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(54) **Title:** MULTI-LAYER FLUOROPOLYMER FOAM STRUCTURE

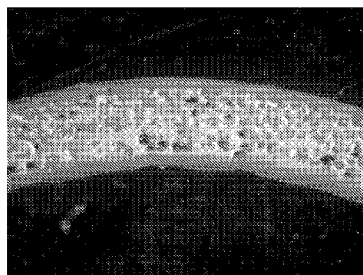


Figure 2

(57) **Abstract:** The invention relates to multi-layer articles consisting of at least one layer of a foamed fluoropolymer. The article is formed by co-extrusion in which the foamed layer is coextruded as a foam, and not foamed in a secondary process. Preferably the fluoropolymer foam is a polyvinylidene fluoride (PVDF), such as KYNAR PVDF from Arkema Inc. The article could be sized into a specific shape during the manufacturing process. Useful multi-layer articles of the invention include pipe, tube, sheet, profile, film, jacketing or any other multilayer foam-core articles are especially useful.



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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/55511

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16L 11/00; C08J 9/00; C08K 3/04 (2013.01)

USPC - 138/103, 115; 428/36.91

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): F16L 11/00, 11/04; C08J 9/00, 9/06, 9/34; C08K 3/04, 3/22, 3/26, 3/30, 3/34; C08L 27/16, 27/18, 27/20 (2013.01)

USPC: 138/103, 115, 116, 137, 141; 428/36.91; 521/51, 79, 82

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

MicroPatent (US Granted, US Applications, EP-A, EP-B, WO, JP, DE-G, DE-A, DE-T, DE-U, GB-A, FR-A); Espacenet; Google Scholar; ProQuest; IP.com; coextruded, expand, foam, fluoropolymer, hexafluoropropylene, melting-point, multi-layer, PVDF, polyvinylidene fluoride, tie-layer

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2005/0056332 A1 (MARTUCCI, NS et al.) 17 March 2005; figures 1-2; paragraphs [0002], [0019]-[0029], [0033]	17 ----- 1-16
X --- Y	US 2012/0045603 A1 (ZERAFATI, S et al.) 23 February 2012; paragraphs [0001]-[0004], [0011]-[0012], [0028]-[0037], [0042]	17-19 ----- 1-16
Y	US 2003/0106602 A1 (HSICH, HS et al.) 12 June 2003; paragraphs [0017], [0019], [0022], [0060]-[0064]; claim 1	5, 15-16
Y	US 5,885,494 A (VENKATARAMAN, SK et al.) 23 March 1999; figure 1; column 1, lines 29-31; column 2, lines 2-4; column 2, line 62 to column 3, line 22; column 4, lines 8-25	7
A	US 2009/0107558 A1 (QUIGLEY, PA et al.) 30 April 2009; entire document	1-17
A	US 2011/0224318 A1 (GLEW, CA et al.) 15 September 2011; entire document	1-19
A	US 2010/0119748 A1 (HENRY, JJ et al.) 13 May 2010; entire document	1-17

☐ Further documents are listed in the continuation of Box C.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/55511

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-16 are directed to a multi-layer structure.

Group II: Claims 17-19 are directed toward a process for the production of a multi-layer foamed fluoropolymer foam structure.

---Continued Within the Next Supplemental Box---

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/55511

\*\*\*-Continued From Box III Above: Observations where unity of invention is lacking-\*\*\*

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical features of Group I include at least one layer comprising a foamed crystalline or semi-crystalline fluoropolymer having a density of at least 3 percent less than an unfoamed semicrystalline fluoropolymer of the same composition, wherein said foamed semicrystalline fluoropolymer is coextruded as a foam, and a thermoplastic polymer layer, which is not present in Group II; the special technical features of Group II include a process for the production of a multi-layer foamed fluoropolymer foam structure comprising the steps of a) coextruding: 1) a fluoropolymer foam- comprising the steps of (a) blending a fluoropolymer resin, optional blowing agent and optional nucleating agent; b) processing the fluoropolymer resin, optional blowing agent, and optional nucleating agent and other additives and gas formed either upon the heating of the blowing agent or by injection of a gas, to form a homogeneous mixture; c) cooling the fluoropolymer/ gas mixture in the end of the extruder, adapter and/or die, and d) extruding the fluoropolymer/gas mixture from the extruder to form a fluoropolymer foam; and 2) at least one other fluoropolymer; b) cooling the resulting structure; and c) optionally cutting the resulting cooled structure to a desired size, which is not present in Group I.

The common technical features of Groups I and II are two coextruded layers comprising a fluoropolymer foam and a second polymer layer.

These common technical features are disclosed by US 2005/0056332 A1 to Martucci, et al. (hereinafter 'Martucci'). Martucci discloses two coextruded layers (tubular first layer 12 and jacket 14 disposed about first layer, utilizing known melt extruded techniques; figures 1 and 2; paragraphs [0002], [0019], [0020], [0025]) comprising a fluoropolymer foam (first layer 12 ideally of polyvinylidene fluoride thermoplastic foams; paragraphs [0020], [0021], [0027]) and a second polymer layer (jacket 14 preferably unexpanded ETFE, polyamide or nylon; paragraph [0023]).

Since the common technical features are previously disclosed by Martucci, these common features are not special and so Groups I and II lack unity.