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(54) **COMPOSITE LAMINATE FOR A THERMAL AND ACOUSTIC INSULATION BLANKET**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,325,340 A 6/1967 Walker
3,346,219 A 10/1967 Salyer et al.

(Continued)

FOREIGN PATENT DOCUMENTS

BE 905985 A1 4/1987
CN 1141866 A 2/1997

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 14/081,010, filed Nov. 15, 2013, Richardson, III et al.

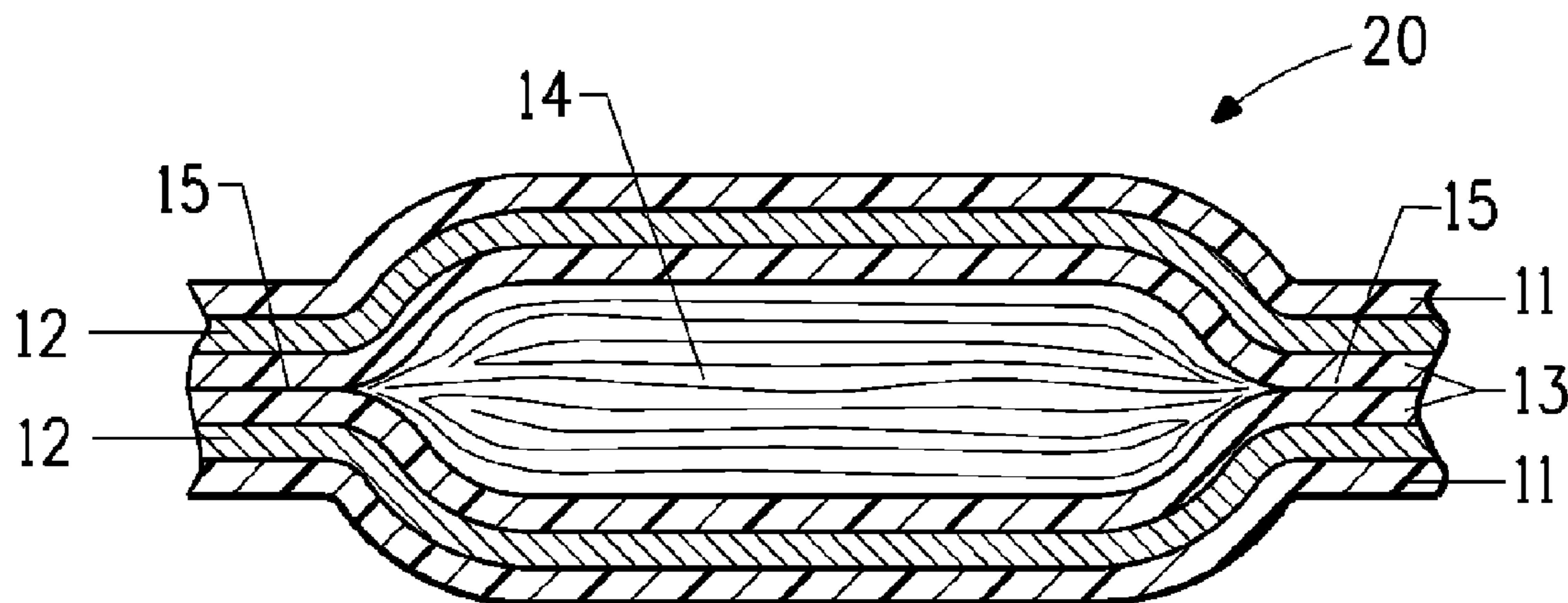
(Continued)

Primary Examiner — Carlos Lopez

(57) **ABSTRACT**

This invention is directed to a composite laminate comprising in order (a) a flame retardant polymeric moisture barrier (b) an inorganic platelet layer and (c) a flame retardant thermoplastic film layer. The invention is also directed to a thermal insulation and acoustic blanket comprising a core of fibrous material or foam surrounded by the above composite laminate wherein the thermoplastic film layer of the composite laminate contacts and encapsulates the core.

19 Claims, 1 Drawing Sheet



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	<i>B64C 1/40</i> (2006.01)		5,126,013 A *	6/1992	Wiker et al. 162/156
	<i>B32B 5/02</i> (2006.01)		5,223,094 A	6/1993	Kirayoglu et al.
	<i>B32B 5/22</i> (2006.01)		5,244,729 A	9/1993	Harrison
	<i>B32B 5/24</i> (2006.01)		5,314,742 A	5/1994	Kirayoglu et al.
	<i>B32B 5/26</i> (2006.01)		5,336,348 A	8/1994	Mindler
	<i>B32B 5/30</i> (2006.01)		5,373,038 A	12/1994	Horacek
	<i>B32B 5/32</i> (2006.01)		5,595,817 A *	1/1997	Sch afer et al. 442/379
	<i>B32B 27/06</i> (2006.01)		5,760,146 A	6/1998	von Gentzkow et al.
	<i>B32B 27/14</i> (2006.01)		5,765,318 A *	6/1998	Michelsen 52/98
	<i>B32B 27/28</i> (2006.01)		5,888,610 A	3/1999	Fournier et al.
	<i>B32B 27/30</i> (2006.01)		6,244,729 B1	6/2001	Waldmann
	<i>B32B 27/32</i> (2006.01)		6,291,053 B1	9/2001	Peiffer et al.
	<i>B32B 27/36</i> (2006.01)		6,322,022 B1	11/2001	Fay et al.
	<i>B32B 3/04</i> (2006.01)		6,443,257 B1	9/2002	Wiker et al.
	<i>B32B 27/12</i> (2006.01)		6,565,040 B2	5/2003	Fay et al.
			6,627,561 B1	9/2003	Wulliman et al.
			6,670,291 B1	12/2003	Tompkins et al.
			7,767,597 B2	8/2010	Garvey
			8,292,027 B2	10/2012	Richardson, III et al.
			8,387,748 B2	3/2013	Richardson, III et al.
			8,607,926 B2	12/2013	Richardson, III et al.
			8,607,927 B2	12/2013	Richardson, III et al.
			8,607,928 B2	12/2013	Richardson, III et al.
			8,678,133 B2	3/2014	Clausi et al.
			8,869,933 B1 *	10/2014	McKnight et al. 181/286
			9,056,666 B2	6/2015	Richardson, III et al.
			9,242,717 B2	1/2016	Richardson, III et al.
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	CPC <i>B32B 5/028</i> (2013.01); <i>B32B 5/22</i> (2013.01); <i>B32B 5/245</i> (2013.01); <i>B32B 5/26</i> (2013.01); <i>B32B 5/30</i> (2013.01); <i>B32B 5/32</i> (2013.01); <i>B32B 27/065</i> (2013.01); <i>B32B 27/12</i> (2013.01); <i>B32B 27/14</i> (2013.01); <i>B32B 27/281</i> (2013.01); <i>B32B 27/285</i> (2013.01); <i>B32B 27/286</i> (2013.01); <i>B32B 27/288</i> (2013.01); <i>B32B 27/304</i> (2013.01); <i>B32B 27/322</i> (2013.01); <i>B32B 27/365</i> (2013.01); <i>B64C 1/40</i> (2013.01); <i>B32B 2255/10</i> (2013.01); <i>B32B 2255/205</i> (2013.01); <i>B32B 2255/26</i> (2013.01); <i>B32B 2262/02</i> (2013.01); <i>B32B 2262/0246</i> (2013.01); <i>B32B 2262/0261</i> (2013.01); <i>B32B 2262/0269</i> (2013.01); <i>B32B 2262/0276</i> (2013.01); <i>B32B 2262/06</i> (2013.01); <i>B32B 2262/062</i> (2013.01); <i>B32B 2262/08</i> (2013.01); <i>B32B 2262/10</i> (2013.01); <i>B32B 2262/101</i> (2013.01); <i>B32B 2262/105</i> (2013.01); <i>B32B 2262/106</i> (2013.01); <i>B32B 2264/10</i> (2013.01); <i>B32B 2266/0214</i> (2013.01); <i>B32B 2307/102</i> (2013.01); <i>B32B 2307/304</i> (2013.01); <i>B32B 2307/3065</i> (2013.01); <i>B32B 2307/50</i> (2013.01); <i>B32B 2307/718</i> (2013.01); <i>B32B 2307/724</i> (2013.01); <i>B32B 2307/7246</i> (2013.01); <i>B32B 2307/7265</i> (2013.01); <i>B32B 2605/18</i> (2013.01); <i>Y02T 50/46</i> (2013.01); <i>Y10T 428/2495</i> (2015.01); <i>Y10T 428/24975</i> (2015.01); <i>Y10T 428/269</i> (2015.01); <i>Y10T 428/3154</i> (2015.04); <i>Y10T 442/10</i> (2015.04)				
			2003/0170418 A1	9/2003	Mormont
			2004/0211506 A1	10/2004	Wang et al.
			2005/0173780 A1	8/2005	Sethumadhavan et al.
			2006/0046598 A1	3/2006	Shah
			2006/0128866 A1	6/2006	Diakoumakos et al.
			2007/0155265 A1	7/2007	Anderson
			2008/0153373 A1	6/2008	Hall et al.
			2008/0156367 A1	7/2008	Uschold et al.
			2008/0189840 A1	8/2008	Knoff et al.
			2008/0254313 A1	10/2008	Kennedy et al.
			2009/0094754 A1	4/2009	Hall, III et al.
			2009/0269565 A1	10/2009	Peng
			2009/0314480 A1	12/2009	Grinbergs et al.
			2010/0024969 A1	2/2010	Wang et al.
			2010/0056687 A1	3/2010	Diakoumakos et al.
			2010/0065368 A1	3/2010	Tazian
			2010/0133039 A1	6/2010	Liguore
			2010/0159221 A1	6/2010	Kourtakis et al.
			2010/0173152 A1	7/2010	Beraud et al.
			2010/0209679 A1	8/2010	Tompkins
			2010/0243807 A1	9/2010	Hossain et al.
			2011/0094826 A1	4/2011	Richardson, III et al.
			2011/0114342 A1	5/2011	Ono et al.
			2012/0003451 A1	1/2012	Weigel et al.
			2012/0128959 A1	5/2012	Fernando
			2012/0273618 A1	11/2012	Fernando
			2012/0321848 A1	12/2012	Richardson, III et al.
			2012/0321849 A1	12/2012	Richardson, III et al.
			2012/0321868 A1	12/2012	Richardson, III et al.
			2012/0321883 A1	12/2012	Richardson, III et al.
			2013/0068555 A1	3/2013	Cherniak et al.
			2013/0092321 A1	4/2013	Fernando et al.
			2013/0196136 A1 *	8/2013	Contzen et al. 428/221
			2013/0240291 A1	9/2013	Tinianov
			2014/0008145 A1	1/2014	Lin et al.
			2014/0011006 A1 *	1/2014	Guinaldo Fernandez et al. 428/201
			2014/0065357 A1	3/2014	Richardson, III et al.
			2014/0072762 A1	3/2014	Richardson, III et al.
			2014/0072763 A1	3/2014	Richardson, III et al.
			2014/0144723 A1	5/2014	Kim et al.
			2014/0272252 A1 *	9/2014	Golden 428/69
(56)	References Cited				
	U.S. PATENT DOCUMENTS				
	3,434,917 A	3/1969	Kraus et al.		
	3,841,954 A	10/1974	Lawler		
	4,655,842 A	4/1987	Ou et al.		
	4,698,267 A	10/1987	Tokarsky		
	4,729,921 A	3/1988	Tokarsky		
	4,780,147 A	10/1988	Ou et al.		
	4,810,565 A	3/1989	Wasitis et al.		
	4,940,112 A	7/1990	O'neill		
	5,026,456 A	6/1991	Hesler et al.		
	5,030,518 A *	7/1991	Keller 428/550		
	5,084,136 A	1/1992	Haines et al.		
					FOREIGN PATENT DOCUMENTS
			EP	0044162 A2	1/1982
			EP	0501271	9/1992
			EP	0601877 A1	6/1994
			EP	1326745 B1	11/2006
			EP	2421750 B1	1/2013
			WO	2001/98434 A1	12/2001
			WO	2002/032663 A1	4/2002

(56)

References Cited

FOREIGN PATENT DOCUMENTS

WO	2006/028666	A2	3/2006
WO	2008/136875	A1	11/2008
WO	2009/052015	A2	4/2009
WO	2014/018107		1/2014

OTHER PUBLICATIONS

- U.S. Appl. No. 14/081,022, filed Nov. 15, 2013, Richardson, III et al.
- U.S. Appl. No. 14/077,394, filed Nov. 12, 2013, Richardson, III et al.
- EPO Communication with Jehier Brief (English Translation)—Oct. 23, 2013.
- EPO Communication with COGEBI Opposition Brief—Oct. 23, 2013.
- DuPont Reply Brief—May 21, 2014.
- Jacques, A. et al., Development of a Thermal/Acoustic Insulating Blanket Responding to the Far 25.856 by the Integration of Mica Flame Barrier, Fire and Cabin Safety Research Conference, Lisbon, pp. 1-9, Nov. 18, 2004.
- Gilmer, Carter T., et al., Polymer Mechanical Properties via a New Laboratory Tensile Tester, *Journal of Chemical Education*, vol. 73, No. 11, pp. 1062-1065, Nov. 1996.
- DOT/FAA/AR-00/12, Aircraft Materials Fire Test Handbook, Office of Aviation Research, Washington, D.C. 20591, Apr. 2000.
- ASTM D882-09, Standard Test Method for Tensile Properties of Thin Plastic Sheeting, ASTM International, Feb. 7, 2014.
- ASTM-F501-93, Standard Test Method for Aerospace Materials Response to Flame, With Vertical Test Specimen (For Aerospace Vehicles Standard Conditions), American Society for Testing and Materials, Mar. 11, 2014.
- ASTM E96/E96M-05.
- FAR 25.853, Oct. 15, 2004.
- FAR 25.856(b).
- FAR 25, Appendix F, Part 1—Jul. 14, 2003.
- NFPA 2112: Section 8.2.
- Affidavit—A signed statement by Mr. Dogan Ogreten, R&D Manager at Jehier SAS, the company marketing the product Terflame 29—Oct. 15, 2013.
- A description of the product Terflame 29 qualified by Airbus since Jun. 2008 and marketed since May 2008—Oct. 16, 2013.
- International Search Report and Written Opinion (PCT/US2010/031377—dated Jul. 27, 2010).
- International Preliminary Report on Patentability (PCT/US2010/031377—dated Oct. 25, 2011).
- U.S. Appl. No. 12/759,741—Non-Final Office Action dated Feb. 1, 2012.
- U.S. Appl. No. 12/759,741—Response to Non-Final Office Action dated Apr. 18, 2012.
- U.S. Appl. No. 12/759,741—Final Office Action dated Jun. 4, 2012.
- U.S. Appl. No. 12/759,741—Response to Final Office Action dated Jun. 22, 2012.
- U.S. Appl. No. 13/325,741—Non-Final Office Action dated Mar. 26, 2013.
- U.S. Appl. No. 13/325,741—Response to Non-Final Office Action dated Jul. 25, 2013.
- U.S. Appl. No. 13/325,770—Non-Final Office Action dated Mar. 26, 2013.
- U.S. Appl. No. 13/325,770—Response to Non-Final Office Action dated Jul. 25, 2013.
- U.S. Appl. No. 13/325,804—Non-Final Office Action dated Mar. 26, 2013.
- U.S. Appl. No. 13/325,804—Response to Non-Final Office Action dated Jul. 25, 2013.
- U.S. Appl. No. 14/077,394—Non-Final Office Action dated Sep. 3, 2014.
- Khang D. Tran, Light Weight Fire Barrier Materials for Aircraft Fuselage Thermal/ Acoustical Insulation; The Mexmil Company, Santa Ana, California, USA 13 Date Unavailable.
- Report on Filing of an Action Regarding a Patent (U.S. Pat. No. 8,607,926), Oct. 1, 2014, Delaware.
- Complaint (U.S. Pat. No. 8,607,926), Oct. 1, 2014, Delaware.
- Answer, Affirmative Defenses, Counterclaims (U.S. Pat. No. 8,607,926), Nov. 21, 2014, Delaware.
- Defendant's First Amended Answer (U.S. Pat. No. 8,607,926), Dec. 19, 2014, Delaware.
- Protective Order (U.S. Pat. No. 8,607,926), Mar. 23, 2015, Delaware.
- Defendant's Invalidity Contentions (Redacted) (U.S. Pat. No. 8,607,926), May 18, 2015, Delaware.
- Memorandum Order re Motion to Dismiss (U.S. Pat. No. 8,607,926), Aug. 5, 2015, Delaware.
- Plaintiff's Brief in Support of Motion to Dismiss (U.S. Pat. No. 8,607,926), Jan. 9, 2015, Delaware.
- Answer Brief in Opposition to Plaintiff's Motion to Dismiss (U.S. Pat. No. 8,607,926), Feb. 2, 2015, Delaware.
- Plaintiff's Reply in Support of Motion to Dismiss (U.S. Pat. No. 8,607,926), Feb. 12, 2015, Delaware.
- Defendant's Letter to Judge Andrews re addl authority (U.S. Pat. No. 8,607,926), Mar. 3, 2015, Delaware.
- Plaintiff's Response to Subsequent Authority (U.S. Pat. No. 8,607,926), Mar. 6, 2015, Delaware.
- Dow Corning 280A Adhesive, 2001 (no month).
- U.S. Appl No. 14/081,010—Final Office Action dated Mar. 12, 2015.
- U.S. Appl No. 14/081,010—Reply to Final Office Action dated May 18, 2015.
- U.S. Appl No. 14/081,022—Final Office Action dated Mar. 12, 2015.
- U.S. Appl No. 14/081,022—Reply to Final Office Action dated May 28, 2015.
- U.S. Appl No. 14/515,267—Non-Final Office Action dated Mar. 17, 2015.
- U.S. Appl No. 14/515,267—Reply to Non-Final Office Action dated Jun. 17, 2015.
- Unifrax's Discovery Letter, Redacted (U.S. Pat. No. 8,607,926), May 27, 2016, Delaware.
- DuPont's Discovery Letter, Redacted (U.S. Pat. No. 8,607,926), May 27, 2016, Delaware.
- Unifrax's Discovery Response, Redacted (U.S. Pat. No. 8,607,926), May 31, 2016, Delaware.
- DuPont's Discovery Response, Redacted (U.S. Pat. No. 8,607,926), May 31, 2016, Delaware.
- Order RE Discovery Dispute (U.S. Pat. No. 8,607,926), Jun. 14, 2016, Delaware.
- Unifrax's Supplemental Discovery Letter, Redacted (U.S. Pat. No. 8,607,926), Jun. 17, 2016, Delaware.
- Expert Report of Thomas J. Nosker, Ph.D. (U.S. Pat. No. 8,607,926), Jun. 17, 2016, Delaware.
- DuPont's Supplemental Discovery Letter, Redacted (U.S. Pat. No. 8,607,926), Jun. 21, 2016, Delaware.
- Unifrax's Initial Invalidity Contentions (U.S. Pat. No. 8,607,926), May 18, 2015, Delaware.
- Revised Joint Claim Construction Chart (U.S. Pat. No. 8,607,926), Sep. 30, 2015, Delaware.
- Markman Joint Claim Construction Brief (U.S. Pat. No. 8,607,926), Nov. 16, 2015, Delaware.
- Markman Hearing Transcript (U.S. Pat. No. 8,607,926), Dec. 14, 2015, Delaware.
- Unifrax's Second Amended Answer, Affirmative Defenses, and Counterclaims, Redacted (U.S. Pat. No. 8,607,926), Dec. 22, 2015, Delaware.
- Plaintiff DuPont's Answer to Defendant Unifrax's Second Amended Answer, Defenses, and Counterclaims, Redacted (U.S. Pat. No. 8,607,926), Jan. 12, 2016, Delaware.
- Markman Claim Construction Decision (U.S. Pat. No. 8,607,926), Jan. 13, 2016, Delaware.
- Letter to Judge Andrews RE: Proposed Claim Construction Orders (U.S. Pat. No. 8,607,926), Jan. 19, 2016, Delaware.

(56)

References Cited

OTHER PUBLICATIONS

Claim Construction Order (U.S. Pat. No. 8,607,926), Jan. 20, 2016, Delaware.

Defendant Unifrax's Supplemental Invalidity Contentions, Redacted (U.S. Pat. No. 8,607,926), Mar. 25, 2016, Delaware.

Stipulation and Order of Dismissal of Defendant Unifrax's Counterclaim III Without Prejudice (U.S. Pat. No. 8,607,926), Apr. 22, 2016, Delaware.

Unifrax's Motion for Leave, Redacted (U.S. Pat. No. 8,607,926), Jul. 15, 2016, Delaware.

DuPont's Opposition to Unifrax's Motion for Leave, Redacted (U.S. Pat. No. 8,607,926), Jul. 29, 2016, Delaware.

Unifrax's Motion for Leave, Redacted (U.S. Pat. No. 8,607,926), Aug. 11, 2016, Delaware.

* cited by examiner

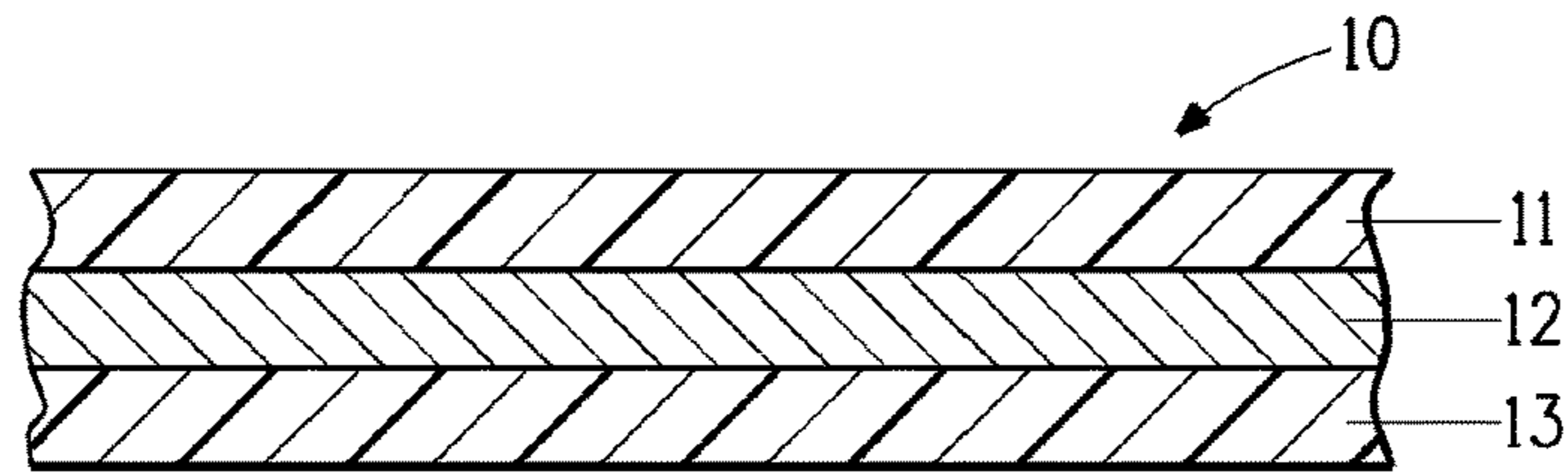


FIG. 1

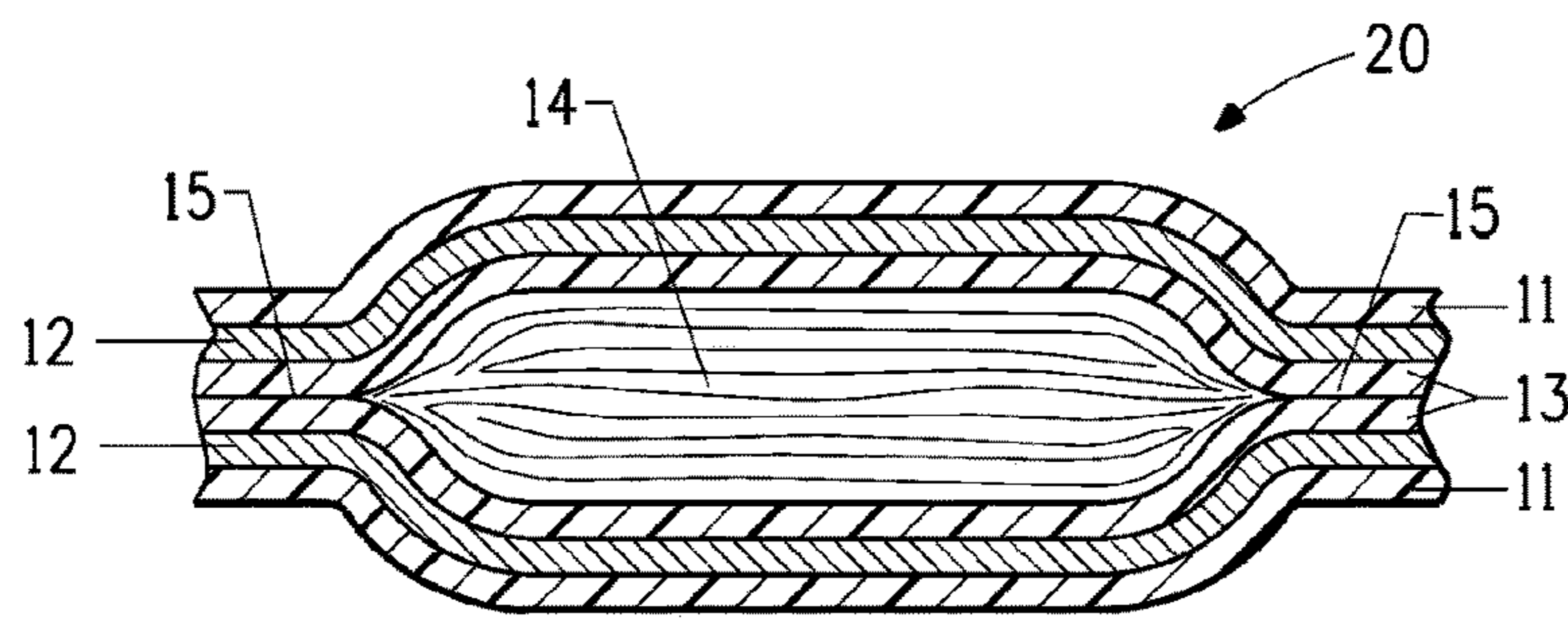


FIG. 2

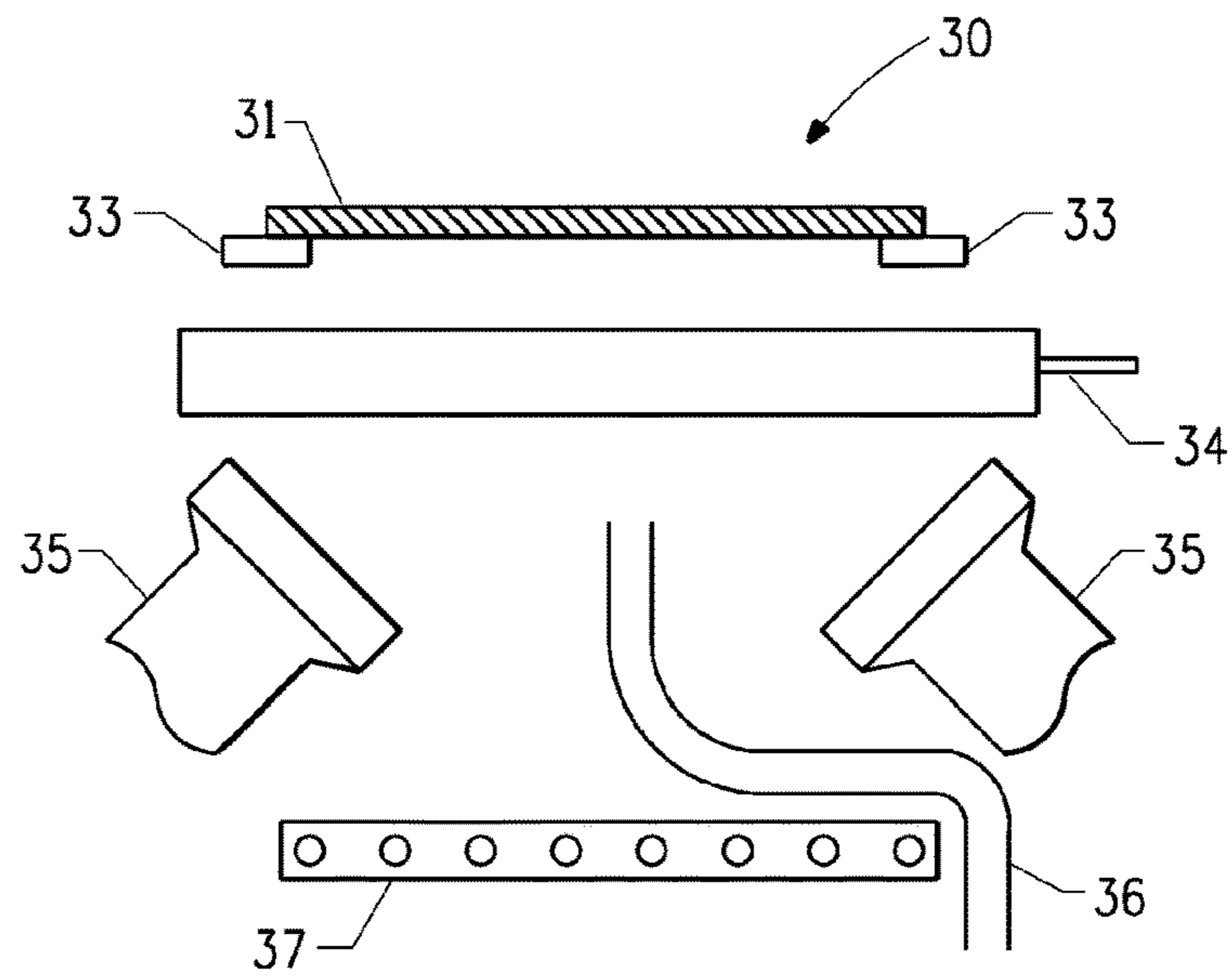


FIG. 3

COMPOSITE LAMINATE FOR A THERMAL AND ACOUSTIC INSULATION BLANKET

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

The present application is a continuation of U.S. application Ser. No. 12/759,741 filed Apr. 14, 2010.

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention covers composite thermal laminates having flame resistant properties. The invention also covers use of the composite laminate in a thermal and acoustic blanket as may be found in an aircraft fuselage or a turbine engine compartment.

2. Background of the Invention

U.S. Pat. No. 6,322,022 to Fay et al. discloses burn-through resistant systems for transportation especially aircraft.

U.S. Pat. No. 6,670,291 to Tomkins and Vogel-Martin describes a laminate sheet material for fire barrier applications.

There remains an ongoing need for thermal and acoustic blankets for aircraft structures having reduced weight and improved flame spread resistance.

SUMMARY OF INVENTION

This invention is directed to a composite laminate comprising in order (a) a polymeric moisture barrier having a thickness from 6.0 to 25.0 micrometers and a UL 94 flame classification of V-0, (b) an inorganic platelet layer having a thickness from 7.0 to 76.0 micrometers and a UL 94 flame classification of V-0 wherein the platelets comprising the platelet layer have an aspect ratio of from 100 to 20,000, and (c) a thermoplastic film layer having a thickness no greater than 25 micrometers, an average elongation to break no greater than 150% and a UL 94 flame classification of V-0. The invention is also directed to a thermal insulation and acoustic blanket comprising an inorganic or organic core surrounded by the above composite laminate wherein the thermoplastic film layer of the composite laminate contacts and encapsulates the core.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic cross section through a burnthrough resistant composite laminate of this invention.

FIG. 2 is a schematic cross section through a thermal and acoustic blanket incorporating a burnthrough resistant composite laminate of this invention.

FIG. 3 is a schematic of the equipment used for the burnthrough test.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a section through a burnthrough resistant composite laminate 10 comprising a polymeric moisture barrier 11, an inorganic platelet layer 12 and a thermoplastic film layer 13.

Moisture Barrier Layer

By moisture barrier is meant that the polymeric layer has an inability to pass liquids but has some ability to pass vapor. Typically, a 25 micrometer thick sample of the barrier material when tested by the water method of ASTM E96/E 96M-05 has a water vapor permeability not exceeding 60 g/(m²24 h). An additional requirement is that the barrier should have a UL 94 flame classification of V-0. UL 94 flame classification is an Underwriters Laboratory test, The Standard for Flammability of Plastic Materials for Parts in Devices and Appliances, which measures a material's tendency either to extinguish or to spread the flame once the specimen has been ignited. V-0 indicates that the material is tested in a vertical position and self-extinguished within ten seconds after the ignition source is removed. A further requirement of the moisture barrier is that it should have a thickness in the range of from 6.0 to 25 micrometers. More preferably the thickness range should be from 6.0 to 20.0 micrometers and most preferably in the range from 6 to 10 micrometers.

The barrier layer further provides mechanical strength and stiffness to the laminate as well as protecting the inorganic platelet layer. Preferred film materials are fluoropolymer, polyimide, polyetheretherketone (PEEK) and polyetherketoneketone (PEKK) all of which are commercially available. A suitable fluoropolymer is available from E.I. du Pont de Nemours, Wilmington, Del. under the tradename Tedlar. The surface of the barrier layer in contact with the inorganic platelet layer may optionally be treated to improve wettability and/or adhesion with the inorganic platelet layer. Suitable surface treatment methods include, but are not limited to, corona etching and washing with coupling agents such as ammonium, phosphonium or sulfonium salts. The outer surface of the barrier layer i.e. the surface not in contact with the inorganic platelet layer may optionally be coated with polytetrafluoroethylene (PTFE) or may be metalized.

Platelet Layer

The thickness of an individual platelet typically ranges from about 5 Angstroms to about 5,000 Angstroms more preferably from about 10 Angstroms to about 4,200 Angstroms. The mean value of the maximum width of a platelet typically ranges from about 10,000 Angstroms to about 30,000 Angstroms. The aspect ratio of an individual platelet typically ranges from 100 to 20,000.

In one embodiment of this invention, the inorganic platelet layer contains 100% platelets i.e. there is no carrier material such as resin, adhesive, cloth or paper. However, there may be some residual dispersant arising from incomplete drying of the platelet dispersion.

In another embodiment of this invention, a lightweight open weave fabric scrim is embedded into or laid onto the inorganic platelet layer to provide additional mechanical strength to the layer. The scrim can be made from natural, organic or inorganic fibers with glass, cotton, nylon or polyester being typical examples. A glass fiber scrim is particularly preferred for embedding into the platelet layer. The scrim may be a woven or knit structure and has a typical areal weight not exceeding 40 grams per square meter. The scrim is positioned into the platelet layer either after the platelet material has been coated onto the moisture barrier layer or while the platelet material is being coated onto the moisture barrier layer.

It is a requirement that the thickness of the platelet layer, without scrim, is from 7.0 to 76 micrometers and more preferably from 7.0 to 50 micrometers. A further requirement is that the platelet layer has a UL 94 flame classification of V-0. The function of the platelet layer, in which

adjacent platelets overlap, is to provide a flame and hot gas impermeable barrier. The inorganic platelets may be clay, such as montmorillonite, vermiculite, mica, talc and combinations thereof. Preferably, the inorganic oxide platelets are stable (i.e., do not burn, melt or decompose) at about 600 degrees C., more preferably at about 800 degrees C. and most preferably at about 1000 degrees C. Vermiculite is the preferred platelet material for this invention. Vermiculite is a hydrated magnesium aluminosilicate micaceous mineral found in nature as a multilayer crystal. Vermiculite typically comprises by (dry) weight, on a theoretical oxide basis, about 38-46% SiO₂, about 16-24% MgO, about 11-16% Al₂O₃, about 8-13% Fe₂O₃ and the remainder generally oxides of K, Ca, Ti, Mn, Cr, Na, and Ba. "Exfoliated" vermiculite refers to vermiculite that has been treated, chemically or with heat, to expand and separate the layers of the crystal, yielding high aspect ratio vermiculite platelets. Suitable vermiculite materials are available from W. R. Grace of Cambridge, Mass., under the trade designations MicroLite 963 and MicroLite HTS-XE.

Film Layer

It is a requirement that the thermoplastic film layer has a thickness no greater than 25 micrometers. In a preferred embodiment, the thermoplastic film layer has a thickness no greater than 15 micrometers. More preferably the thickness is no greater than 10 micrometers. An additional requirement is that the thermoplastic film layer also has a UL 94 flame classification of V-0. A further requirement of this film layer is that the average elongation to break of the film is no greater than 150% and more preferably no greater than 125%. By average elongation we mean the average value of the elongation as measured in the machine direction and in the transverse direction which is a direction orthogonal to the machine direction. Preferably the film layer must also be capable of softening. By softening we mean that the film layer can soften sufficiently to bond to another thermoplastic film layer without completely melting. Preferred thermoplastic materials are polyketone, polyimide, polysulfone, polyarylene sulfide, fluoropolymers, liquid crystal polymers and polycarbonate. Examples of polyketone are polyetheretherketone (PEEK) and polyetherketoneketone (PEKK). Polyethersulfone and polyphenylsulfone are examples of polysulfone. Poly(p-phenylene sulfide is a suitable polyarylene sulfide for use in this invention. Polyvinylfluoride (PVF) and polyvinylidene fluoride (PVDF) are suitable examples of fluoropolymers. Polyarylate is an example of a suitable liquid crystal polymer. Some of these films may also be coated with a second polymeric material. For example, a polyimide film, Kapton®, may be coated with fluorinated ethylene propylene, FEP and used in this invention.

In a preferred embodiment, the moisture barrier membrane layer is polyimide and the thermoplastic film layer is PEKK.

Acoustic Blanket

The composite laminate as described above may be used as a component in a thermal insulation and acoustic blanket. A thermal insulation and acoustic blanket of this invention comprises:

(a) an inorganic or organic core having a self extinguishing time no greater than 10 seconds and a maximum burn length of no greater than 102 mm when tested in accordance with BSS7230 Method F1.

(b) a composite laminate surrounding the core material the laminate further comprising

(1) a polymeric moisture barrier having a thickness from 6.0 to 25.0 micrometers and a UL 94 flame classification of V-0,

(2) an inorganic platelet layer having a thickness from 7.0 to 76.0 micrometers and a UL 94 flame classification of V-0 wherein the platelets comprising the platelet layer have an aspect ratio of from 100 to 20,000, and

(3) a thermoplastic film layer having a thickness no greater than 25 micrometers, an average elongation to break no greater than 150% and a UL 94 flame classification of V-0,

wherein the thermoplastic film layer of the composite laminate contacts and encapsulates the core.

FIG. 2 shows a section through a thermal and acoustic blanket 20 suitable for use in an aircraft fuselage comprising a core material 14 encapsulated by a burnthrough resistant composite laminate said composite laminate comprising, in order, a thermoplastic film layer 13 in contact with the core, an inorganic platelet layer 12 and a moisture barrier 11 forming the outer surface of the laminate. The blanket is placed against the interior skin of an aircraft fuselage.

It is a requirement for the core 14 to meet the following flammability requirements. In a vertical test (60 seconds ignition), when tested according to Federal Aviation Regulation, Section 25, Appendix F, Part1, the core must be self extinguishing in no greater than 10 seconds and must have a maximum burn length of no greater than 102 mm. In a 45 Degree Angle Test, when tested according to BSS7230, the self extinguishing time must be no greater than 5 seconds and the afterglow no greater than 10 seconds.

The core may be foam or an organic or inorganic fibrous material. A suitable foam material is polyimide available under the tradename INSULMIDE from Johns Manville Insulations Group, Denver, Col. or SOLIMIDE from Inspec Foams, Allen, Tex. Suitable non-metallic fibers include, but are not limited to, glass fibers, aramid fibers, crystalline ceramic oxide (including quartz) fibers, silicon nitride fibers, silicon carbide fibers, oxidized polyacrylonitrile fibers, carbon fibers, and combinations thereof.

Glass fiber is a preferred material with E-glass, a low alkali borosilicate glass, being particularly suitable. Ceramic oxide materials are typically metal oxides that have been consolidated by the action of heat. Ceramic oxide fibers generally refer to a class of fibers typically containing one or more oxides of aluminum, silicon, and boron. Many other additives may also be present (e.g., oxides of sodium, calcium, magnesium, and phosphorus) within the fibers, although the fibers include primarily metal oxides. Typically, the ceramic oxide fibers are crystalline ceramics and/or a mixture of crystalline ceramic and glass (i.e., a fiber that contains both crystalline ceramic and glass phases). Preferred ceramic oxide fibers are aluminosilicate, aluminoborosilicate, and alumina fibers, and may be in the form of yarns or in the form of staple fibers. The preferred form of non-metallic fiber is a batting which is a soft bulky assembly of fibers, usually carded. Battings have a typical density range of from 5.5 to 24.0 kg./m³. Suitable glass batting is available under the MICROLITE AA tradename from Johns Manville OEM Insulations Division, Denver, Col. The core may comprise more than one layer of material. The materials in different layers of the core need not be the same.

The core is encapsulated by the composite laminate. This is achieved by wrapping the composite laminate around the core 14 such that the thermoplastic film layer 13 is adjacent to the core. The composite laminate is subjected to sufficient heat to partially soften and fuse together the two thermoplastic film layers, as shown at 15 in FIG. 2. The thermoplastic film layers on the upper and lower surfaces of the core thus encapsulate the core around all four of its edges.

The partial softening can be achieved by means such as heat guns or ultrasonic bonding. The relative amount of core and laminate materials can be adjusted to suit particular thermal and acoustic blanket specifications but the general objective is to meet the necessary flame and noise standards at as low a blanket weight as possible. The moisture barrier outer layer of the blanket assembly minimizes moisture uptake and hence weight gain of the blanket during service. The composite laminate provides a flame spread barrier to the blanket assembly.

Test Methods

Burnthrough time was measured on a modified thermal protective performance (TPP) instrument as specified in Section 8.2 of NFPA 2112: Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire, 2007 Edition. This is further explained by reference to FIG. 3. The TPP instrument, shown generally at 30, comprises two Meeker burners 35 positioned at 45 degree angles to the vertical providing flames that intersect to impinge the sample 31. In addition there is a bank of quartz tubes 37 that provides radiant heat. The sample is held in position by supports 33. A 9.5 mm copper airflow tube 36 allows approximately 20 liters per minute of air flow through the flame thus providing mass flux pressure beneath the sample. This allows the simulation of mass flux specified in Federal Aviation Regulation (FAR) 25.856(b). Propane flow to the burners was set at 5.0 liters per minute to produce an overall heat flux at the sample of 2.3 cal/cm²-sec. with temperatures exceeding 1000° C. A water cooled shutter 34 prevents flame and heat from reaching the sample until the test is ready to start at which time the shutter is removed. Samples were subjected to the heat and mass fluxes until a hole developed in the sample, at which point the time was recorded as the burnthrough time and the test completed.

EXAMPLES

In the following examples, all parts and percentages are by weight and all degrees in centigrade unless otherwise indicated. Examples prepared according to the current invention are indicated by numerical values. Control or Comparative Examples are indicated by letters. Data and test results relating to the Comparative and Inventive Examples are shown in Table 1.

Example A was a 127 micron thick sample of Nomex® Type 418™ paper having an areal weight of 149 g/m². Nomex® Type 418™ is paper produced by blending about 50% mica platelets with short fibers (floc) and filmy particles (fibrils) of a synthetic m-aramid polymer followed by calendaring the paper at elevated temperature and pressure. Nomex® Type 418™ paper is available from E.I. DuPont de Nemours, Wilmington, Del. The use of Nomex® Type 418™ as a burnthrough barrier paper for aircraft thermal blanket applications is further described in U.S. Pat. Nos. 6,627,561 and 6,670,291 as well as in PCT patent application WO2006/028666. Three samples of this paper were submitted to the burnthrough test and gave burn times in the range of 1.05 to 2.28 minutes with an average burn time of 1.61 minutes. The end of test times were the same as the burn through times. The grade of a paper tested is compliant with FAR 25.856(b).

Example 1 was prepared in the following manner. A 7.6 micron layer of polyimide film available from DuPont under the tradename Kapton was used as the moisture barrier. The polyimide film had an areal weight of 12.2 g/m². An aqueous dispersion of MicroLite® 963 grade vermiculite platelets were used as received and coated onto the polyimide film

using an adjustable micrometer film applicator from the Paul N. Gardner Company Inc., Pompano Beach, Fla. The coated vermiculite film was dried overnight at room temperature to remove residual dispersant. The vermiculite layer had an areal weight of 37.9 g/m². A 6.0 micrometer thick layer of PEKK having an areal weight of 9.2 g/m² and an average elongation to break of 120% was used as the thermoplastic film layer and was placed onto the vermiculite layer. The composite assembly was then placed in a press at a temperature of 180° C. for 40 seconds to consolidate the layers together into a laminate weighing 59.3 g/m². The consolidated composite laminate was subjected to the burnthrough test. There was no burnthrough after 5 minutes when the test was stopped. The composite laminate weighed only 40% of that of the Nomex® Type 418™ comparator yet had a far superior burnthrough resistance.

Example 2 was prepared in the following manner. A 6.0 micrometer thick layer of PEKK having an areal weight of 9.2 g/m² was used as the moisture barrier. Platelets of MicroLite®963 grade were coated onto the PEKK film as in Example 1. The coated film was dried overnight at room temperature to remove residual traces of dispersant. The vermiculite layer had an areal weight of 51.1 g/m². A 6.0 micrometer thick layer of PEKK having an areal weight of 9.2 g/m² and an average elongation to break of 120% was used as the thermoplastic film layer and was placed onto the vermiculite layer. The composite assembly was then placed in a press at a temperature of 180° C. for 40 seconds to consolidate the layers together into a laminate weighing 69.5 g/m². The consolidated composite laminate was subjected to the burnthrough test. There was no burnthrough after 5 minutes when the test was stopped. The composite laminate weighed only 47% of that of the Nomex® Type 418™ comparator yet had a far superior burnthrough resistance.

TABLE 1

Example	Laminate Description	Burnthrough Time (min)	End of Test Time (min)
A	127 micron Nomex® Type 418™ 149 gsm	1.61	1.61
1	59.3 gsm composite of Kapton®, vermiculite and PEKK	No burnthrough	5
2	69.5 gsm composite of PEKK, vermiculite and PEKK	No burnthrough	5

It is contemplated that the composite laminate of Examples 1 or 2 can be combined with a core of fiberglass batting such as a 25.4 mm thick sheet of MicroLite® AA having a density of 6.7 Kg/m³. In such a combination, a sheet of composite laminate is placed over both outer surfaces of the batting such that the thermoplastic film layer of the laminate is adjacent to, and in contact with, the outer surfaces of the batting. Furthermore, the composite laminates are of a larger area than the batting and extend over the four edges of the batting. The batting is encapsulated by crimping together the ends of the composite laminates that extend over the batting and, by applying heat in the crimp zone to soften and fuse the two laminates together, the batting is encapsulated.

It is also contemplated that the composite laminate of Examples 1 or 2 can be combined with a core of polyimide foam such as a 25.4 mm thick sheet of Solimide® TA-301 having a density of 6.4 Kg/m³. In such a combination, a sheet of composite laminate is placed over both outer surfaces of the foam such that the thermoplastic film layer of the laminate is adjacent to, and in contact with, the outer surfaces of the foam. Furthermore, the composite laminates are of a larger area than the foam and extend over the four edges of the foam. The foam is encapsulated by crimping together the ends of the composite laminates that extend over the foam and, by applying heat in the crimp zone to soften and fuse the two laminates together, the foam is encapsulated.

What is claimed is:

1. A composite laminate comprising in order
 - (a) a polymeric moisture barrier having a thickness from 6.0 to 25.0 micrometers and a UL 94 flame classification of V-0,
 - (b) an inorganic platelet layer having a thickness from 7.0 to 76.0 micrometers and a UL 94 flame classification of V-0 wherein the platelets comprising the platelet layer have an aspect ratio of from 100 to 20,000, wherein, the inorganic platelet layer consists of 100% platelets without carrier material, and
 - (c) a thermoplastic film layer having a thickness no greater than 25 micrometers, an average elongation to break no greater than 150% and a UL 94 flame classification of V-0.
2. The composite laminate of claim 1 wherein the moisture barrier contains a polymer wherein the polymer is selected from the group consisting of fluoropolymer, polyimide, polyetheretherketone and polyetherketoneketone.
3. The composite laminate of claim 1 wherein the outer surface of the moisture barrier is metalized.
4. The composite laminate of claim 1 wherein the inorganic platelet layer contains platelets selected from the group consisting of clay, vermiculite, mica, talc and combinations thereof.
5. The composite laminate of claim 1 wherein the thermoplastic film contains polymer selected from the group consisting of polyketone, polyimide, polysulfone, polyarylene sulfide, fluoropolymer, liquid crystal polymer and polycarbonate.
6. The composite laminate of claim 5 wherein the thermoplastic film contains polymer selected from the group consisting of polyetheretherketone, polyetherketoneketone,

polyetherimide, polyethersulfone, polyphenylsulfone, poly(p-phenylenesulfide), polyvinylfluoride, polyvinylidene fluoride and polyarylate.

7. A laminate, comprising in order

- (a) a polymeric moisture barrier,
- (b) a carrier free, inorganic platelet layer consisting essentially of platelets of vermiculite, and
- (c) a thermoplastic film layer.

8. The laminate of claim 7, wherein the moisture barrier contains polymer selected from the group consisting of fluoropolymer, polyimide, polyetheretherketone and polyetherketoneketone.

9. The laminate of claim 7, wherein an outer surface of the moisture barrier is metalized.

10. The laminate of claim 7, wherein the thermoplastic film layer contains polymer selected from the group consisting of polyketone, polyimide, polysulfone, polyarylene sulfide, fluoropolymer, liquid crystal polymer and polycarbonate.

11. The laminate of claim 7, wherein the thermoplastic film layer contains polymer selected from the group consisting of polyetheretherketone, polyetherketoneketone, polyetherimide, polyethersulfone, polyphenylsulfone, poly(p-phenylenesulfide), polyvinylfluoride, polyvinylidene fluoride and polyarylate.

12. The laminate of claim 7, wherein the carrier free inorganic platelet layer consists of platelets of vermiculite.

13. The laminate of claim 7, wherein the platelets have an aspect ratio of from 100 to 20,000.

14. The laminate of claim 13, wherein the platelets have a thickness of from 5 Angstroms to 5,000 Angstroms.

15. The laminate of claim 7, wherein the carrier free inorganic platelet layer has a thickness from 7.0 to 76.0 micrometers.

16. The laminate of claim 15, wherein the polymeric moisture barrier has a thickness from 6.0 to 25.0 micrometers.

17. The laminate of claim 16, wherein the thermoplastic film layer has a thickness no greater than 25 micrometers.

18. The laminate of claim 7 wherein the polymeric moisture barrier and thermoplastic film layer are flame retardant.

19. The laminate of claim 18 wherein the polymeric moisture barrier and the thermoplastic film layer contain polyetheretherketone.

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