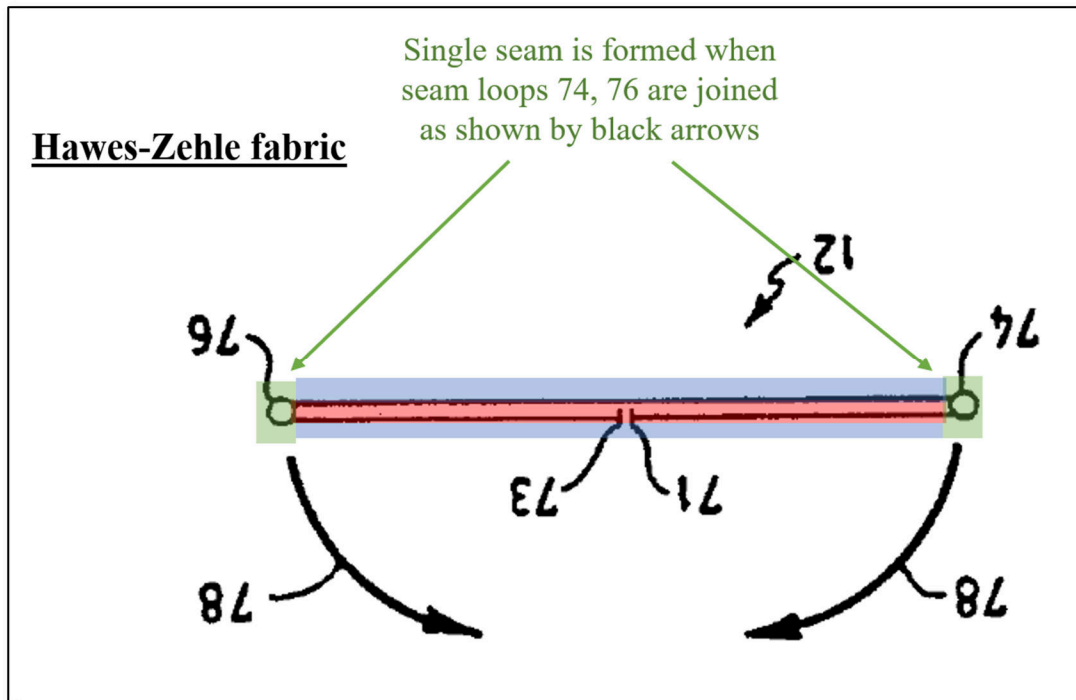
290. Zehle also discloses the inclusion of a layer of batt, as indicated by the description that the base fabric is “needled” (i.e., needled with a layer of batt). EX1020, 4:61-64, 5:5-8, 6:27-28. For example, Zehle describes that “This invention relates to papermakers’ felts and especially to needled press felts with a woven base fabric...into which is needled a batt consisting of wool or synthetic

fibers.” EX1020, 1:6-9. Zehle further discloses that batt needling is used to attach two base fabrics to one another in a laminated fabric, in agreement with Hawes. EX1020, 4:61-64, 5:5-8, 5:36-41, 6:27-29. For example, Zehle describes that “[t]he batting material is positioned on the outside surface of the base fabric assembly adjacent the finer fabric and the entire structure is needled together to form a press felt having a continuous surface layer batting needled to a double base fabric construction.” EX1020, 5:36-41.

(i) ***Claim 14***

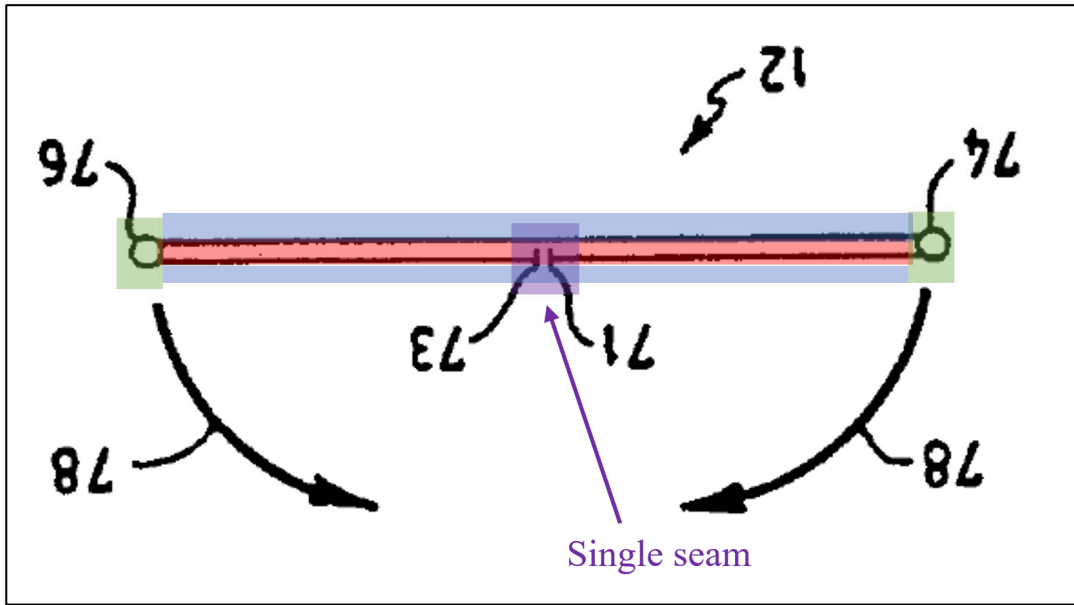
291. See claim 14 at §VII.B.4(l). As described in that section, Hawes’ fabric is on-machine seamable. EX1004, 11:48-49; EX1016, Abstract, 4:38-40, 7:17-27. Zehle’s fabric is compatible with on-machine seaming because it includes seam loops 74, 76 that are “intermeshed” and through which “a pintle cable is inserted to join the fabric into an endless base fabric,” as in a typical on-machine seaming process. EX1020, 6:25-29; EX1011, 165.

292. Further, the Hawes-Zehle fabric (illustrated below) includes only a single seam. The single seam (understood to refer to a single seam formed using seam loops) is formed when the seam loops 74, 76 of the Zehle base fabric (included in the Hawes-Zehle fabric) are interdigitated, as shown below. This drawing shows Zehle’s base fabric rotated 180°, in line with the discussion above that its illustrated orientation is arbitrary.



Hawes-Zehle Fabric

293. Alternatively, to the extent the “single seam” is interpreted to refer to a single seam between joined terminal ends, the Hawes-Zehle fabric includes only a single seam (shown in purple), where the fabric ends 71, 73 are connected (e.g., “stitched together”) as discussed for claims 11 and 12.



Hawes-Zehle fabric

(j) ***Claim 15***

294. See claim 15 at §VII.B.4(m) for discussion of how Hawes satisfies claim 15. Like Hawes, Zehle describes a “method for producing a fiber web” that includes “providing a web-producing machine” with the fabric. For example, Zehle describes that “the conventional papermaking process” includes “feeding” “a water slurry or suspension of cellulose fibers...onto the top of the upper run of a traveling endless forming belt. The forming belt...operates as a filter...to form a wet paper web.” EX1020, 1:11-16. Further, “the somewhat self-supporting paper web is transferred to the press section in the machine and onto a press felt, where still more of its water content is removed.” EX1020, 1:23-28. The forming belt and the press felt would have been “provid[ed]” on the machine in order to perform these operations on the paper web.

E. [GROUND 3B] – Hawes-Zehle-Yook renders claims 7-10 obvious

1. Analysis of claims

(a) *Claims 7, 8*

295. See claims 7 and 8 at §§VII.C.1(a)-(b). Yook’s FIG. 12 fabric is a “laminated fabric” that includes two attached, woven base fabrics. EX1006, 10:16-31. For the reasons discussed in §§VII.C.1(a)-(b), it is my opinion that it would have been obvious to use Yook’s base fabric 60 as the laminate material 1512 of the Hawes-Zehle fabric. EX1006, 10:16-31. In addition to the reasoning provided above (e.g., the widely-recognized advantages of laminated press fabrics), Zehle also motivates the use of a woven fabric as the laminate material. For example, Zehle describes advantages of fabrics that include “two base fabrics” attached to one another, namely that “two base fabrics with different characteristics can be used” for optimal interaction with the papermaking machine and the paper sheet. EX1020, 3:1-4, 5:16-23. Further, each of Yook, Hawes, and Zehle describe that multiple woven base fabrics can be attached to one another by needling, indicating that a POSITA would have had a reasonable expectation of success in attaching Yook’s base fabric 60 to Zehle’s base fabric by needling. EX1006, 10:23-26; EX1004, 2:35-38, 11:40-42; EX1020, 5:5-8.

296. Yook’s base fabric 60 is a one-layer plain weave, satisfying claims 7 and 8. EX1006, FIG. 12, 12:62-64.

(b) ***Claim 9***

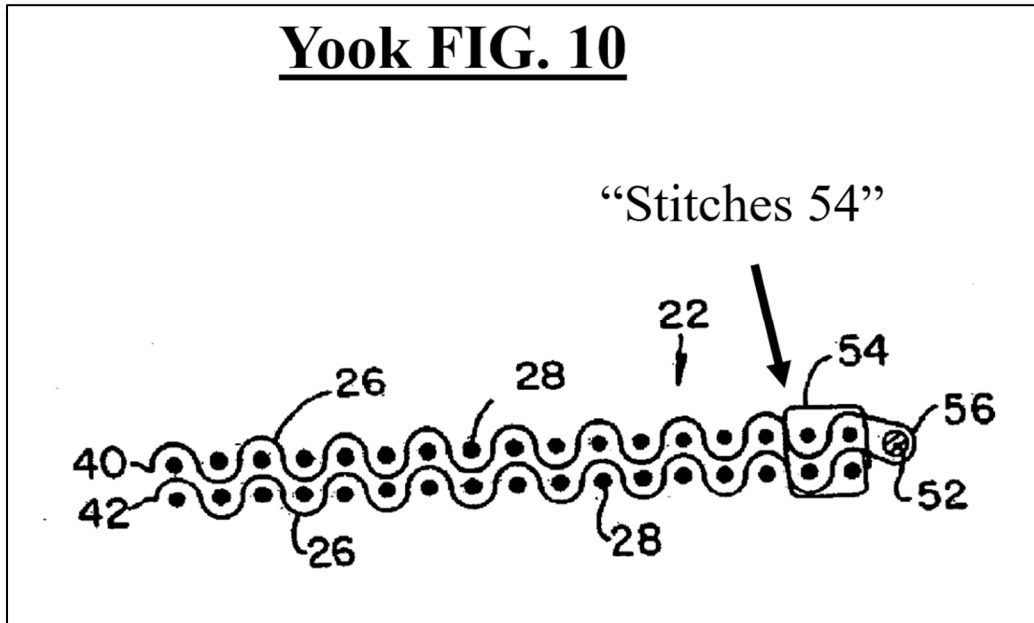
297. Yook teaches use of two of the same base fabric layer 22 in a laminated, two-base-fabric structure that, as discussed for claims 7 and 8, would have been obvious based on Hawes, Zehle, and Yook. EX1006, 10:19-21. Specifically, Yook describes that, as an “alternative” to the FIG. 12 fabric which includes base fabric 60 attached to base fabric layer 22, “a second on-machine-seamable base fabric layer 22 may be used instead of on-machine-seamable base fabric 60.” EX1006, 10:19-21, FIG. 12. The alternative fabric, therefore, simply includes two base fabric layers 22 attached to one another. *See* §VII.A.4(b).

298. Following this teaching, it is my opinion that it would have been obvious to select, as the laminate material 1512 of the Hawes-Zehle fabric, a fabric formed of the same woven material as Zehle’s fabric 72 to which the laminate material 1512 is attached. This fabric would then include a sheet ply (Zehle’s base fabric 72) and a woven base material (Zehle’s base fabric), the sheet ply and the woven base material naturally being formed of the same woven material and satisfying claim 9.

(c) ***Claim 10***

299. Yook teaches the inclusion of “[s]titches 54” that “connect first fabric ply 40 to second fabric ply 42” within the same base fabric. EX1006, 9:49-52.

Yook FIG. 10



Yook, FIG. 10

300. These stitches 54 serve the same purpose as the analogous “seam stitching” of Ryan and “stitch[es]” of Crook. EX1006, 9:46-52; EX1007, [0029], [0031]; EX1005, 5:1-3. For the reasons provided in §§VII.A.4(h) and VII.B.4(h), it is my opinion that it would have been obvious to provide the stitches also through the attached laminate material 1512 of the Hawes-Zehle fabric, to better secure the laminate material to the underlying fabric 72 of Zehle. EX1005, 5:1-5; EX1007, [0029], [0031].

VIII. LEGAL PRINCIPLES

A. Obviousness

301. I have been informed that a patent claim is invalid as “obvious” under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art,

(2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others. For purposes of my analysis above and because I know of no indication from the patent owner or others to the contrary, I have applied a date of August 13, 2015, as the date of invention in my obviousness analyses, although in many cases the same analysis would hold true even at an earlier time than August 13, 2015.

302. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason to modify the single prior art reference, or combine two or more references, in order to achieve the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved, and may be explicit or implicit from the prior art as a whole. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more

than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

303. I have also been informed of the Supreme Court decision *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398 (2007), which I am informed guides obviousness analyses. Under *KSR*, the mere application of a known technique to a piece of prior art ready for the improvement is obvious. In addition, the selection of one of a finite number of identified, predictable solutions to achieve a predictable result is obvious. Further, the simple substitution of one known element for another to obtain a predictable result is obvious.

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.

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"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

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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)

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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.

"Initial Lessons from Nexus Learning for Engineering Students Achieved Via Interdisciplinary Projects for Outside Clients," M. J. Traum, C. F. Anderson, C. M. Pastore, and M. J. Leonard, *Proceedings of the Spring 2015 Mid-Atlantic ASEE Conference*, Villanova, PA, April 10-11, 2015.

"Architectural and Transportation Applications of Fibrous Materials", session chair: C. Pastore, *Fiber Society Annual Meeting*, Philadelphia, PA, October 2014.

"Microtectonic Responsive Textile Systems", S. Frostén and C. Pastore, *Fiber Society 2014 Fall Meeting and Technical Conference: Fibers for the Future*, Philadelphia, PA, October 2014.

"Multimaterial Preforming of Structural Composites", Pastore, C., Sudbury, T., Norris, R., Eberle, C., Hartman, D. and Anderson, C., *Fiber Society 2014 Fall Meeting and Technical Conference: Fibers for the Future*, Philadelphia, PA, October 2014.

"Multimaterial Preforming of Structural Composites", T. Sudbury and C. Pastore, *National Conference on Undergraduate Research*, Lexington, KY, April 2014.

"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.

"Chitosan Composites", Y. Rane and C. Pastore, PaGGP Forum, Harrisburg, PA September, 2007

"Development of Interdisciplinary Research Centers", AICUP Conference, July, 2007, Harrisburg, PA.

"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

"Direct measurement of punch force during two professional boxing matches ", Pierce, Jr., J.D., Reinbold, K.A., Goldman, R.J., Lyngard, B.C., and Pastore, C.M. (2004), May meeting of the American Psychological Society, Chicago, IL.

"Sustainability and Composites", C. Pastore, *TechTextil North America*, Atlanta, GA, March 2004.

"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. Gawayed, 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