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(54) **FILTER MEDIA SUITABLE FOR HYDRAULIC APPLICATIONS**

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USPC 55/485-488, 527, 528; 162/141, 156, 162/157.1; 210/335, 488-490, 500.26, 210/503-505, 509; 428/300.7, 308.4, 428/304.4, 311.11, 311.51, 315.5, 315.9, 428/316.6, 210, 312.6, 426, 428
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS
3,353,682 A 11/1967 Pall et al.
3,849,241 A 11/1974 Butin et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1970131 A 5/2007
CN 101098741 A 1/2008

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion for Application No. PCT/US2008/082759 mailed Aug. 4, 2009.

(Continued)

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(57) **ABSTRACT**

Filter media, including those suitable for hydraulic applications, and related components, systems, and methods associated therewith are provided. The filter media described herein may include two or more layers, at least one of the layers having a relatively high percentage of microglass fibers. Additionally, the filter media may be designed such that the ratio of average fiber diameters between two layers is relatively small, which can lead to a relatively low resistance ratio between the layers. In some embodiments, at least one layer of the filter media comprises synthetic polymer fibers. Certain filter media described herein may have desirable properties including high dirt holding capacity and a low resistance to fluid flow. The media may be incorporated into a variety of filter element products including hydraulic filters.

40 Claims, 4 Drawing Sheets

Sample #	Layer3 Melblown Grammage (g/m ²)	Layer3 Melblown Frazier Permeability (ft ³ /ft ²)	Layer3 Melblown Thickness (mm)	Layer3 Melblown Avg. Fiber Diameter (µm)	Layer3/Layer2 Normalized Resistance Ratio	Layer3+Layer2 Composite Micron Rating (µm(c) @ Beta=200)	Layer3+Layer2 Composite DHC (g/m ²)	Layer2 Glass Grammage (g/m ²)	Layer2 Glass Frazier Permeability (ft ³ /ft ²)	Layer2 Glass Avg. Fiber Diameter (µm)	Layer2/Layer1 Normalized Resistance Ratio	Layer1 Glass Grammage (g/m ²)
1	19	68.9	0.095	0.096	3	10.4	142.70	65.1	60	4.3	4	32.5
2	19	68.9	0.095	0.096	3			32.5	119	4.3	4	65.1
3	19	68.9	0.095	0.096	5	10.9	165.92	32.5	198	5.1	2	65.1
4	19	68.9	0.095	0.096	3			32.5	119	4.3	2	65.1
5	19	68.9	0.095	0.096	3	9.9	164.94	65.1	60	4.3	2	32.5
6	19	68.9	0.095	0.096	5	11.3	181.83	65.1	99	5.1	4	32.5
7	19	68.9	0.095	0.096	5	11.4	194.72	65.1	99	5.1	2	32.5
8	20	64	0.095	0.096	3			32.5	115	4.1	5	48.8
9	20	64	0.095	0.096	4			16.3	307	4.7	4	65.1
10	20	64	0.095	0.096	4			16.3	307	4.7	6	65.1
11	20	64	0.095	0.096	2			16.3	153	2.9	6	65.1
12	20	64	0.095	0.096	2			16.3	153	2.9	4	65.1
13	20	64	0.095	0.096	4			48.8	102	4.7	6	32.5
14	20	64	0.095	0.096	2			48.8	51	2.9	4	32.5
15	20	64	0.095	0.096	3			32.5	115	4.1	5	48.8
16	20	64	0.095	0.096	4			48.8	102	4.7	4	32.5
17	20	64	0.095	0.096	2			48.8	51	2.9	6	32.5

(51)	Int. Cl.			7,008,465 B2	3/2006	Graham et al.
	B32B 5/26	(2006.01)		7,070,640 B2	7/2006	Chung et al.
	B32B 17/02	(2006.01)		7,097,694 B1	8/2006	Jaroszczuk et al.
	B32B 17/06	(2006.01)		7,137,510 B1	11/2006	Klein et al.
	G06K 9/00	(2006.01)		7,144,533 B2	12/2006	Koslow
	B01D 39/16	(2006.01)		7,163,625 B1	1/2007	Williamson et al.
	B01D 39/20	(2006.01)		7,179,317 B2	2/2007	Chung et al.
				7,235,122 B2	6/2007	Bryner et al.
				7,309,372 B2	12/2007	Kahlbaugh et al.
				7,314,497 B2	1/2008	Kahlbaugh et al.
				7,316,723 B2	1/2008	Chung et al.
				7,318,852 B2	1/2008	Chung et al.
				7,319,122 B2	1/2008	Cheng et al.
				7,390,760 B1	6/2008	Chen et al.
				7,491,770 B2	2/2009	Autran et al.
				7,597,773 B2	10/2009	Kume et al.
				7,645,312 B2	1/2010	Hamlin et al.
				7,781,527 B2	8/2010	Autran et al.
				7,918,913 B2	4/2011	Kalayci et al.
				7,960,478 B2	6/2011	Autran et al.
				7,985,802 B2	7/2011	Chien et al.
				7,993,427 B2*	8/2011	Hassmann et al. 55/486
				8,142,535 B2*	3/2012	Grove, III 55/486
				8,545,587 B2	10/2013	Guimond et al.
				8,608,817 B2	12/2013	Wertz et al.
				2001/0003082 A1	6/2001	Kahlbaugh et al.
				2001/0035094 A1	11/2001	Takagaki et al.
				2002/0013112 A1	1/2002	Bontaites et al.
				2002/0083837 A1	7/2002	Doherty
				2002/0193553 A1	12/2002	Qin et al.
				2003/0003834 A1	1/2003	Berrigan et al.
				2003/0082979 A1	5/2003	Bean et al.
				2003/0106294 A1	6/2003	Chung et al.
				2003/0150199 A1	8/2003	Tanaka et al.
				2003/0168401 A1	9/2003	Koslow
				2003/0177909 A1	9/2003	Koslow
				2003/0196963 A1	10/2003	Koslow
				2003/0196964 A1	10/2003	Koslow
				2003/0201231 A1	10/2003	Koslow
				2003/0203696 A1	10/2003	Healey
				2003/0205529 A1	11/2003	Koslow
				2003/0205530 A1	11/2003	Koslow
				2003/0205531 A1	11/2003	Koslow
				2003/0211802 A1	11/2003	Keck et al.
				2003/0213750 A1	11/2003	Koslow
				2003/0220039 A1	11/2003	Chen et al.
				2003/0226792 A1	12/2003	Tumbrink et al.
				2004/0060268 A1	4/2004	Chung et al.
				2004/0060269 A1	4/2004	Chung et al.
				2004/0083695 A1	5/2004	Schultink et al.
				2004/0112023 A1	6/2004	Choi
				2004/0116028 A1	6/2004	Bryner
				2004/0123572 A1	7/2004	Chung et al.
				2004/0135274 A1	7/2004	Matsuda et al.
				2004/0163540 A1	8/2004	Mori et al.
				2004/0178142 A1	9/2004	Koslow
				2004/0187454 A1	9/2004	Chung et al.
				2004/0211160 A1	10/2004	Rammig et al.
				2004/0226886 A1	11/2004	Hester et al.
				2004/0255783 A1	12/2004	Graham et al.
				2004/0266300 A1	12/2004	Isele et al.
				2005/0006303 A1	1/2005	Sanders
				2005/0079379 A1	4/2005	Wadsworth et al.
				2005/0109393 A1	5/2005	Anderson
				2005/0109554 A1	5/2005	Ishikawa et al.
				2005/0109557 A1	5/2005	Dravet et al.
				2005/0136292 A1	6/2005	Mariani et al.
				2005/0148261 A1	7/2005	Close et al.
				2005/0193696 A1	9/2005	Muller et al.
				2005/0217226 A1	10/2005	Sundet et al.
				2005/0235619 A1*	10/2005	Heinz et al. 55/486
				2005/0240517 A1	10/2005	Wolzenski et al.
				2005/0241598 A1	11/2005	Ezaki
				2005/0250726 A1	11/2005	Krieg et al.
				2005/0266760 A1	12/2005	Chhabra et al.
				2006/0000196 A1	1/2006	Beier et al.
				2006/0096260 A1	5/2006	Bryner et al.
(56)	References Cited					
	U.S. PATENT DOCUMENTS					
	4,018,646 A	4/1977	Ruffo et al.			
	4,033,881 A	7/1977	Pall			
	4,102,785 A *	7/1978	Head et al. 210/767			
	4,188,197 A	2/1980	Amberkar et al.			
	4,455,195 A	6/1984	Kinsley			
	4,622,259 A	11/1986	McAmish et al.			
	4,892,667 A	1/1990	Parker, III et al.			
	4,925,601 A	5/1990	Vogt et al.			
	5,108,827 A	4/1992	Gessner			
	5,135,719 A	8/1992	Hillman et al.			
	5,149,576 A *	9/1992	Potts et al. 428/198			
	5,178,931 A	1/1993	Perkins et al.			
	5,238,474 A	8/1993	Kahlbaugh et al.			
	5,240,479 A	8/1993	Bachinski			
	5,288,402 A	2/1994	Yoshida			
	5,290,446 A	3/1994	Degen et al.			
	5,306,321 A	4/1994	Osendorf			
	5,342,424 A	8/1994	Pfeffer			
	5,401,446 A	3/1995	Tsai et al.			
	5,496,507 A	3/1996	Angadjivand et al.			
	5,580,459 A	12/1996	Powers et al.			
	5,620,785 A	4/1997	Watt et al.			
	5,647,881 A	7/1997	Zhang et al.			
	5,672,188 A	9/1997	Choi			
	5,672,399 A	9/1997	Kahlbaugh et al.			
	5,702,616 A	12/1997	Degen et al.			
	5,783,503 A	7/1998	Gillespie et al.			
	5,785,725 A	7/1998	Cusick et al.			
	5,786,065 A	7/1998	Annis et al.			
	5,804,512 A	9/1998	Lickfield et al.			
	5,935,883 A	8/1999	Pike			
	5,955,174 A	9/1999	Wadsworth et al.			
	5,993,501 A *	11/1999	Cusick et al. 55/486			
	6,007,608 A	12/1999	Johnson			
	6,034,008 A	3/2000	Lim et al.			
	6,099,729 A	8/2000	Cella et al.			
	6,113,784 A	9/2000	Stoyell et al.			
	6,123,752 A	9/2000	Wu et al.			
	6,171,369 B1	1/2001	Schultink et al.			
	6,171,684 B1	1/2001	Kahlbaugh et al.			
	6,183,536 B1	2/2001	Schultink et al.			
	6,193,773 B1	2/2001	Schlor et al.			
	6,261,979 B1	7/2001	Tanaka et al.			
	6,267,252 B1	7/2001	Amsler			
	6,315,806 B1	11/2001	Torobin et al.			
	6,372,004 B1	4/2002	Schultink et al.			
	6,422,396 B1 *	7/2002	Li et al. 210/489			
	6,428,610 B1	8/2002	Tsai et al.			
	6,476,135 B1	11/2002	Bugada et al.			
	6,517,612 B1	2/2003	Crouch et al.			
	6,554,881 B1	4/2003	Healey			
	6,576,323 B2	6/2003	Wise et al.			
	6,579,350 B2	6/2003	Doherty			
	6,603,054 B2	8/2003	Chen et al.			
	H2086 H	10/2003	Amsler			
	6,743,273 B2	6/2004	Chung et al.			
	6,746,517 B2	6/2004	Benson et al.			
	6,759,356 B1	7/2004	Myers			
	6,858,057 B2	2/2005	Healey			
	6,872,311 B2	3/2005	Koslow			
	6,872,431 B2	3/2005	Kahlbaugh et al.			
	6,924,028 B2	8/2005	Chung et al.			
	6,936,554 B1	8/2005	Singer et al.			

(56)

References Cited

U.S. PATENT DOCUMENTS

2006/0137318 A1 6/2006 Lim et al.
 2006/0205306 A1 9/2006 Rock et al.
 2006/0230731 A1 10/2006 Kalayci
 2006/0277877 A1 12/2006 Shields
 2006/0292947 A1 12/2006 LaVietes et al.
 2007/0021021 A1 1/2007 Verdegan et al.
 2007/0039300 A1 2/2007 Kahlbaugh et al.
 2007/0054579 A1 3/2007 Baker et al.
 2007/0065643 A1 3/2007 Kopacz et al.
 2007/0074628 A1 4/2007 Jones et al.
 2007/0075015 A1 4/2007 Bates et al.
 2007/0084786 A1 4/2007 Smithies
 2007/0125700 A1 6/2007 Ding et al.
 2007/0138698 A1 6/2007 Gerndt et al.
 2007/0190319 A1 8/2007 Kalayci
 2007/0220852 A1 9/2007 Lifshutz et al.
 2007/0264520 A1 11/2007 Wood et al.
 2007/0271883 A1 11/2007 Chung et al.
 2007/0283808 A1 12/2007 Chung et al.
 2008/0017038 A1 1/2008 Wu
 2008/0022643 A1 1/2008 Fox et al.
 2008/0026661 A1 1/2008 Fox et al.
 2008/0032110 A1 2/2008 Wood et al.
 2008/0060328 A1 3/2008 Devine
 2008/0073296 A1 3/2008 Dema et al.
 2008/0105626 A1 5/2008 Jones et al.
 2008/0108265 A1 5/2008 Pourdeyhimi et al.
 2008/0110822 A1 5/2008 Chung et al.
 2008/0134652 A1 6/2008 Lim et al.
 2008/0160856 A1 7/2008 Chen et al.
 2008/0302072 A1* 12/2008 Hassmann et al. 55/486
 2008/0302242 A1 12/2008 Schelling et al.
 2008/0314009 A1 12/2008 Ziebold et al.
 2008/0314010 A1 12/2008 Smithies et al.
 2009/0017710 A1 1/2009 Bugada et al.
 2009/0039013 A1 2/2009 Sakadume et al.
 2009/0042475 A1 2/2009 Pourdeyhimi
 2009/0044702 A1 2/2009 Adamek et al.
 2009/0050578 A1* 2/2009 Israel et al. 210/767
 2009/0077938 A1 3/2009 Kume et al.
 2009/0078637 A1* 3/2009 Shane 210/243
 2009/0118451 A1 5/2009 Fuchs et al.
 2009/0120048 A1 5/2009 Wertz et al.
 2009/0120868 A1 5/2009 Huppchen et al.
 2009/0142234 A1 6/2009 Tatarchuk et al.
 2009/0266759 A1 10/2009 Green
 2009/0301304 A1 12/2009 Bass et al.
 2010/0000411 A1 1/2010 Wertz et al.
 2010/0031618 A1* 2/2010 Grove, III 55/524
 2010/0044289 A1 2/2010 Koslow
 2010/0107881 A1 5/2010 Healey et al.
 2010/0133173 A1 6/2010 Inagaki
 2010/0187171 A1* 7/2010 Gupta 210/491
 2010/0187712 A1 7/2010 Gupta et al.
 2010/0233927 A1 9/2010 Standaert
 2010/0252510 A1 10/2010 Godsay et al.
 2010/0282682 A1 11/2010 Eaton et al.
 2010/0285101 A1 11/2010 Moore et al.
 2010/0297720 A1 11/2010 Medoff et al.
 2010/0323573 A1 12/2010 Chu et al.
 2011/0059668 A1 3/2011 Bieser et al.
 2011/0139706 A1 6/2011 Kalayci et al.
 2011/0147976 A1 6/2011 Wertz et al.
 2011/0215046 A1* 9/2011 Rogers et al. 210/491
 2011/0259813 A1 10/2011 Wertz et al.
 2012/0108714 A1 5/2012 Wittner
 2012/0152821 A1 6/2012 Cox et al.
 2012/0152824 A1 6/2012 Cox et al.
 2012/0318754 A1 12/2012 Cox et al.

FOREIGN PATENT DOCUMENTS

DE 10 2005 059 214 A1 6/2007
 DE 10 2005 059 214 B4 10/2007
 DE 10 2006 017 553 B3 12/2007
 DE 20 2007 015 994 U1 1/2008
 EP 0 109 282 B1 9/1988
 EP 0 462 574 A1 12/1991
 EP 0 612 551 A2 8/1994
 EP 0 587 682 B1 4/1995
 EP 0 391 661 B1 9/1995
 EP 1 048 335 A1 11/2000
 EP 1 236 494 B1 10/2003
 EP 1 048 335 B1 4/2005
 EP 1 721 555 A1 11/2006
 EP 1 775 006 A1 4/2007
 EP 1 795 248 A3 3/2008
 EP 1 483 039 B1 4/2008
 JP 2002-001027 A 1/2002
 JP 2008-095266 A 4/2008
 WO WO 00/02006 A2 1/2000
 WO WO 01/98574 A2 12/2001
 WO WO 02/16681 A1 2/2002
 WO WO 02/20668 A2 3/2002
 WO WO 03/064006 A1 8/2003
 WO WO 03/064013 A1 8/2003
 WO WO 2004/028662 A2 4/2004
 WO WO 2004/069378 A2 8/2004
 WO WO 2004/112937 A1 12/2004
 WO WO 2005/034659 A2 4/2005
 WO WO 2006/030407 A1 3/2006
 WO WO 2006/049664 A1 5/2006
 WO WO 2006/053295 A1 5/2006
 WO WO 2006/071979 A1 7/2006
 WO WO 2006/071980 A1 7/2006
 WO WO 2006/074383 A2 7/2006
 WO WO 2006/096180 A1 9/2006
 WO WO 2007/024445 A1 3/2007
 WO WO 2007/041310 A2 4/2007
 WO WO 2007/041311 A2 4/2007
 WO WO 2007/068302 A1 6/2007
 WO WO 2007/068408 A1 6/2007
 WO WO 2007/068444 A1 6/2007
 WO WO 2007/076015 A2 7/2007
 WO WO 2007/112443 A2 10/2007
 WO WO 2008/011450 A1 1/2008
 WO WO 2008/016771 A1 2/2008
 WO WO 2008/057397 A1 5/2008
 WO WO 2008/057431 A2 5/2008
 WO WO 2008/066813 A2 6/2008
 WO WO 2008/103736 A1 8/2008
 WO WO 2008/150548 A2 12/2008
 WO WO 2009/085679 A1 7/2009
 WO WO 2011/058118 A1 5/2011

OTHER PUBLICATIONS

International Preliminary Report on Patentability for Application No. PCT/US2008/082759 mailed May 20, 2010.
 International Search Report and Written Opinion for Application No. PCT/US2010/000996 mailed Nov. 29, 2010.
 International Preliminary Report on Patentability for Application No. PCT/US2010/000996 mailed Oct. 13, 2011.
 International Search Report for Application No. PCT/US2011/054898 mailed Feb. 27, 2012.
 European Search Report for EP 10759158.8 mailed on Dec. 5, 2012.
 International Search Report and Written Opinion for PCT/US2011/034074 mailed on Jul. 11, 2011.
 International Preliminary Report on Patentability for PCT/US2011/034074 mailed on Nov. 8, 2012.
 [No Author Listed] Global industrial solutions, vacuum dehydration oil purification system. Brochure. Date not available.
 [No Author Listed] Utipor III filter element specifications. Pall Corporation. Date not available. pp. 15-19.
 [No Author Listed] Vacuum dehydration oil purification system. Brochure. Oil Filtration Systems, Inc. Date unavailable.

(56)

References Cited

OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT/US2011/065499 mailed Apr. 20, 2012.

International Preliminary Report on Patentability for Application No. for PCT/US2011/065499 mailed Jun. 27, 2013.

International Preliminary Report on Patentability for Application No. for PCT/US2011/054898 mailed Feb. 27, 2014.

International Search Report and Written Opinion for PCT/US2013/046746 mailed Nov. 5, 2013.

Berkalp, Air Permeability & Porosity in Spun-laced Fabrics. *Fibres and Textiles in Eastern Europe*. 2006; 14(3): 81-5.

Dahiya et al., Melt Blown Technology. Apr. 2004. 13 pages.

Keith et al., The Surface Area of Fibrous Filters. *Tobacco Science*. 1977;68-72. Accessed Sep. 19, 2013.

* cited by examiner

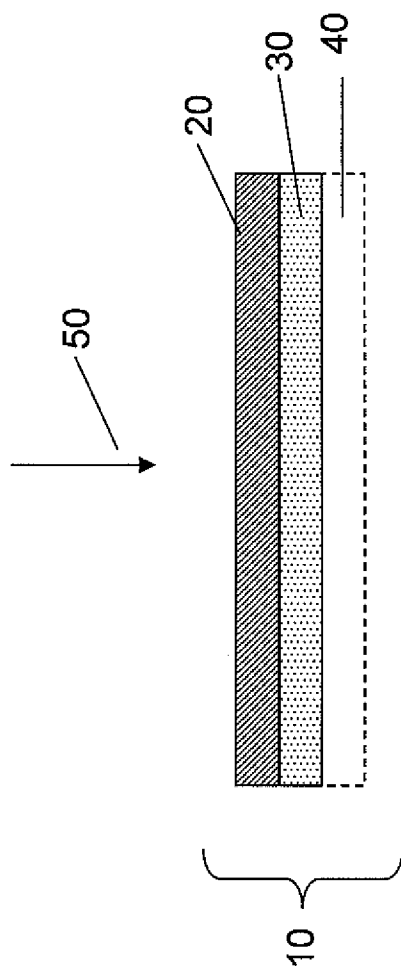


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