

(19)



(11)

EP 2 323 506 B2

(12)

NEW EUROPEAN PATENT SPECIFICATION

After opposition procedure

(45) Date of publication and mention of the opposition decision:
27.07.2016 Bulletin 2016/30

(51) Int Cl.:
A24D 3/02 ^(2006.01) **A24D 3/06** ^(2006.01)
A24D 3/08 ^(2006.01)

(45) Mention of the grant of the patent:
10.04.2013 Bulletin 2013/15

(86) International application number:
PCT/US2009/044829

(21) Application number: **09751566.2**

(87) International publication number:
WO 2009/143338 (26.11.2009 Gazette 2009/48)

(22) Date of filing: **21.05.2009**

(54) **APPARATUS AND ASSOCIATED METHOD FOR FORMING A FILTER COMPONENT OF A SMOKING ARTICLE AND SMOKING ARTICLES MADE THEREFROM**

VORRICHTUNG UND DAMIT IN ZUSAMMENHANG STEHENDES VERFAHREN ZUR BILDUNG EINER FILTERKOMPONENTE EINES RAUCHARTIKELS, UND DARAUS HERGESTELLTER RAUCHARTIKEL

APPAREIL ET PROCÉDÉ ASSOCIÉ POUR FORMER UN COMPOSANT DE FILTRE D UN ARTICLE À FUMER ET ARTICLES À FUMER QUI EN SONT CONSTITUÉS

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR

- **ARZONICO, Barbara, Walker**
Winston-Salem, NC 27106 (US)
- **HUTCHENS, Ronald, Keith**
East Bend, NC 27018 (US)

(30) Priority: **25.02.2009 US 392725**
21.05.2008 US 124891
21.05.2008 US 124874

(74) Representative: **Hoeger, Stellrecht & Partner**
Patentanwälte mbB
Uhlandstrasse 14c
70182 Stuttgart (DE)

(43) Date of publication of application:
25.05.2011 Bulletin 2011/21

- (56) References cited:
- | | |
|-----------------------------|----------------------------|
| EP-A1- 0 987 276 | EP-A1- 1 167 589 |
| WO-A1-98/49912 | WO-A1-2006/059134 |
| WO-A1-2006/059134 | WO-A1-2007/026131 |
| WO-A2-2007/085830 | WO-A2-2009/016513 |
| BE-A7- 1 007 973 | DE-A1- 1 298 032 |
| DE-B3-102006 025 738 | FR-A5- 2 103 346 |
| GB-A- 1 058 343 | GB-A- 1 331 096 |
| GB-A- 2 223 393 | GB-A- 2 223 393 |
| US-A- 3 428 049 | US-A1- 2003 098 033 |
| US-A1- 2003 200 973 | US-A1- 2005 066 981 |
| US-A1- 2007 068 540 | |

(60) Divisional application:
12181299.4 / 2 537 427

(73) Proprietor: **R.J. Reynolds Tobacco Company**
Winston-Salem, NC 27102 (US)

- (72) Inventors:
- **ANDRESEN, Norman, Philip**
Lewisville, NC 27023 (US)
 - **DUBE, Michael, Francis**
Winston-Salem, NC 27106 (US)

EP 2 323 506 B2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] Embodiments of the present invention relate to the formation of tobacco products, such as smoking articles (e.g., cigarettes), and more particularly, to apparatuses and associated methods for inserting an adsorbent material into a cigarette filter.

Description of Related Art

[0002] Popular smoking articles, such as cigarettes, have a substantially cylindrical rod shaped structure and include a charge, roll or column of smokable material, such as shredded tobacco (e.g., in cut filler form), surrounded by a paper wrapper, thereby forming a so-called "smokable rod" or "tobacco rod." Normally, a cigarette has a cylindrical filter element aligned in an end-to-end relationship with the tobacco rod. Typically, a filter element comprises plasticized cellulose acetate tow circumscribed by a paper material known as "plug wrap." Certain filter elements can incorporate polyhydric alcohols. Typically, the filter element is attached to one end of the tobacco rod using a circumscribing wrapping material known as "tipping paper." Descriptions of cigarettes and the various components thereof are set forth in Tobacco Production, Chemistry and Technology, Davis et al. (Eds.) (1999). A cigarette is employed by a smoker by lighting one end thereof and burning the tobacco rod. The smoker then receives mainstream smoke into his/her mouth by drawing on the opposite end (e.g., the filter end) of the cigarette.

[0003] Certain cigarettes incorporate filter elements having adsorbent materials dispersed therein, such as activated carbon or charcoal materials (collectively, carbonaceous materials) in particulate or granular form (i.e., powder). For example, an exemplary cigarette filter can possess multiple segments, and at least one of those segments can comprise particles of high carbon-content materials. Various types of filters incorporating charcoal particles or activated carbon types of materials are set forth in U.S. Pat. Nos. 2,881,770 to Touey; 3,101,723 to Seligman et al.; 3,236,244 to Irby et al.; 3,311,519 to Touey et al.; 3,347,247 to Lloyd; 3,349,780 to Sublett et al.; 3,370,595 to Davis et al.; 3,413,982 to Sublett et al.; 3,602,231 to Dock; 3,972,335 to Tiggelbeck et al.; 5,360,023 to Blakley et al.; and 6,537,186 to Veluz; U.S. Pat. Publication No. 2007/0056600 to Coleman, III et al.; PCT WO 2006/064371 to Banerjea et al. and PCT WO 2006/051422 to Jupe et al..

[0004] As mentioned, such carbonaceous material types are typically in the form of particles or granules when incorporated into the filter elements. For example, granules of carbonaceous material can be incorporated into "dalmation" types of filter regions using the general

types of techniques used for traditional dalmation filter manufacture. Techniques for production of dalmation filters are known, and representative dalmation filters have been provided commercially by Filtrona Greensboro Inc.

5 Alternatively, granules of carbonaceous material can be incorporated into "cavity" types of filter regions using the general types of techniques used for traditional "cavity" filter manufacture. Alternatively, other known types of techniques and equipment for producing filter segments incorporating granular materials can be suitably altered so as to introduce carbonaceous material into the filter segments. However, such techniques often are rudimentary in that the particulates or granules of carbonaceous material are roughly inserted into the filter element as either a loose powder or a slurry, a process which can be described as, for example, inconsistent, wasteful, and "messy."

[0005] As such, there exists a need for apparatuses and methods for inserting the adsorbent material into the filter segments/elements of a smoking article in a manner facilitating a cleaner and more efficient process. Such apparatuses and methods should desirably be able to insert the adsorbent material in various forms into the filter element.

SUMMARY OF THE INVENTION

[0006] The above and other needs are met by embodiments of the present invention which, according to various aspects, provide apparatuses, as defined by claims 1 to 5, and methods, as defined by claims 6 to 13, for inserting an adsorbent material carried by a carrier material into a filter rod member of a smoking article. Accordingly, one aspect relates to an apparatus for forming filter rods used in the manufacture of smoking articles, wherein each rod has an adsorbent material, carried by a carrier material, inserted into the filter rod along its length such that, when the rod is longitudinally subdivided into rod portions, each rod portion includes at least a portion of the adsorbent material. The apparatus incorporates equipment for supplying a continuous supply of filter material (e.g., a filter tow processing unit adapted to supply filter tow to a continuous rod forming unit). A representative apparatus may also include, for example, a hopper and rotating wheel arrangement such as disclosed in U.S. Patent Application Publication No. US 2007/0068540 A1 to Thomas et al., operably engaged with the filter supply equipment, for supplying the carrier material carrying the adsorbent material to the filter material. Other arrangements for inserting objects into the filter material are disclosed, for example, in U.S. Patent No. 4,862,905 to Green, Jr. et al. (i.e., insertion of individual strand portions); U.S. Patent Application Publication No. US 2007/0068540 A1 to Thomas et al. (i.e., insertion of capsules); U.S. Patent Application No. 11/461,941 to Nelson et al. (i.e., insertion of continuous strands); U.S. Patent Application No. 11/760,983 to Stokes et al. (i.e., insertion of continuous strands); and

U.S. Patent No. 7,074,170 to Lanier, Jr. et al..

[0007] The continuous supply of filter material is formed, for example, by a rod-forming unit into a continuous cylindrical rod member. The carrier material carrying the adsorbent material is inserted by an insertion unit into the rod member. In some aspects, the continuous rod may then be subdivided at predetermined intervals by a rod-dividing unit so as to form a plurality of filter rods or rod portions or filter elements such that each rod portion includes at least a portion of the adsorbent material.

[0008] In some aspects, a method of forming a cigarette filter rod member comprises forming a continuous supply of a filter material into a continuous cylindrical rod member, and inserting an adsorbent material carried by a carrier material into the rod member such that the adsorbent material is disposed within the rod member. Such a method may further comprise dividing the rod member into a plurality of rod portions along the longitudinal axis thereof such that each rod portion includes at least a portion of the adsorbent material.

[0009] A cigarette filter can comprise at least one filter segment having one or more composite fiber structures imbedded therein, the composite fiberstructure comprising a carrier fiber and an adsorbent fiber (e.g., a carbonaceous fiber), the adsorbent fiber comprising an adsorbent material. Exemplary carbonaceous fibers can be prepared by carbonization of a precursor fiber, such as phenolic fibers, cellulosic fibers, rayon fibers, acrylic fibers, and pitch fibers. In certain embodiments, the filter comprises one or more segments of fibrous tow material, such as cellulose acetate tow.

[0010] The composite fiber structure can comprise multiple carrier fibers or multiple adsorbent fibers. One or both of the carrier fiber and adsorbent fiber can be in the form of a yarn. The entire composite fiber structure can also be in the form of a yarn. The carrier fiber acts as a carrier for the adsorbent fiber, such as by enwrapping the adsorbent fiber around the carrier fiber.

[0011] In another aspect, a cigarette filter can comprise at least one filter segment having at least one degradable fiber imbedded therein, such as a biodegradable fiber. The fiber can be any strand, thread, or yarn that has any of a variety of cross-sections, including a circular or a flattened cross-section. The fiber can provide a visual difference or a textural/tactile difference to the filter element. The fiber itself could alter the character or nature of the smoke passing through the filter, or optionally carry an additive capable of altering the character or nature of the smoke (e.g., such as one or more adsorbent materials, flavorants, deodorizing agents, or combinations thereof). The additive can be carried by, or associated with, the degradable fiber using a variety of techniques, such as by absorption of the additive into the fiber structure, coating of the additive onto the fiber structure, adherence of a solid additive onto the surface of the fiber, or wrapping of an additive in the form of a fiber (e.g., a carbonaceous fiber) around the degradable fiber.

[0012] Exemplary biodegradable fibers include cellu-

losic fibers, polyvinyl alcohol, aliphatic polyesters, aliphatic polyurethanes, cis-polyisoprene, cis-polybutadiene, polyhydroxy alkanooates, polyanhydrides, and copolymers and blends thereof. In one embodiment, the biodegradable fiber is a bamboo fiber or a polylactic acid fiber.

[0013] Smoking articles can incorporate a filter element as described herein, such as a smoking article comprising a rod of smokable material circumscribed by a wrapping material, the rod of smokable material being attached to a cigarette filter.

[0014] Embodiments of the present invention thus provide significant advantages as disclosed herein in further detail.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In order to assist the understanding of embodiments of the invention, reference will now be made to the appended drawings, which are not necessarily drawn to scale. The drawings are exemplary only, and should not be construed as limiting the invention.

FIG. 1 is an exploded perspective view of a smoking article having the form of a cigarette, showing the smokable material, the wrapping material components, and the filter element of the cigarette;

FIG. 2 is a cross-sectional view of a filter element incorporating an adsorbent material therein according to one embodiment of the present invention;

FIGS. 3A-3D are cross-sectional views of a smoking article having the form of a cigarette, showing the smokable material, the wrapping material components, and the adsorbent material-containing filter element of that cigarette;

FIG. 4 is a schematic of a rod-making apparatus including a portion of the filter tow processing unit, a source of an adsorbent material carried by a carrier material, an insertion unit, and a filter rod-forming unit, in accordance with one embodiment of the present invention;

FIG. 5 is a cross-sectional view of a filter element incorporating a carbonaceous fiber carried by a carrier fiber; and

FIG. 6 is a perspective view of a carbonaceous fiber carried by a carrier fiber.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The present inventions now will be described more fully hereinafter with reference to the accompanying drawing. The invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout. As used in this specification and

the claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

[0017] Referring to FIG. 1, there is shown a smoking article **10** in the form of a cigarette and possessing certain representative components of a smoking article produced or formed by the present invention. The cigarette **10** includes a generally cylindrical rod **12** of a charge or roll of smokable filler material contained in a circumscribing wrapping material **16**. The rod **12** is conventionally referred to as a "tobacco rod." The ends of the tobacco rod **12** are open to expose the smokable filler material. The cigarette **10** is shown as having one optional band **22** (e.g., a printed coating including a film-forming agent, such as starch, ethylcellulose, or sodium alginate) applied to the wrapping material **16**, and that band circumscribes the cigarette rod in a direction transverse to the longitudinal axis of the cigarette. That is, the band **22** provides a cross-directional region relative to the longitudinal axis of the cigarette. The band **22** can be printed on the inner surface of the wrapping material (i.e., facing the smokable filler material), or less preferably, on the outer surface of the wrapping material. Although the cigarette can possess a wrapping material having one optional band, the cigarette also can possess wrapping material having further optional spaced bands numbering two, three, or more.

[0018] At one end of the tobacco rod **12** is the lighting end **18**, and at the mouth end **20** is positioned a filter element **26**. The filter element **26** positioned adjacent one end of the tobacco rod **12** such that the filter element and tobacco rod are axially aligned in an end-to-end relationship, preferably abutting one another. Filter element **26** may have a generally cylindrical shape, and the diameter thereof may be essentially equal to the diameter of the tobacco rod. The ends of the filter element **26** permit the passage of air and smoke therethrough.

[0019] In some instances, the filter element **26** may be configured as shown in FIG. 2, wherein the filter includes a first filter segment **32** positioned adjacent one end of the tobacco rod **12**. The first filter segment **32** includes filter material **40** (e.g., cellulose acetate tow impregnated with plasticizer, such as triacetin). In other instances, the filter element **26** may not be divided into segments, such as shown in FIG. 3. With continuing reference to FIG. 2, within the filter material **40** of the first segment may be inserted an adsorbent material/particulate **50**. Previously, such adsorbent material **50** had been roughly inserted into the filter material **40**. That is, the adsorbent material **50** had been inserted while in a loose particulate form, such as a powder or slurry. Further, within the filter material **40** of the first segment may also be optionally dispersed a plurality of particles **52** or otherwise breakable or rupturable capsules comprising a flavoring agent. In certain embodiments where a carbonaceous material is used as the adsorbent material **50**, at least a portion of the carbonaceous material, and typically virtually all of the carbonaceous material, is in intimate contact with an

effective amount of a mixture of polyol ester (e.g., triacetin) and polyol (e.g., propylene glycol). If desired, the filter element also can be incorporate other components that have the ability to alter the properties of the mainstream smoke that passes throughout the filter element. See, for example, U.S. Pat. Application Publication Nos. 2004/0237984 to Figlar et al.; 2005/0268925 to Schluter et al.; 2006/0130861 to Luan et al.; and 2006/0174899 to Luan et al..

[0020] The filter element **26** may also possess a second filter segment **36** longitudinally disposed relative to the first segment **32** and positioned at the extreme mouth end of the cigarette **10**. The second filter segment **36** includes filter material **48** (e.g., cellulose acetate tow impregnated with plasticizer, such as triacetin) that is overwrapped along the longitudinally extending surface thereof with circumscribing plug wrap material **28**. The second filter segment **36** may be substantially free of adsorbent and breakable or rupturable capsules, meaning that such additives are not visible when viewing the extreme mouth end of the filter element **26**.

[0021] The filter element **26** is circumscribed along its outer circumference or longitudinal periphery by a layer of outer plug wrap **28**. The outer plug wrap **28** overlies each of the first filter segment **32** and the second filter segment **36**, so as to provide a combined, two-segment filter element.

[0022] The filter element **26** is attached to the tobacco rod **12** using tipping material **46** (e.g., essentially air impermeable tipping paper), that circumscribes both the entire length of the filter element **26** and an adjacent region of the tobacco rod **12**. The inner surface of the tipping material **46** is fixedly secured to the outer surface of the plug wrap **28** and the outer surface of the wrapping material **16** of the tobacco rod, using a suitable adhesive; and hence, the filter element and the tobacco rod are connected to one another. See also the tipping materials and configurations set forth in U.S. Pat. Publication No. 2008/0029111 to Dube et al..

[0023] A ventilated or air diluted smoking article can be provided with an optional air dilution mechanisms, such as a series of perforations **30**, each of which extend through the tipping material and plug wrap. The optional perforations **30**, shown in FIG. 1, can be made by various techniques known to those of ordinary skill in the art, such as laser perforation techniques. Alternatively, so-called off-line air dilution techniques can be used (e.g., through the use of porous paper plug wrap and pre-perforated tipping paper). For cigarettes that are air diluted or ventilated, the amount or degree of air dilution or ventilation can vary. Frequently, the amount of air dilution for an air diluted cigarette is greater than about 10 percent, generally is greater than about 20 percent, often is greater than about 30 percent, and sometimes is greater than about 40 percent. Typically, the upper level for air dilution for an air diluted cigarette is less than about 80 percent, and often is less than about 70 percent. As used herein, the term "air dilution" is the ratio (expressed as a

percentage) of the volume of air drawn through the air dilution means to the total volume and air and smoke drawn through the cigarette and exiting the extreme mouth end portion of the cigarette.

[0024] During use, the smoker lights the lighting end **18** of the cigarette **10** using a match or cigarette lighter. As such, the smokable material **12** begins to burn. The mouth end **20** of the cigarette **10** is placed in the lips of the smoker. Thermal decomposition products (e.g., components of tobacco smoke) generated by the burning smokable material **12** are drawn through the cigarette **10**, through the filter element **26**, and into the mouth of the smoker. During draw, certain amount of certain gaseous components of the mainstream smoke are removed from the mainstream smoke or neutralized by the adsorbent material **50** within the filter element **26**. Filters incorporating such adsorbent material **50**, such as carbonaceous filter components (e.g., activated charcoal particles), have the capability of capturing a wide range of mainstream tobacco smoke vapor phase components. If desired, prior to, during or after the smoking experience, the smoker can optionally squeeze the filter element. As a result, at least a portion of the optional breakable capsules that remain unbroken can be broken, and hence release the particles **52** of flavoring agent contained therein.

[0025] Other filter element arrangements may be produced or formed without departing from embodiments of the present invention. For example, the filter element **26** could include more than the two segments set forth in FIG. 2. Although less preferred, the filter element **26** could also include a cavity formed between two filter material segments, with the adsorbent material **50** and the optional flavoring agent **52** mixed together therein. Although it is preferable to avoid positioning the filter segment comprising the adsorbent material **50** and optional flavoring agent **52** at the extreme mouth end of the filter, it is not necessary for the filter segment comprising these additives to be located at the tobacco end of the filter. Instead, the filter segment comprising the dispersed additives can be more centrally located within the filter element **26** with one or more filter segments toward each end that do not contain the additives.

[0026] The dimensions of a representative cigarette **10** can vary. Preferred cigarettes are rod shaped, and can have diameters of about 7.5 mm (e.g., circumferences of about 20 mm to about 27 mm, often about 22.5 mm to about 25 mm); and can have total lengths of about 70 mm to about 120 mm, often about 80 mm to about 100 mm. The length of the filter element **30** can vary. Typical filter elements can have total lengths of about 15 mm to about 40 mm, often about 20 mm to about 35 mm. For a typical dual-segment filter element, the downstream or mouth end filter segment often has a length of about 10 mm to about 20 mm; and the upstream or tobacco rod end filter segment often has a length of about 10 mm to about 20 mm.

[0027] If desired, suitable catalytic compounds, e.g.,

for the conversion of carbon monoxide to carbon dioxide, can be incorporated into one or more segments of the filter element **26**. Exemplary catalysts include noble metals (e.g., silver, gold, platinum), metal oxides, ceramics, and mixtures thereof.

[0028] As illustrated in FIG. 2, one filter element **26** that may be formed in accordance with the present invention comprises multiple, longitudinally-extending segments. Each segment can have varying properties and may include various materials capable of filtration or adsorption of particulate matter and/or vapor phase compounds from the mainstream smoke. Typically, the filter element of various aspects of the invention includes 2 to 6 segments, frequently 2 to 4 segments. In some instances, the filter element **26** may include a mouth end segment and a tobacco end segment, with the tobacco end segment comprising the dispersed adsorbent material **50** and flavoring agent **52**.

[0029] As shown in FIG. 2, the filter element may incorporate adsorbent material/particulate **50**. Such adsorbent material **50** may be a material with relatively high surface area capable of adsorbing smoke constituents without a high degree of specificity, or a material that adsorbs certain compounds with a greater degree of specificity, such as an ion exchange resin. Exemplary types of adsorbent material may include activated carbon, a molecular sieve (e.g., zeolites and carbon molecular sieves), clay, an ion exchange resin, activated alumina, silica gel, meerschaum, and combinations thereof. Any adsorbent material, or mixture of materials, that has the ability to alter the character or nature of mainstream smoke passing through the filter element may be used.

[0030] Exemplary ion exchange resins comprise a polymer backbone, such as styrene-divinylbenzene (DVB) copolymers, acrylates, methacrylates, phenol formaldehyde condensates, and epichlorohydrin amine condensates, and a plurality of electrically charged functional groups attached to the polymer backbone, and can be a weak base anion exchange resin or a strong base anion exchange resin. Commercially available embodiments of such resins include DIAION® ion-exchange resins available from Mitsubishi Chemical Corp. (e.g., WA30 and DCA11), DUOLITE® ion exchange resins available from Rohm and Haas (e.g., DUOLTTE® A7), and XOR-BEX resins available from Dalian Trico Chemical Co. of China.

[0031] A preferred adsorbent is a carbonaceous material, which is a material that is composed primarily of carbon, and preferred carbonaceous materials are composed of virtually all carbon. Typically carbonaceous materials comprise carbon in amounts of more than about 85 percent, generally more than about 90 percent, often more than about 95 percent, and frequently more than about 98 percent, by weight. The carbonaceous material can have the form of charcoal, but most preferably is an activated carbon material. Activated carbon materials are high surface area materials. Exemplary activated carbon materials have surface areas of more than about 200

m²/g, often more than about 1000 m²/g, and frequently more than about 1500 m²/g, as determined using the Brunaver, Emmet and Teller (BET) method described in J. Amer. Chem. Soc., Vol. 60(2), pp. 309-319 (1938). Suitable examples of such carbonaceous materials are disclosed, for example, in WO 2007/104908 to White et al.; WO 2007/093757 to Awty et al.; WO 2007/010249 to Fiebelkorn; WO 2007/028957 to Lee; WO 2006/136950 to Nunziata et al.; WO 2006/103404 to Cashmore et al.; WO 2005/118133 to Branton et al.; WO 2005/112670 to Bhattacharyya et al.; WO 2005/082180 to Sampson et al.; WO 2005/023026 to Branton et al.; WO 2004/095957 to Bray et al.; WO 2004/014161 to Grzonka; WO 2003/092416 to Dittrich et al.; WO 2003/034847 to Abhulimen et al.; WO 2003/051144 to Schlüter et al.; WO 2003/034848 to Abhulimen et al.; WO 2001/041590 to Bushby et al.; and US Pat. No. 7,370,657 to Zhuang et al.

[0032] The filter element **26** may incorporate an effective amount of adsorbent material **50**, such as an effective amount of activated carbon. The effective amount is an amount that, when incorporated into the filter element **26**, provides some desired degree of alteration of the mainstream smoke of a cigarette incorporating that filter element **26**. For example, a cigarette filter element incorporating activated carbon particles or granules can act to lower the yield of certain gas phase components of the mainstream smoke passing through that filter element. Typically, the amount of carbonaceous material or other adsorbent within the filter element is at least about 20 mg, often at least about 30 mg, and frequently at least about 40 mg, on a dryweight basis. Typically, the amount of carbonaceous material or other adsorbent material **50** within the filter element does not exceed about 500 mg, generally does not exceed about 400 mg, often does not exceed about 300 mg, and frequently does not exceed about 200 mg, on a dry weight basis.

[0033] The carbonaceous materials can be derived from synthetic or natural sources. Materials such as rayon or nylon can be carbonized, followed by treatment with oxygen to provide activated carbonaceous materials. Materials such as wood and coconut shells can be carbonized, followed by treatment with oxygen to provide activated carbonaceous materials. The level of activity of the carbon may vary. Typically, the carbon has an activity of about 60 to about 150 Carbon Tetrachloride Activity (i.e., weight percent pickup of carbon tetrachloride). Preferred carbonaceous materials are provided by carbonizing or pyrolyzing bituminous coal, tobacco material, softwood pulp, hardwood pulp, coconut shells, almond shells, grape seeds, walnut shells, macadamia shells, kapok fibers, cotton fibers, cotton linters, and the like. Examples of suitable carbonaceous materials are activated coconut hull based carbons available from Calgon Corp. as PCB and GRC-11 or from PICA as G277, coal-based carbons available from Calgon Corp. as S-Sorb, Sorbite, BPL, CRC-11F, FCA and SGL, wood-based carbons available from Westvaco as WV-B, SA-20 and BSA-20, carbonaceous materials available from Calgon Corp.

as HMC, ASC/GR- 1 and SC II, Witco Carbon No. 637, AMBERSORB 572 or AMBERSORB 563 resins available from Rohm and Haas, and various activated carbon materials available from Prominent Systems, Inc. Other carbonaceous materials are described in U.S. Pat. Nos. 4,771,795 to White, et al. and 5,027,837 to Clearman, et al.; and European Patent Application Nos. 236,922; 419,733 and 419,981.

[0034] Preferred carbonaceous materials are coconut shell types of activated carbons available from sources such as Calgon Carbon Corporation, Gowrishankar Chemicals, Carbon Activated Corp. and General Carbon Corp. See, also, for example, Activated Carbon Compendium, Marsh (Ed.) (2001), which is incorporated herein by reference.

[0035] Certain carbonaceous materials can be impregnated with substances, such as transition metals (e.g., silver, gold, copper, platinum, and palladium), nanoparticles, potassium bicarbonate, tobacco extracts, polyethyleneimine, manganese dioxide, eugenol, and 4-ketono-nanoic acid. The carbon composition may also include one or more fillers, such as semolina. Grape seed extracts may also be incorporated into the filter element **20** as a free radical scavenger. Sintered or foamed carbon materials (see, e.g., US Pat. No. 7,049,382 to Haftka et al.) or gathered webs (see, e.g., US Pat. Appl. Pub. Nos. US 2008/0092912 to Robinson et al. and US 2007/0056600 to Coleman, III et al.) may be other options for incorporating an adsorbent material **50** into a filter element **20**.

[0036] Various types of charcoals and activated carbon materials suitable for incorporation into cigarette filters, various other filter element component materials, various types of cigarette filter element configurations and formats, and various manners and methods for incorporating carbonaceous materials into cigarette filter elements, are set forth in U.S. Pat Nos. 3,217,715 to Berger et al.; 3,648,711 to Berger et al.; 3,957,563 to Sexstone; 4,174,720 to Hall; 4,201,234 to Neukomm; 4,223,597 to Lebert; 5,137,034 to Perfetti et al.; 5,360,023 to Blakley et al.; 5,568,819 to Gentry et al.; 5,622,190 to Arterbery et al.; 6,537,186 to Veluz; 6,584,979 to Xue et al.; 6,761,174 to Jupe et al.; 6,789,547 to Paine III; and 6,789,548 to Bereman; US Pat. Appl. Pub. Nos. 2002/0166563 to Jupe et al.; 2002/0020420 to Xue et al.; 2003/0200973 to Xue et al.; 2003/0154993 to Paine et al.; 2003/0168070 to Xue et al.; 2004/0194792 to Zhuang et al.; 2004/0226569 to Yang et al.; 2004/0237984 to Figlar et al.; 2005/0133051 to Luan et al.; 2005/0049128 to Buhl et al.; 2005/0066984 to Crooks et al.; 2006/0144410 to Luan et al.; 2006/0180164 to Paine, III et al.; and 2007/0056600 to Coleman, III et al.; European Pat. Appl. 579410 to White; and PCT WO 2006/064371 to Banerjee et al.. Representative types of cigarettes possessing filter elements incorporating carbonaceous materials have been available as "Benson & Hedges Multifilter" by Philip Morris Inc., in the State of Florida during 2005 as a Philip Morris

Inc. test market brand known as "Marlboro Ultra Smooth," and as "Mild Seven" by Japan Tobacco Inc.

[0037] In light of the aforementioned issues associated with insertion of loose particulates or granules of carbonaceous material into the filter element as either a loose powder or a slurry, which may be inconsistent, wasteful, inefficient, and/or "messy," one aspect of the present disclosure, as shown, for example, in FIGS. **3A-3D**, involves engaging the adsorbent material **50** with a carrier material **55** prior to insertion of the resulting assembly into the filter element **26** (or a continuous filter rod before longitudinal severance thereof to form multiple filter elements **26**). Selection of a suitable carrier material **55** may facilitate, for example, improved production by more effectively and efficiently inserting the now "captive" adsorbent material **50** into the filter element **26**. That is, the adsorbent material **50** is carried by the carrier material **55** upon insertion thereof into the filter element **26**. In some embodiments, the carrier material **55** may be in the form of, for example, a pellet (FIG. **3A**), a capsule (FIG. **3B**), a tube (FIG. **3C**), a continuous elongate structure, a continuous strip, a strand or the like capable of receiving and "holding captive" the adsorbent material **50** (FIG. **3D**) so as to facilitate insertion thereof into the filter element **26** in a cleaner, more effective manner. In some embodiments, individual or multiple forms of the carrier material **55** may be inserted into the filter element **26**. For example, individual or multiple capsules, tubes, pellets, etc. or combinations thereof may be inserted into the filter element **26** in accordance with various aspects.

[0038] In some instances, the carrier material **55** may comprise a matrix material, such as, for example, a polymer material, which may be impregnated with the adsorbent material **50** (i.e., the adsorbent material **50** may be suspended in or otherwise held by the matrix material) such that the adsorbent material **50** may be carried with and by the matrix material into the filter element **26**. For example, in some embodiments, the matrix material may comprise a high-density or low-density polymer material, such as, for example, polyethylene or polypropylene, impregnated with the adsorbent material **50** or otherwise having the adsorbent material **50**, such as, for example, a carbonaceous material (e.g., activated carbon, charcoal) dispersed therein. Preferably, the adsorbent material **50** is relatively evenly dispersed, but such even dispersion may not be absolutely necessary. In embodiments where the carrier material **55** is formed as a tubular or capsular member, the adsorbent material **50** may be inserted into the tubular or capsular member so as to be contained thereby upon insertion into the filter element **26**. In embodiments where the carrier material **55** is formed as a continuous elongate structure, the adsorbent material **50** may engage, contact, or otherwise interact with the continuous elongate structure such that the adsorbent material **50** can be carried into the filter element **26** thereby. In embodiments where the carrier material **55** is formed as a continuous strip, the continuous strip may be lengthwise wrapped around the adsorbent ma-

terial **50** so as to contain the adsorbent material **50** therein (i.e., similar to a "tube") for insertion into the filter element **26**.

[0039] Accordingly, the carrier material **55** may have a form that can be generally characterized as a containment or capturing vehicle for the adsorbent material **50** that hold the same in a relatively secure manner such that the adsorbent material **50** can be delivered into the filter element/rod **26** via the carrier material **55** in a captive manner, as compared to the loose powdered, granular, or particulate form of the adsorbent material **50** inserted within filter element **26** of smoking articles in some prior art processes. As such, the insertion or incorporation of the carrier material **55** carrying the adsorbent material **50** into the filter element **26** may be accomplished in a "cleaner" and more consistent and efficient manner (i.e., since the adsorbent material **50** is held "captive"), as compared to directing a loose powdered adsorbent material **50**, or slurry form thereof, into the filter elements **26** (i.e., less dust, spillage, overflow, contamination, cross-contamination, etc.). Such benefits may, in turn, translate into, for instance, less maintenance, a faster process, higher efficiency and/or more consistent delivery of the adsorbent material **50**, and increased safety. Further, the carrier material **55** may be readily configured in any manner suitable for facilitating insertion thereof into individual filter elements **26**. Other advantages may include a consistent measured size and/or amount of an adsorbent material introduced into, partially disposed in, deposited in, intimately placed with, centrally located in, disposed within, extending substantially all the way through, or otherwise engaged with the filter material of the filter element of the smoking article. In some instances, a matrix material such as a gel-type substance or otherwise suitable substance may contain, though not necessarily through impregnation, the adsorbent material **50** in a form capable of being incorporated within an individual filter element **26**. In other instances, the carrier material **55** carrying the adsorbent material **50** may comprise a strand, strip, or otherwise elongate structure that is severed to form individual portions capable of being inserted into the filter rod and/or filter element **26**.

[0040] In some instances, the carrier material **55** may be in the form of a pellet. In such instances, the pellets may be produced using devices such as the FL-M Series granulator equipment (e.g., FL-M-3) from Vector Corporation and as WP 120V and WP 200VN from Alexanderwerk, Inc. Exemplary compaction devices, such as compaction presses, are available as Colton 2216 and Colton 2247 from Vector Corporation and as 1200i, 2200i, 3200, 2090, 3090 and 4090 from Fette Compacting. Devices for providing outer coating layers to compacted pelletized formulations are available as CompuLab 24, CompuLab 36, Accela-Cota 48 and Accela-Cota 60 from Thomas Engineering.

[0041] The pellets may be manufactured using a wide variety of extrusion techniques. For example, such pellets may be manufactured using co-extrusion techniques

(e.g., using a twin screw extruder). In such a situation, successive wet or dry components or component mixtures can be placed within separate extrusion hoppers. Steam, gases (e.g., ammonia, air, carbon dioxide, and the like), and humectants (e.g., glycerin or propylene glycol) can be injected into the extruder barrel as each dry mix is propelled, plasticized, and cooked. As such, the various components are processed so as to be very well mixed, and hence, come in complete contact with each other. For example, the contact of components is such that individual components (e.g., adsorbent material or flavoring agents) may be well embedded in the extrusion matrix or extrudate. See, for example, US Pat. No. 4,821,749 to Toft et al..

[0042] The carrier material **55** carrying the adsorbent material **50** may be incorporated within a segment of a cavity filter (e.g., as pellets within the central cavity region of a three-segment or stage filter element). Alternatively, the carrier material **55** carrying the adsorbent material **50** may be dispersed within a fibrous filter material (e.g., as pellets dispersed throughout a filter tow or gathered non-woven web material) as a segment of longitudinally multi-segmented filter element (e.g., a two-segment filter element).

[0043] According to another aspect of the present invention, after insertion of the carrier material **55** / adsorbent material **50** assembly into the filter element **26** (or the continuous filter rod), the adsorbent material **50** may be released from the carrier material **55** and into the filter material. For example, carrier material **55** may be dissolved, disintegrated, degraded, or otherwise destroyed *in situ* so as to release and/or disperse or otherwise effectively expose the adsorbent material **50** into the filter element **26** such that the adsorbent material **50** can have the desired effect on the mainstream smoke drawn through the filter element **26**. Accordingly, a representative cigarette filter element **26** may possess the adsorbent material **50** within at least one component or segment of the filter element in a manner sufficient to affect the mainstream smoke gas phase removal within the filter element **26**.

[0044] In instances, where the adsorbent material **50** comprises a carbonaceous material, the moisture content of the carbonaceous material (or any other suitable adsorbent) can vary. Typically, the moisture content of the carbonaceous material or other adsorbent within the filter element, prior to use of the cigarette incorporating that filter element, is less than about 30 percent, often less than about 25 percent, and frequently less than about 20 percent, based on the combined weight of the carbonaceous material and moisture. Typically, the moisture content of the carbonaceous material or other adsorbent within the filter element, prior to use of the cigarette incorporating that filter element, is greater than about 3 percent, often greater than about 5 percent, and frequently greater than about 8 percent, based on the combined weight of the carbonaceous material and moisture.

[0045] In some instances, an optional flavoring agent may also be impregnated or otherwise suspended or included within or on the carrier material **55**, in addition to the adsorbent material **50**. That is, the carrier material **55** may carry both the adsorbent material **50** and an optional flavoring agent into the filter element **26**. As such, the complexity of the formation process for the filter element **26** and/or smoking article may be reduced. For example, in some embodiments, the carrier material **55** may comprise a polymer matrix material impregnated with the adsorbent material **50**, such as, for example, a carbonaceous material, and an optional flavoring agent. Accordingly, a single insertion device/step may only be needed to insert the adsorbent material **50** and the optional flavoring agent, rather than using multiple insertion devices/steps to insert the adsorbent material **50** and the optional flavoring agent (i.e., in the form of a rupturable capsule) into the filter element **26**.

[0046] In other embodiments of the present invention, the adsorbent material **50** may be formed as a sphere, pellet, capsule, tube or other structured object, with or without the carrier material **55**. For example, the pellets may be manufactured using a wide variety of extrusion techniques. For instance, such pellets may be manufactured using co-extrusion techniques (e.g., using a twin screw extruder). For example, a spherical carbon object may be formed so as to be more easily inserted into the filter material (e.g., cellulose acetate tow). In some instances, the as-formed adsorbent material **50** may be provided with a carrier material **55** in the form of an "outer shell" through the application of, for example, food grade shellac, ethyl cellulose, any suitable hydrophobic coating, or an electrostatically-applied material, to the adsorbent material object. Such a resulting object may be inserted with an object-insertion device, as commonly known in the art, such as those used to insert rupturable capsules containing flavoring agents. As such, one skilled in the art will appreciate that spheres, capsules, or other forms of the adsorbent material **50** may be inserted in a similar manner (as well as embodiments wherein the carrier material **55** carries the adsorbent material **50**). In such embodiments, for example, one or more spherical carbon objects may be disposed within the filter material of the smoking article. Such objects formed as a sphere, pellet, tube, etc. may provide a concentrated form of the adsorbent material **50** into the filter material. As such, the particles comprising the object may have to be released and/or dispersed into or otherwise exposed to the filter element **26** to have the desired effect. For example, a force (physical, sound wave, or otherwise) may be employed while the object is disposed *in situ* within the filter element **26** to rupture, crack, or otherwise break, degrade, or disintegrate the adsorbent material **50** and/or carrier material **55** comprising the object so as to disperse or otherwise release the adsorbent material **50** into the filter element **26**. This step may occur at any point after which the object has been inserted into the filter material. That is, this step could be employed

late in the manufacturing process, such as after fabrication of the entire smoking article. In other instances, the step may occur directly after insertion of the object into the filter rod.

[0047] The size and weight of a capsule may vary. Certain types of capsules are generally spherical in shape. However, suitable capsules may have other types of shapes, such as generally rectilinear, oblong, elliptical, or oval shapes. Exemplary generally spherical capsules have diameters of less than about 3.5 mm, generally less than about 1.5 mm, often less than about 1 mm, and frequently less than about 0.5 mm. For example, several capsules can be employed, and those capsules can be in the range of about 0.25 mm to about 2 mm in diameter. A plurality of very small capsules, commonly referred to as "microcapsules," can also be incorporated within the filter element (see, e.g., various microencapsulation options available from Euracli, which protect the active ingredient (from oxidation, humidity, etc.) and allows the active ingredient to be released at the desired moment either by rupture of the membrane when subjected to a precise mechanical action or via a protracted diffusion through the membrane for an extended effect), wherein such microcapsules may, in some instances, be held together in a cohesive manner by an appropriate binder material. The total weight of the capsules contained within the filter may vary, but is typically greater than about 10 mg, often greater than about 20 mg, and can be greater than about 30 mg. The total weight of the capsules is typically less than about 200 mg, often less than about 100 mg, and can be less than 50 mg.

[0048] The number of capsules incorporated into the filter element can vary, depending upon factors such as the size of the capsules, the character or nature of the payload (i.e., adsorbent material, optional flavoring agent or both), the positioning of the capsules within the filter element, and the like. The number of capsules incorporated within the relevant region of the filter element can exceed about 5, can exceed about 10, can exceed about 20, can exceed about 40, and can even exceed about 100. In certain embodiments, the number of capsules can be greater than about 500, and even greater than about 1,000. Larger numbers of capsules in certain embodiments can be advantageous because it can provide the smoker with increased control over the smoke-affecting properties of the payload.

[0049] Filter elements of the present invention can be incorporated within the types of cigarettes set forth in US Pat. Nos. 4,756,318 to Clearman et al.; 4,714,082 to Banerjea et al.; 4,771,795 to White et al.; 4,793,365 to Sensabaugh et al.; 4,989,619 to Clearman et al.; 4,917,128 to Clearman et al.; 4,961,438 to Korte; 4,966,171 to Serrano et al.; 4,969,476 to Bale et al.; 4,991,606 to Serrano et al.; 5,020,548 to Farrier et al.; 5,027,836 to Shannon et al.; 5,033,483 to Clearman et al.; 5,040,551 to Schlatter et al.; 5,050,621 to Creighton et al.; 5,052,413 to Baker et al.; 5,065,776 to Lawson; 5,076,296 to Nystrom et al. ; 5,076,297 to Farrier et al.; 5,099,861 to Clearman et al. ;

5,105,835 to Drewett et al.; 5,105,837 to Barnes et al.; 5,115,820 to Hauser et al.; 5,148,821 to Best et al.; 5,159,940 to Hayward et al.; 5,178,167 to Riggs et al.; 5,183,062 to Clearman et al.; 5,211,684 to Shannon et al.; 5,240,014 to Deevi et al.; 5,240,016 to Nichols et al. ; 5,345,955 to Clearman et al.; 5,396,911 to Casey, III et al.; 5,551,451 to Riggs et al.; 5,595,577 to Bensalem et al.; 5,727,571 to Meiring et al.; 5,819,751 to Barnes et al.; 6,089,857 to Matsuura et al.; 6,095,152 to Beven et al.; and 6,578,584 Beven; and US Pat. Appl. Serial Nos. US 2007/0215167 to Crooks et al. and US 2008/00092912 to Robinson et al.. For example, filter elements of the present invention can be incorporated within the types of cigarettes that have been commercially marketed under the brand names "Premier" and "Eclipse" by R. J. Reynolds Tobacco Company. See, for example, those types of cigarettes described in Chemical and Biological Studies on New Cigarette Prototypes that Heat Instead of Burn Tobacco, R. J. Reynolds Tobacco Company Monograph (1988) and Inhalation Toxicology, 12:5, p. 1-58 (2000).

[0050] Cigarette rods typically are manufactured using a cigarette making machine, such as a conventional automated cigarette rod making machine. Exemplary cigarette rod making machines are of the type commercially available from Molins PLC or Hauni-Werke Korber & Co. KG. For example, cigarette rod making machines of the type known as MkX (commercially available from Molins PLC) or PROTOS (commercially available from Hauni-Werke Korber & Co. KG) can be employed. A description of a PROTOS cigarette making machine is provided in U.S. Patent No. 4,474,190 to Brand, at col. 5, line 48 through col. 8, line 3. Types of equipment suitable for the manufacture of cigarettes also are set forth in U.S. Patent Nos. 4,781,203 to La Hue; 4,844,100 to Holznagel; 5,131,416 to Gentry; 5,156,169 to Holmes et al.; 5,191,906 to Myracle, Jr. et al.; 6,647,870 to Blau et al.; 6,848,449 to Kitao et al.; and 6,904,917 to Kitao et al.; and U.S. Patent Application Publication Nos. 2003/0145866 to Hartman; 2004/0129281 to Hancock et al.; 2005/0039764 to Barnes et al.; and 2005/0076929 to Fitzgerald et al..

[0051] The components and operation of conventional automated cigarette making machines will be readily apparent to those skilled in the art of cigarette making machinery design and operation. For example, descriptions of the components and operation of several types of chimneys, tobacco filler supply equipment, suction conveyor systems and garniture systems are set forth in U.S. Patent Nos. 3,288,147 to Molins et al.; 3,915,176 to Heitmann et al.; 4,291,713 to Frank; 4,574,816 to Rudszinat; 4,736,754 to Heitmann et al. 4,878,506 to Pinck et al.; 5,060,665 to Heitmann; 5,012,823 to Keritsis et al. and 6,360,751 to Fagg et al.; and U.S. Patent Publication No. 2003/0136419 to Muller. The automated cigarette making machines of the type set forth herein provide a formed continuous cigarette rod or smokable rod that can be subdivided into formed smokable rodsof desired lengths.

[0052] Various types of cigarette components, including tobacco types, tobacco blends, top dressing and casing materials, blend packing densities and types of paper wrapping materials for tobacco rods, can be employed. See, for example, the various representative types of cigarette components, as well as the various cigarette designs, formats, configurations and characteristics, that are set forth in Johnson, Development of Cigarette Components to Meet Industry Needs, 52nd T.S.R.C. (Sept., 1998); U.S. Patent Nos. 5,101,839 to Jakob et al.; 5,159,944 to Arzonico et al.; 5,220,930 to Gentry and 6,779,530 to Kraker; U.S. Patent Publication Nos. 2005/0016556 to Ashcraft et al.; 2005/0066986 to Nestor et al.; 2005/0076929 to Fitzgerald et al.; and 2007/0056600 to Coleman, III et al.; U.S. Patent Application Serial Nos. 11/375,700, filed March 14, 2006, to Thomas et al. and 11/408,625, filed April 21, 2006, to Oglesby. Most preferably, the entire smokable rod is composed of smokable material (e.g., tobacco cut filler) and a layer of circumscribing outer wrapping material.

[0053] As such, another aspect of the present invention comprises an apparatus suitably configured for incorporating the adsorbent material 50 with the carrier material 55, and, in some instances, an optional flavoring agent 52, forming the filter element of the smoking article by incorporating the carrier material 55 carrying the adsorbent material 50, and/or for forming the smoking article itself having such a filter element incorporating the carrier material 55 / adsorbent material 50. To that end, apparatuses have been developed for providing filter rods for use in the manufacture of smoking articles, wherein each rod has one or more forms of the carrier material 55 (e.g., pellets, capsules, strands, or combinations thereof) carrying the adsorbent material 50, disposed along the length of the rod, such that, when the rod is subdivided into rod portions, each rod portion includes at least one form of the carrier material 55 carrying the adsorbent material 50. See, for example, U.S. Patent No. 7,115,085 to Deal. Such apparatuses can incorporate equipment for supplying a continuous supply of filter material (e.g., a filter tow processing unit adapted to supply filter tow to a continuous rod forming unit). A representative apparatus may also include, for example, an object delivery device such as a hopper and rotating wheel arrangement disclosed in U.S. Patent Application Publication No. US 2007/0068540 A1 to Thomas et al., for supplying certain forms of the carrier material 55 carrying the adsorbent material 50 into the filter material. In still other instances, multiple forms of the carrier material 55 (i.e., pellets and/or strands, or at least one of a pellet or strand in combination with at least one other of the pellet or strand) can be inserted into the filter material by an object-insertion unit. Arrangements for inserting such strands/objects into the filter material are disclosed, for example, in U.S. Patent Application No. 11/461,941 to Nelson et al. (US 2008/0029118 A1) and U.S. Patent Application No. 11/760,983 to Stokes et al..

[0054] A rod-making apparatus 210 as illustrated in

FIG. 4, in some instances, may include a forming unit 450 configured to engage the adsorbent material 50 with the carrier material 55 in an on-line or off-line manner to form an insertion object. For example, the forming unit 450 may be configured to insert the adsorbent material 50 into a tubular or capsular member comprising the carrier material 55, to suspend the adsorbent material 50 in a matrix material comprising the carrier material 55, to engage the adsorbent material 50 with a continuous elongate member comprising the carrier material 55, and/or to wrap a continuous strip member comprising the carrier material 55 about the adsorbent material 50. Once the insertion object is formed, the insertion object can be delivered from the forming unit 450 to an insertion unit/device 214 configured to insert the carrier material 55 carrying the adsorbent material 50 into the filter material. In some instances, the forming unit may be in cooperation with or otherwise linked to such an insertion unit/device 214 (i.e., on-line vs off-line). Still in other embodiments, the forming unit 450 and the insertion unit/device 214 may be a single unit configured to perform both functions of forming the carrier material 55 carrying the adsorbent material 50, and inserting the carrier material 55 carrying the adsorbent material 50 into the filter material.

[0055] During the manufacturing process, the filter material may be formed into a continuous rod having the carrier material 55 carrying the adsorbent material 50 disposed therein and extending along the longitudinal axis thereof. The continuous rod then may be subdivided at predetermined intervals so as to form a plurality of filter rods or rod portions such that each rod portion includes at least a portion of the adsorbent material 50 therein. In instances of the carrier material 55 comprising, for example, a pellet and a strand, the pellets may be disposed at predetermined positions within and along the filter rod or filter element, while the strand, if any, extends through the filter rod or filter element.

[0056] As shown in FIG. 4, an exemplary rod-making apparatus 210 may include a rod-forming unit 212 (e.g., a KDF-2 unit available from Hauni-Werke Korber & Co. KG) and an object-insertion unit 214 suitably adapted to provide for placement of the insertion object(s) along a continuous length of filter material 40. The continuous length or web of filter material may be supplied from a source (not shown) such as a storage bale, bobbin, spool or the like. Generally, the filter material 40 may be processed using a filter material processing unit 218. The continuous length of filter material has the carrier material 55 carrying the adsorbent material 50 incorporated therein by the object insertion unit 214, and is then passed through the rod-forming unit 212 to thereby forming a continuous rod 220. The continuous rod 220 can be subdivided using a rod cutting assembly 222 into a plurality of rod portions 205 each having at least a portion of the adsorbent material 50 disposed therein. The succession or plurality of rod portions 205 may be collected for use in collection device 226 which may be a tray, a rotary collection drum, conveying system, or the like. If desired,

the rod portions can be transported directly to a cigarette making machine.

[0057] The filter material **40** can vary, and can be any material of the type that can be employed for providing a tobacco smoke filter for cigarettes. Preferably a traditional cigarette filter material is used, such as cellulose acetate tow, gathered cellulose acetate web, polypropylene tow, gathered cellulose acetate web, gathered paper, strands of reconstituted tobacco, or the like. Especially preferred is filamentary tow such as cellulose acetate, polyolefins such as polypropylene, or the like. One highly preferred filter material that can provide a suitable filter rod is cellulose acetate tow having 3 denier per filament and 40,000 total denier. As another example, cellulose acetate tow having 3 denier per filament and 35,000 total denier can provide a suitable filter rod. As another example, cellulose acetate tow having 8 denier per filament and 40,000 total denier can provide a suitable filter rod. For further examples, see the types of filter materials set forth in US Pat. Nos. 3,424,172 to Neurath; 4,811,745 to Cohen et al.; 4,925,602 to Hill et al.; 5,225,277 to Takegawa et al. and 5,271,419 to Arzonico et al.

[0058] Filamentary tow, such as cellulose acetate, may be processed using a conventional filter tow processing unit 218 such as a commercially available E-60 supplied by Arjay Equipment Corp., Winston-Salem, N.C. Other types of commercially available tow processing equipment, as are known to those of ordinary skill in the art, may similarly be used. Normally a plasticizer such as triacetin or carbowax is applied to the filamentary tow in traditional amounts using known techniques. In one embodiment, the plasticizer component of the filter material comprises triacetin and carbowax in a 1:1 ratio by weight. The total amount of plasticizer is generally about 4 to about 20 percent by weight, preferably about 6 to about 12 percent by weight. Other suitable materials or additives used in connection with the construction of the filter element will be readily apparent to those skilled in the art of cigarette filter design and manufacture. See, for example, U.S. Patent No. 5,387,285 to Rivers.

[0059] The continuous length of filter material **40** may be pulled through a block **230** by the action of the rod-forming unit **212**, and the carrier material **55** carrying the adsorbent material **50** may be inserted along the length of and within the web of filter material. However, the carrier material **55** carrying the adsorbent material **50** may also be introduced into the filter material at other points in the process, and this exemplary embodiment is not intended to be limiting in that regard. The filter material may be further directed into a gathering region **232** of the rod-forming unit **212**. The gathering region can have a tongue and horn configuration, a gathering funnel configuration, stuffer or transport jet configuration, or other suitable type of gathering device. The tongue **232** provides for further gathering, compaction, conversion or formation of the cylindrical composite from block **230** into an essentially cylindrical (i.e., rod-like) shape whereby

the continuously extending strands or filaments of the filter material extend essentially along the longitudinal axis of the cylinder so formed. In some instances, the carrier material **55** carrying the adsorbent material **50** may also be placed into the filter material in the gathering region **232**, as appropriate.

[0060] The filter material **40**, which has been compressed into a cylindrical composite, is received further into the rod-forming unit **212**. The cylindrical composite is fed into wrapping mechanism **234**, which includes endless garniture conveyer belt **236** or other garniture device. The garniture conveyer belt **236** is continuously and longitudinally advanced using advancing mechanism **238** such as a ribbon wheel or cooperating drum so as to transport the cylindrical composite through wrapping mechanism **234**. The wrapping mechanism provides a strip of wrapping material **28** (e.g., non-porous paper plug wrap) to the outer surface of the cylindrical composite in order to produce the continuous wrapped rod **220**. In some instances, the carrier material **55** carrying the adsorbent material **50** may also be engaged with the filter material in the wrapping or garniture region **232**, as appropriate. For example, the elongate member, as otherwise disclosed herein, may be in the form of a wrapping material **28** having the carrier material **55** carrying the adsorbent material **50** attached thereto or otherwise engaged therewith.

[0061] Generally, the strip or web of wrapping material **28** may be provided from rotatable bobbin **242**. The wrapping material may be drawn from the bobbin, trained over a series of guide rollers, passed under block **230**, and enter the wrapping mechanism **234** of the rod-forming unit. The endless garniture conveyer belt **236** transports both the strip of wrapping material and the cylindrical composite in a longitudinally extending manner through the wrapping mechanism **234** while draping or enveloping the wrapping material about the cylindrical composite.

[0062] The seam formed by an overlapping marginal portion of wrapping material has adhesive (e.g., hot melt adhesive) applied thereto at applicator region **244** in order that the wrapping material can form a tubular container for the filter material. Alternatively, the hot melt adhesive may be applied directly upstream of the wrapping material's entry into the garniture of the wrapping mechanism **234** or block **230**, as the case may be. The adhesive can be cooled using chill bar **246** in order to cause rapid setting of the adhesive. It is understood that various other sealing devices and other types of adhesives can be employed in providing the continuous wrapped rod.

[0063] The continuous wrapped rod **220** passes from the sealing device and is subdivided (e.g., severed) at regular intervals at the desired, predetermined length using cutting assembly **222** which includes as a rotary cutter, a highly sharpened knife, or other suitable rod cutting or subdividing device. It is particularly desirable that the cutting assembly does not flatten or otherwise adversely affect the shape of the rod. The rate at which the cutting

assembly severs the continuous rod at the desired points is controlled via an adjustable mechanical gear train (not shown), or other suitable device. The rate at which the carrier material **55** carrying the adsorbent material **50** is inserted into the continuous web of filter material may be in a direct relationship to the speed of operation of the rod-making machine. The insertion unit can be geared in a direct drive relationship to the drive assembly of the rod-making apparatus. Alternatively, the insertion unit **214** can have a direct drive motor synchronized with the drive assembly of the rod-forming unit. In some instances, the insertion unit **214** may be configured to be in communication with an inspection/detection system **247**, for example, in the form of a feedback loop, whereby some defects detected by the inspection/detection system **247** may be eliminated by adjusting the upstream insertion unit **214**. In light of the relationship of the rate of object insertion and the rod-making machine, embodiments of the present invention are also directed to maintaining or increasing the production rate of the rod-making machine, without adversely affecting the placement of the carrier material **55** carrying the adsorbent material **50** within the filter material.

[0064] The insertion unit **214** may include a rotatable insertion member **248** having the shape of a wheel, which may be positioned so as to rotate in a vertical plane. The insertion unit **214** may also include a hopper assembly **252** and/or other transfer device for feeding or otherwise providing transfer of various forms of the carrier material **55** (such as, for example, pellets) to insertion member **248**. As the insertion member **248** rotates, the carrier material **55** on the peripheral face of the wheel is brought into contact with the filter material **40** within the block **230**, where the carrier material **55** is ejected from the pockets into the gathered filter material **40**. Details of such an object-insertion arrangement are further detailed, for example, in U.S. Patent No. 7,115,085 to Deal; U.S. Patent No. 4,862,905 to Green, Jr. et al. (i.e., insertion of individual strand portions); U.S. Patent Application Publication No. US 2007/0068540 A1 to Thomas et al. (i.e., insertion of capsules); U.S. Patent Application No. 11/461,941 to Nelson et al. (i.e., insertion of continuous strands); and U.S. Patent Application No. 11/760,983 to Stokes et al. (i.e., insertion of continuous strands).

[0065] Such object-insertion apparatuses may include, for example, a tongue or tongue portion configured to gather the supply of filter material into a continuous rod and/or an insertion unit for inserting a tubular member having the adsorbent material **50** therein into the filter material. In some instances, various forms of the carrier material **55** may be serially attached or otherwise serially engaged with each other so as to form a continuous chain, wherein the insertion unit **214** may be configured to place the continuous chain into the filter material. Certain forms of the carrier material **55** may also be attached or otherwise engaged with an elongate member, wherein the elongate member may comprise, for example, a strand, and the carrier material **55** is thus strung together

by the strand. Multiple forms of the carrier material **55** (i.e., pellets and/or strands) or at least one of a pellet or strand in combination with at least one other of the pellet or strand may be inserted into the filter material by the insertion unit **214**. One arrangement for inserting a strand into the filter material is disclosed, for example, in U.S. Patent Application No. 11/461,941 to Nelson et al.. another example, the elongate member may also be configured to extend laterally (i.e., as a two dimensional sheet). As such, the rod-forming apparatus **210** may include a garniture device configured to wrap the elongate member having the adsorbent material **50** attached thereto about the filter material such that the elongate member forms a wrap encompassing the filter material and the adsorbent material **50** such as disclosed in U.S. Patent Application No. 11/760,983 to Stokes et al., which is incorporated herein by reference.

[0066] After insertion of the carrier material **55** carrying the adsorbent material **50** into the continuous rod of filter material, the adsorbent material may be released from the carrier material and into the filter material. For example, the carrier material **55** may be dissolved, disintegrated, degraded, or otherwise destroyed so as to release and/or disperse the adsorbent material **50** into the filter material so as to allow the adsorbent material **50** to have the desired effect on the mainstream smoke drawn through the filter element. The release of the adsorbent material into the filter material may occur before or after the continuous rod has been severed into filter segments (e.g., filter element **26**). Such release can occur during the manufacturing process. In some embodiments, an adsorbent material releasing unit **400** may be provided downstream in the production line from the insertion unit **214**, wherein the adsorbent material releasing unit **400** may be configured to interact with the carrier material **55** *in situ* within the filter element so as to release the adsorbent material **50** into the filter material using, for example, a thermal process, an ultrasonic process, or any other suitable mechanism for releasing the adsorbent material **50** from the carrier material **55**.

[0067] More particularly, the adsorbent material **50** may be, for example, plasticized (i.e., moistened to form a "paste") such that the resulting object is resilient, flexible, and/or otherwise capable of being handled (see, e.g., US Pat. No. 4,862,905 to Green, Jr. et al.). Once the object is inserted into the filter material, the adsorbent material **50** can then be processed into a releasable form, for instance, by a heating and/or drying procedure applied to the filter element having the object therein. That is, the heating/drying process may cause the plasticizer to be removed from the object, which then becomes brittle or otherwise breakable. The filter element can then be mechanically processed, for example, through opposed rollers, through an "impact" process (i.e., sonic vibration, heating/cooling cycles, etc.), and/or through an irradiation procedure (i.e., microwave energy causing the expansion of liquid/gas associated with the object, leading to the breakdown of the object structure).

[0068] In some instances, various forms of the adsorbent material 50 (i.e., strands, beads, pellets, capsules, or combinations thereof) may be disposed in a closed cell foam as the carrier material 55, wherein, once inserted into a filter element 20, may be irradiated or heated to break down the foam and release the adsorbent material therefrom. Alternately, the carrier material 55 may comprise an open cell foam, wherein, for example, air and/or physical force may be used to release the adsorbent material 50 once the object is inserted into the filter element 20.

[0069] In other instances, the carrier material 55 may be provided, for example, in the form of a breakable capsule, a "capsule-in-capsule," or a strand, formed of a water-or other liquid-soluble polymer and configured to carry the adsorbent material 50. Such a soluble polymer may comprise, for example, polylactic acid, polyvinyl alcohol (PVA), starches and/or starch-based polymers, carrageenans, polyvinyl acetate, hydroxypropylcellulose, pullulan, carboxymethylcellulose and its salts (i.e., alkali metal salts), alginates and their salts, gelatin, and/or any other suitable polymers or combinations thereof. Because the releasable form of the carrier material 55 causes the dispersion of the adsorbent material, thereby allowing the mainstream smoke to pass through the filter element and interact with the adsorbent material, the object can be relatively larger than previous "solid state" objects inserted into filter elements (i.e., relatively larger than between about 2 mm and about 3.5 mm).

[0070] In controlling this process, a control system may include appropriate control hardware and/or software. An exemplary control system 290 can incorporate, for example, a Siemens 315-2DP Processor, a Siemens FM352-5 Boolean Processor and a 16 input bit/16 output bit module. Such a system can utilize a system display 293, such as a Siemens MP370 display. An exemplary rod-making unit 212 may include controls configured, for a rod of desired length, to adjust the speed of the knife of the severing unit to be timed relative to the speed of continuous rod formation. In such instances, a first encoder 296, by way of connection with the drive belt of the rod-making unit, and the control unit 299 of the insertion unit, may provide a reference of the knife position of the cutting assembly relative to the wheel position of the insertion unit. Thus, the first encoder 296 may provide one manner of controlling the speed of rotation of the wheel of the insertion unit relative to the speed at which continuous web of filter tow passes through the rod-making unit. An exemplary first encoder 296 is available as a Heidenhain Absolute 2048 encoder.

[0071] In one embodiment of the invention, the adsorbent material 50 and the carrier material 55 are both in the form of a fiber, with the adsorbent material fiber comprising or incorporating an adsorbent material as defined herein. The fibers can comprise conventional staple fiber as well as substantially continuous structures, such as continuous filaments. The fibers of the invention can be hollow or solid, and can have a substantially round or

circular cross section or non-circular cross sections (e.g., oval, square, rectangular, multi-lobed, and the like). The fibers can be in the form of a single thread or filament or in the form of a multiple thread or filament structure, such as in the form of a yarn or other structure wherein multiple filaments are bonded, twisted, or entangled together. Where the fibers are twisted, bonded, or entangled together, the fibers can be adapted for unraveling after insertion into a filter so as to increase the available surface area of the adsorbent fiber. The fibers can be formed by any fiber-forming process known in the art, including extrusion, melt-spinning, solution spinning, and the like. The color of each fiber can vary, but the adsorbent fiber will often appear black where the adsorbent fiber is a carbonaceous fiber as described herein.

[0072] The fibers used for the adsorbent material 50 or the carrier material 55 can be constructed of natural or synthetic materials. Exemplary natural fibers include cotton, linen, jute, hemp, cotton, wool, and wood pulp. Exemplary synthetic polymers that can be used to form the fibers include polyamides, polyamines, polyimides, polyacrylics, polycarbonates, polydienes, polyepoxides, polyesters, polyethers, polyfluorocarbons, polyolefins, polyphenylenes, silicon containing polymers, polyurethanes, polyvinyls, polyacetals, polyarylates, modified cellulosic fibers (e.g., cellulose acetate), copolymers thereof, terpolymers thereof, and mixtures thereof. Non-limiting examples of specific polymeric materials useful as the fiber material according to the present invention include the following: Nylon 6, Nylon 6/6, Nylon 12, polyaspartic acid, polyglutamic acid, polyacrylamide, polyacrylonitrile, esters of methacrylic acid and acrylic acid, polybisphenol A carbonate, polypropylene carbonate, polybutadiene, polyisoprene, polynorbonene, polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, polycaprolactone, polyglycolide, polylactide, polyhydroxybutyrate, polyhydroxyvalerate, polyethylene adipate, polybutylene adipate, polypropylene succinate, polyethylene glycol, polybutylene glycol, polypropylene oxide, polyoxymethylene, polytetramethylene ether, polytetrahydrofuran, polyepichlorohydrin, urea-formaldehyde, melamine-formaldehyde, phenol formaldehyde, polyethylene, polypropylene, polybutylene, polybutene, polyoctene, polyphenylene oxide, polyphenylene sulfide, polyether sulfone, polyphenylene ether sulfone, polydimethyl siloxane, polycarbomethyl silane, polyvinyl butyral, polyvinyl alcohol, esters and ethers of polyvinyl alcohol, polyvinyl acetate, polystyrene, polymethylstyrene, polyvinyl chloride, polyvinyl pyrrolidone, polymethyl vinyl ether, polyethyl vinyl ether, polyvinyl methyl ketone, polyethylene-co-vinyl acetate, polyethylene-co-acrylic acid, polybutylene terephthalate-co-polyethylene terephthalate, and polylauryl-lactam-block-polytetrahydrofuran.

[0073] The adsorbent material 50 can be incorporated into the adsorbent fiber in any manner known in the art, including by adhering adsorbent particles to the fiber, by imbedding or suspending adsorbent particles within the

fiber, or by forming a fiber and then chemically altering the fiber such that an adsorbent material is formed (e.g., carbonization of a fiber). In one embodiment, the adsorbent fiber is constructed of a carbonaceous material (i.e., a carbon fiber).

[0074] Carbon fibers can be described as fibers obtained by the controlled pyrolysis of a precursor fiber. Since carbon is typically difficult to shape into fiber form, commercial carbon fibers are often made by extrusion of a precursor material into filaments, which is followed by carbonization, usually at high temperature. Common precursors for carbon fibers include rayon, acrylic fibers (such as polyacrylonitrile or PAN), and pitch (which can include isotropic pitch and anisotropic mesophase pitch, as well as meltblown pitch fibers). Other precursors, such as cellulose, may also be converted to carbon fibers. KY-NOL™ novoloid fibers (available from American Kynol, Inc., Pleasantville, NY), are high-performance phenolic fibers that are transformed into activated carbon by a one-step process combining both carbonization and activation. Forming carbon fibers from rayon or acrylics generally consists of stabilization, carbonization, and graphitization, each taking place at successively higher temperatures, to sufficiently remove non-carbon species, such as oxygen, nitrogen, and hydrogen. Preparation of fibers using pitch also typically includes stabilization and carbonization; however, pitch is typically spun as part of the carbon fiber forming process, whereas pre-formed fibers from rayon or acrylics can be used directly. Activation can sometimes add yet further production steps. Sources of carbon fibers include Toray Industries, Toho Tenax, Mitsubishi, Sumitomo Corporation, Hexcel Corp., Cytec Industries, Zoltek Companies, and SGL Group.

[0075] Carbon fibers are often classified in three separate ways. First, they can be classified based on modulus and strength. Examples include ultra high modulus (UHM) fibers (modulus >450 Gpa); high modulus (HM) fibers (modulus between 350 and 450 Gpa); intermediate modulus (IM) fibers (modulus between 200 and 350 Gpa); low modulus, high tensile (HT) fibers (modulus <100 Gpa and tensile strength >3.0 Gpa); and super high tensile (SHT) fibers (tensile strength >4.5 Gpa). Second, carbon fibers can be classified based on the precursor material used to prepare the fiber (e.g., PAN, rayon, pitch, mesophase pitch, isotropic pitch, or gas phase grown fibers). Third, carbon fibers can be classified based on the final heat treatment temperature. Examples include Type-I, high heat treatment (HTT) fibers (final heat treatment temperature above 2,000 °C), Type-II, intermediate heat treatment (IHT) fibers (final heat treatment temperature around 1,500 °C), and Type-III low heat treatment (LHT) fibers (final heat treatment not greater than 1,000 °C). Any of the above classifications of carbon fibers could be used in the present invention.

[0076] Examples of starting materials, methods of preparing carbon-containing fibers, and types of carbon-containing fibers are disclosed in U.S. Patent Nos. 3,319,629 to Chamberlain; 3,413,982 to Sublett et al.;

3,904,577 to Buisson; 4,281,671 to Bynre et al.; 4,876,078 to Arakawa et al.; 4,947,874 to Brooks et al.; 5,230,960 to Iizuka; 5,268,158 to Paul, Jr.; 5,338,605 to Noland et al.; 5,446,005 to Endo; 5,482,773 to Bair; 5,536,486 to Nagata et al.; 5,622,190 to Arterbery et al.; and 7,223,376 to Panter et al.; and U.S. Pat. Publication Nos. 2006/0201524 to Zhang et al. and 2006/023111 to Newbery et al.. Disclosure around PAN-based carbon fibers particularly (including manufacturers thereof) is provided in the report to congress entitled "Polyacrylonitrile (PAN) Carbon Fibers Industrial Capability Assessment: OUSD(AT&L) Industrial Policy" (October 2005), available on-line at http://www.acq.osd.mil/ip/docs/pan_carbon_fiber_report_to_congress_10-2005.pdf

[0077] The size of the carrier fiber and the adsorbent fiber (e.g., the carbon fiber) can vary without departing from the invention. Typically, fiber sizes vary from about 0.5 denier to about 20 denier. The size of the adsorbent fiber will often depend, at least in part, on the desired amount of adsorbent in the filter element. For example, the size of the adsorbent fiber can be determined based on the desired weight of adsorbent in the filter, such as the weight ranges for carbonaceous materials set forth herein.

[0078] The carrier fiber and the adsorbent fiber (e.g., the carbon fiber) can be connected or associated with each other for purposes of insertion into a cigarette filter material using any of a variety of methods, including wrapping, intertwining or weaving the two fiber types together, bonding the fiber types together using an adhesive or binder, co-extruding the fibers, or tying the fiber types together using a separate connecting element, such as a separate thread or clip. Each composite fiber structure (i.e., combination of a carrier fiber and an adsorbent fiber) can include one or multiple fibers of each type, meaning each fiber structure can include, for example, 1 to about 20 carrier fibers and 1 to about 20 adsorbent fibers.

[0079] In another embodiment of the invention, the filter material incorporates a fiber material that is degradable, meaning the fiber is capable of undergoing degradation or decomposition, for example through chemical reaction that breaks down the fiber into decomposition products, under environmental conditions associated with disposal of the fiber material. One exemplary type of degradation is biodegradation. As used herein, the term "biodegradable fiber" refers to a polymeric fiber material that degrades under aerobic and/or anaerobic conditions in the presence of bacteria, fungi, algae, and other microorganisms to carbon dioxide/methane, water and biomass, although materials containing heteroatoms can also yield other products such as ammonia or sulfur dioxide. "Biomass" generally refers to the portion of the metabolized materials incorporated into the cellular structure of the organisms present or converted to humus fractions indistinguishable from material of biological origin. Exemplary biodegradable fibers include, without limitation, cellulosic or other organic plant-derived fibers

(e.g., cotton, wool, cedar, hemp, bamboo, kapok, or flax), polyvinyl alcohol, aliphatic polyesters, aliphatic polyurethanes, cis-polyisoprene, cis-polybutadiene, polyhydroxy alkanoates, polyamides, and copolymers and blends thereof. The term "aliphatic polyester" refers to polymers having the structure $[-C(O)-R-O]_n$, wherein n is an integer representing the number of monomer units in the polymer chain and R is an aliphatic hydrocarbon, preferably a C1-C10 alkylene, more preferably a C1-C6 alkylene (e.g., methylene, ethylene, propylene, isopropylene, butylene, isobutylene, and the like), wherein the alkylene group can be a straight chain or branched. Exemplary aliphatic polyesters include polyglycolic acid (PGA), polylactic acid (PLA) (e.g., poly(L-lactic acid) or poly(DL-lactic acid)), polyhydroxy butyrate (PHB), polyhydroxy valerate (PHV), polycaprolactone (PCL), and copolymers thereof.

[0080] In certain embodiments, the biodegradable fiber is a bamboo fiber or a PLA fiber. Suitable bamboo fibers are described, for example, in U.S. Pat. No. 7,313,906 to Zhou et al., which is incorporated by reference herein. Bamboo fibers are commercially available from China Bambro Textile Co., Ltd. PLA fibers can be derived from corn or made synthetically. Suitable PLA fibers are described in U.S. Pat. No. 7,445,841 to Kaijiyama et al., and are commercially available from NatureWorks LLC.

[0081] The degradable fiber can be utilized in the form of a single strand or as part of a multi-strand yarn structure. In certain embodiments, the fibrous material can be used in the form of a sheet. The degradable fiber can be used in combinations containing multiple fiber types, such as degradable fiber materials of different types woven together or otherwise combined into a unitary structure or combinations of degradable fibers with non-degradable fibers and/or adsorbent fibers woven together or otherwise combined into a unitary structure (e.g., combining bamboo fibers, cotton fibers, and carbon fibers into a single fiber structure such as a single yarn structure). Alternatively, multiple fiber types could be combined or mixed within a single fiber strand.

[0082] Where the fiber is described as comprising a particular type of fiber material, the fiber often will be comprised primarily of the given fiber material (e.g., above about 50% by weight based on the total weight of the fiber) or consist essentially of the fiber material (e.g., above about 90% by weight) or consist virtually entirely of the fiber material (e.g., above about 98% by weight or about 100% by weight). For example, a fiber described as a "bamboo fiber" can incorporate relatively minor amounts of bamboo fibrous material (e.g., in combination with other types of fibrous materials or in combination with additives), or be comprised primarily of bamboo fibrous material, or consist essentially of bamboo fibrous material, or consist virtually entirely of bamboo fibrous material.

[0083] The degradable fibers can act as a carrier fiber for an adsorbent material (e.g., a carbon fiber) as de-

scribed herein, or as a carrier for other additives adapted to alter the flavor or aroma of a smoking article, or as a carrier for both an adsorbent material and a flavor/aroma additive. Alternatively, the inherent properties of the degradable fiber itself may alter the character or nature of the smoke passing through the filter. Exemplary flavoring agents or aroma agents include any solid or liquid composition that can be incorporated into a fiber structure by, for example, absorption, adhesion, or physical entanglement within a fibrous structure. The additives can be any composition capable of altering the character or nature of the smoke passing through the filter material, such as by action of a flavorant or a deodorizing agent. Exemplary additives include natural or synthetic flavorants that can alter the flavor and/or aroma of mainstream smoke, and the character of the flavors imparted thereby may be described, without limitation, as fresh, sweet, herbal, confectionary, floral, fruity or spice. Specific types of flavors or aromas include, but are not limited to, vanilla, coffee, chocolate/cocoa, cream, mint, spearmint, menthol, peppermint, wintergreen, eucalyptus, lavender, cardamon, nutmeg, cinnamon, dove, cascarilla, sandalwood, honey, jasmine, ginger, anise, sage, licorice, lemon, orange, apple, peach, lime, cherry, strawberry, and any combinations thereof. See also, Leffingwell et al., Tobacco Flavoring for Smoking Products, R. J. Reynolds Tobacco Company (1972). Flavorings also may include components that are considered moistening, cooling or soothing agents, such as eucalyptus. These flavors may be provided neat (i.e., alone) or in a composite (e.g., spearmint and menthol, or orange and cinnamon). Exemplary deodorizing agents include any composition adapted to mask or remove tobacco smoke aroma. One exemplary composition comprises inorganic salts and odor adsorbents such as described in U.S. Pat. No. 7,407,922 to Leskowitz. Another deodorizing composition contains a mandarin orange essential oil fraction such as described in U.S. Pat. No. 7,434,586 to Higashi et al..

[0084] The degradable fiber can be incorporated into a filter material in the same manner as described herein for the carrier fiber/adsorbent material embodiments. For example, the degradable fiber could be utilized as the carrier fiber in the composite fiber structures set forth in FIGS. 5 and 6. Alternatively, the degradable fiber can be imbedded in a filter material without a second fiber structure. For example, a degradable fiber comprising a flavoring agent could be added to a filter material. In yet another embodiment, the degradable fiber, with or without additives as described herein, can be incorporated into any of the wrapping materials utilized in a smoking article filter, such as in the plug wrap or tipping material.

[0085] In another embodiment, the degradable fiber can be replaced with a non-degradable fiber, such as any of the numerous synthetic fiber materials described herein that are not typically viewed as degradable in nature (e.g., polyethylene terephthalate or polypropylene). The non-degradable fiber can be used in any of the ap-

plications described herein for degradable fibers. Both the degradable fibers and the non-degradable fibers can be derived from natural materials, synthetic materials, or materials of a natural origin that have been chemically modified.

[0086] The number of degradable or non-degradable fibers imbedded within a filter element can vary. Typical ranges of the number of fiber insertions within a filter element segment include 1 to about 500 fiber insertions, more typically 1 to about 100, and often 1 to about 50.

[0087] FIG. 5 illustrates one example of a composite fiber structure 60 imbedded within a filter segment 32. Although multiple composite fiber structures 60 are set forth in FIG. 5, the number of composite fiber structures can vary. An exemplary range of the number of composite fiber structures 60 incorporated into a filter 26 is 1 to about 500, more typically 1 to about 100, and often 1 to about 50. The composite fiber structures 60 can be included in a single segment 32 of a multi-segment filter 26 as shown in FIG. 5, or the composite fiber structures can be imbedded within a filter element comprising only a single segment or can extend throughout multiple sections of a multi-segment filter. The composite fiber structures 60 can extend linearly in the longitudinal direction of the cigarette filter as shown in FIG. 5, or can extend transverse to the longitudinal axis of the filter element or can be randomly dispersed at various angles throughout the filter segment. As shown in FIG. 6, the composite fiber structure 60 can include at least one carrier fiber 62 and at least one adsorbent fiber 64.

[0088] As shown in FIGS. 5 and 6, one method of connecting the two fiber types is to wrap the adsorbent fiber 64 around the carrier fiber 62. The number of wraps of the adsorbent fiber 64 per unit of length of the carrier fiber 62 can vary, and will depend on a number of factors including the desired amount of adsorbent material in the filter element. An exemplary range of wrappings of the adsorbent fiber 64 around the carrier fiber 62 is 1 to about 50 circumferential wrappings of the adsorbent fiber per inch of carrier fiber.

[0089] Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing description; and it will be apparent to those skilled in the art that variations and modifications of the present invention can be made without departing from the scope of the invention. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

Claims

1. An apparatus (210) for forming a cigarette filter rod member defining a longitudinal axis, the apparatus comprising:

a rod-forming unit (212) configured to form a continuous supply of a filter material (40) into a continuous cylindrical rod member (220);
 an insertion unit (214) configured to insert an adsorbent material (50) carried by a carrier material (55) into the rod member (220), the carrier material comprising one of a capsular member, a tubular member, a continuous elongate member, a carrier matrix, a continuous strip member, and combinations thereof; and
 an adsorbent material releasing unit (400) configured to release the adsorbent material from the carrier material once the adsorbent material carried by the carrier material is disposed within the rod member.

2. The apparatus according to Claim 1, further comprising a rod-dividing unit (222) configured to divide the rod member (220) into a plurality of rod portions (26, 205) along the longitudinal axis thereof such that each rod portion includes at least a portion of the adsorbent material.

3. The apparatus according to Claim 1 or 2, further comprising an adsorbent forming unit (450) configured to engage the adsorbent material (50) with the carrier material (55).

4. The apparatus according to one of Claims 1 to 3, wherein the insertion unit (214) is further configured to insert the adsorbent material carried by the carrier material, in the form of one of a tube, a pellet, and a strand, into the rod member.

5. The apparatus according to one of Claims 1 to 4, wherein the adsorbent material releasing unit (400) is further configured to one of dissolve, disintegrate, and degrade the carrier material.

6. A method of forming a cigarette filter rod member defining a longitudinal axis, the method comprising:

forming a continuous supply of a filter material (40) into a continuous cylindrical rod member (220);
 inserting an adsorbent material (50) carried by a carrier material (55) into the rod member (220) such that the adsorbent material is disposed within the rod member, the carrier material comprising one of a capsular member, a tubular member, a continuous elongate member, a carrier matrix, a continuous strip member, and com-

- binations thereof;
 dividing the rod member into a plurality of rod portions (26, 205) along the longitudinal axis thereof such that each rod portion includes at least a portion of the adsorbent material; and releasing the adsorbent material from the carrier material into the filter material *in situ* after the adsorbent material carried by the carrier material is inserted into the filter material by means of an adsorbent material releasing unit (400) configured to release the adsorbent material from the carrier material once the adsorbent material carried by the carrier material is disposed within the rod member.
7. The method according to Claim 6, wherein inserting an adsorbent material further comprises inserting an adsorbent material, comprising a carbonaceous material carried by a carrier material, into the rod member.
8. The method according to Claim 6 or 7, wherein inserting an adsorbent material further comprises inserting an adsorbent material carried by a carrier material into the rod member, the carrier material comprising at least one of a high-density polyethylene material and a low-density polyethylene material.
9. The method according to one of Claims 6 to 8, wherein inserting an adsorbent material further comprises inserting an adsorbent material carried by a carrier material, configured as at least one of a tube, a pellet and a strand, into the rod member.
10. The method according to one of Claims 6 to 9, wherein inserting an adsorbent material further comprises inserting an adsorbent material carried by a carrier material, the carrier material further carrying a flavoring agent.
11. The method according to one of Claims 6 to 10, further comprising one of inserting the adsorbent material into the capsular member, inserting the adsorbent material into the continuous tubular member, engaging the adsorbent material with the continuous elongate member, and suspending the adsorbent material in the carrier matrix.
12. The method according to one of Claims 6 to 11, wherein inserting an adsorbent material further comprises inserting an adsorbent material carried by a carrier material comprising a continuous strip member, the method further comprising lengthwise wrapping the continuous strip member about the adsorbent material.
13. The method according to one of Claims 6 to 12, wherein releasing the adsorbent material comprises

one of dissolving the carrier material, disintegrating the carrier material, and degrading the carrier material.

Patentansprüche

1. Eine Vorrichtung (210) zum Bilden eines Zigarettenfilterstabgliedes, welches eine Längsachse definiert, die Vorrichtung umfassend:
- eine stabbildende Einheit (212), welche dazu ausgebildet ist, ein kontinuierliches Angebot an Filtermaterial (40) zu einem kontinuierlichen zylindrischen Stabglied (220) zu formen;
 eine Einführungseinheit (214), welche dazu ausgebildet ist, ein Adsorbensmaterial (50), welches von einem Trägermaterial (55) getragen ist, in das Stabglied (220) einzuführen, wobei das Trägermaterial eines der Elemente kapseiförmiges Glied, röhrenförmiges Glied, kontinuierliches längliches Glied, Trägermatrix, kontinuierliches Streifenglied und Kombinationen hiervon umfasst; und
 eine Adsorbensmaterialfreisetzungseinheit (400), welche dazu ausgebildet ist, das Adsorbensmaterial aus dem Trägermaterial freizusetzen, nachdem das von dem Trägermaterial getragene Adsorbensmaterial innerhalb des Stabgliedes angeordnet worden ist.
2. Die Vorrichtung nach Anspruch 1, ferner umfassend eine Stabteilungseinheit (222), welche dazu ausgebildet ist, das Stabglied (220) entlang seiner Längsachse in eine Mehrzahl von Stabteilmitteln (26, 205) aufzuteilen, derart, dass jeder Stabteilmittel mindestens einen Teil des Adsorbensmaterials enthält.
3. Die Vorrichtung nach Anspruch 1 oder 2, ferner umfassend eine adsorbensbildende Einheit (450), welche dazu ausgebildet ist, das Adsorbensmaterial (50) mit dem Trägermaterial (55) in Eingriff zu bringen.
4. Die Vorrichtung nach einem der Ansprüche 1 bis 3, wobei die Einführungseinheit (214) ferner dazu ausgebildet ist, das von dem Trägermaterial getragene Adsorbensmaterial in einer der Formen Röhre, Pellet und Strang in das Stabglied einzuführen.
5. Die Vorrichtung nach einem der Ansprüche 1 bis 4, wobei die Adsorbensmaterialfreisetzungseinheit (400) ferner dazu ausgebildet ist, das Trägermaterial einem der Prozesse Auflösen, Zersetzen und Abbauen zu unterwerfen.
6. Ein Verfahren zum Bilden eines Zigarettenfilterstab-

glied, welches eine Längsachse definiert, das Verfahren umfassend:

Formen eines kontinuierlichen Angebots an Filtermaterial (40) zu einem kontinuierlichen zylindrischen Stabglied (220);

Einführen eines Adsorbensmaterials (50), welches von einem Trägermaterial (55) getragen ist, in das Stabglied (220), derart, dass das Adsorbensmaterial innerhalb des Stabgliedes angeordnet wird, wobei das Trägermaterial eines der Elemente kapseiförmiges Glied, röhrenförmiges Glied, kontinuierliches längliches Glied, Trägermatrix, kontinuierliches Streifenglied und Kombinationen hiervon umfasst;

Teilen des Stabgliedes entlang seiner Längsachse in eine Mehrzahl von Stabteilbereichen (26, 205), derart, dass jeder Stabteilbereich mindestens einen Teil des Adsorbensmaterials enthält; und

In-situ-Freisetzen des Adsorbensmaterials aus dem Trägermaterial in das Filtermaterial, nachdem das von dem Trägermaterial getragene Adsorbensmaterial in das Filtermaterial eingeführt worden ist, mittels einer Adsorbensmaterialfreisetzungseinheit (400), welche dazu ausgebildet ist, das Adsorbensmaterial aus dem Trägermaterial freizusetzen, nachdem das von dem Trägermaterial getragene Adsorbensmaterial innerhalb des Stabgliedes angeordnet worden ist.

7. Das Verfahren nach Anspruch 6, wobei das Einführen eines Adsorbensmaterials ferner umfasst: Einführen eines Adsorbensmaterials, umfassend ein kohlenstoffhaltiges Material, welches von einem Trägermaterial getragen ist, in das Stabglied.
8. Das Verfahren nach Anspruch 6 oder 7, wobei das Einführen eines Adsorbensmaterials ferner umfasst: Einführen eines Adsorbensmaterials, welches von einem Trägermaterial getragen ist, in das Stabglied, wobei das Trägermaterial mindestens eines der Materialien Polyethylenmaterial hoher Dichte und Polyethylenmaterial niedriger Dichte umfasst.
9. Das Verfahren nach einem der Ansprüche 6 bis 8, wobei das Einführen eines Adsorbensmaterials ferner umfasst: Einführen eines Adsorbensmaterials, welches von einem Trägermaterial getragen ist, in das Stabglied, wobei das Adsorbensmaterial in mindestens einer der Formen Röhre, Pellet und Strang ausgebildet ist.
10. Das Verfahren nach einem der Ansprüche 6 bis 9, wobei das Einführen eines Adsorbensmaterials ferner umfasst: Einführen eines Adsorbensmaterials, welches von einem Trägermaterial getragen ist, wobei das Adsorbensmaterial ferner ein Flavouring-

Agens trägt.

11. Das Verfahren nach einem der Ansprüche 6 bis 10, ferner umfassend einen der Schritte: Einführen des Adsorbensmaterials in das kapselförmige Glied, Einführen des Adsorbensmaterials in das kontinuierliche röhrenförmige Glied, Ineingriffbringen des Adsorbensmaterials mit dem kontinuierlichen länglichen Glied und Suspendieren des Adsorbensmaterials in der Trägermatrix.
12. Das Verfahren nach einem der Ansprüche 6 bis 11, wobei das Einführen eines Adsorbensmaterials ferner umfasst: Einführen eines Adsorbensmaterials, welches von einem Trägermaterial getragen ist, das ein kontinuierliches Streifenglied umfasst, wobei das Verfahren ferner umfasst: Längsumwickeln des Adsorbensmaterials mit dem kontinuierlichen Streifenglied.
13. Das Verfahren nach einem der Ansprüche 6 bis 12, wobei das Freisetzen des Adsorbensmaterials einen der Prozesse Auflösen des Trägermaterials, Zersetzen des Trägermaterials und Abbauen des Trägermaterials umfasst.

Revendications

1. Appareil (210) pour former un élément de bâtonnet-filtre de cigarette définissant un axe longitudinal, l'appareil comprenant :
 - une unité de formation de bâtonnet (212) configurée pour former une alimentation continue d'un matériau de filtre (40) dans un élément de bâtonnet (220) cylindrique continu ;
 - une unité d'insertion (214) configurée pour insérer un matériau adsorbant (50) supporté par un matériau de support (55) dans l'élément de bâtonnet (220), le matériau de support comprenant l'un d'un élément capsulaire, d'un élément tubulaire, d'un élément allongé continu, d'une matrice de support, d'un élément en bande continue, et des combinaisons de ceux-ci ; et
 - une unité de libération de matériau adsorbant (400) configurée pour libérer le matériau adsorbant du matériau de support une fois que le matériau adsorbant supporté par le matériau de support a été disposé dans l'élément de bâtonnet.
2. Appareil selon la revendication 1, comprenant en outre une unité de division de bâtonnet (222) configurée pour diviser l'élément de bâtonnet (220) en une pluralité de parties de bâtonnet (26, 205) le long de l'axe longitudinal de celui-ci de sorte que chaque partie de bâtonnet comprenne au moins une partie

- du matériau adsorbant.
3. Appareil selon la revendication 1 ou 2, comprenant en outre une unité de formation d'adsorbant (450) configurée pour mettre le matériau adsorbant (50) en prise avec le matériau de support (55). 5
4. Appareil selon les revendications 1 à 3, dans lequel l'unité d'insertion (214) est en outre configurée pour insérer le matériau adsorbant supporté par le matériau de support, sous la forme de l'un d'un tube, d'une pastille et d'un toron, dans l'élément de bâtonnet. 10
5. Appareil selon l'une des revendications 1 à 4, dans lequel l'unité de libération de matériau adsorbant (400) est en outre configurée pour l'une de la dissolution, de la désintégration et de la dégradation du matériau de support. 15
6. Procédé de formation d'un élément de bâtonnet-filtre de cigarette définissant un axe longitudinal, le procédé comprenant : 20
- la formation d'une alimentation continue d'un matériau de filtre (40) dans un élément de bâtonnet cylindrique continu (220) ; 25
- l'insertion d'un matériau adsorbant (50) supporté par un matériau de support (55) dans l'élément de bâtonnet (220) de sorte que le matériau adsorbant soit disposé dans l'élément de bâtonnet, le matériau de support comprenant l'un d'un élément capsulaire, d'un élément tubulaire, d'un élément allongé continu, d'une matrice de support, d'un élément en bande continue, et des combinaisons de ceux-ci ; 30
- la division de l'élément de bâtonnet en une pluralité de parties de bâtonnet (26, 205) le long de l'axe longitudinal de celui-ci de sorte que chaque partie de bâtonnet comprenne au moins une partie du matériau adsorbant ; et 35
- la libération du matériau adsorbant du matériau de support dans le matériau de filtre *in situ* après que le matériau adsorbant supporté par le matériau de support a été inséré dans le matériau de filtre au moyen d'une unité de libération de matériau adsorbant (400) configurée pour libérer le matériau adsorbant du matériau de support une fois que le matériau adsorbant supporté par le matériau de support a été disposé dans l'élément de bâtonnet. 40 45 50
7. Procédé selon la revendication 6, dans lequel l'insertion d'un matériau adsorbant comprend en outre l'insertion d'un matériau adsorbant, comprenant une substance carbonée supportée par un matériau de support, dans l'élément de bâtonnet. 55
8. Procédé selon la revendication 6 ou 7, dans lequel
- l'insertion d'un matériau adsorbant comprend en outre l'insertion d'un matériau adsorbant supporté par un matériau de support dans l'élément de bâtonnet, le matériau de support comprenant au moins l'un d'un matériau polyéthylène à haute densité et d'un matériau polyéthylène à faible densité.
9. Procédé selon l'une des revendications 6 à 8, dans lequel l'insertion d'un matériau adsorbant comprend en outre l'insertion d'un matériau adsorbant supporté par un matériau de support, configuré comme au moins l'un d'un tube, d'une pastille et d'un toron, dans l'élément de bâtonnet.
10. Procédé selon l'une des revendications 6 à 9, dans lequel l'insertion d'un matériau adsorbant comprend en outre l'insertion d'un matériau adsorbant supporté par un matériau de support, le matériau de support supportant en outre un agent aromatisant.
11. Procédé selon l'une des revendications 6 à 10, comprenant en outre l'une de l'insertion du matériau adsorbant dans l'élément capsulaire, de l'insertion du matériau adsorbant dans l'élément tubulaire continu, de la mise en prise du matériau adsorbant avec l'élément allongé continu et de la suspension du matériau adsorbant dans la matrice de support.
12. Procédé selon l'une des revendications 6 à 11, dans lequel l'insertion d'un matériau adsorbant comprend en outre l'insertion d'un matériau adsorbant supporté par un matériau de support comprenant un élément en bande continue, le procédé comprenant en outre l'enroulement dans le sens de la longueur de l'élément en bande continue autour du matériau adsorbant.
13. Procédé selon l'une des revendications 6 à 12, dans lequel la libération du matériau adsorbant comprend l'une de la dissolution du matériau de support, de la désintégration du matériau de support et de la dégradation du matériau de support.

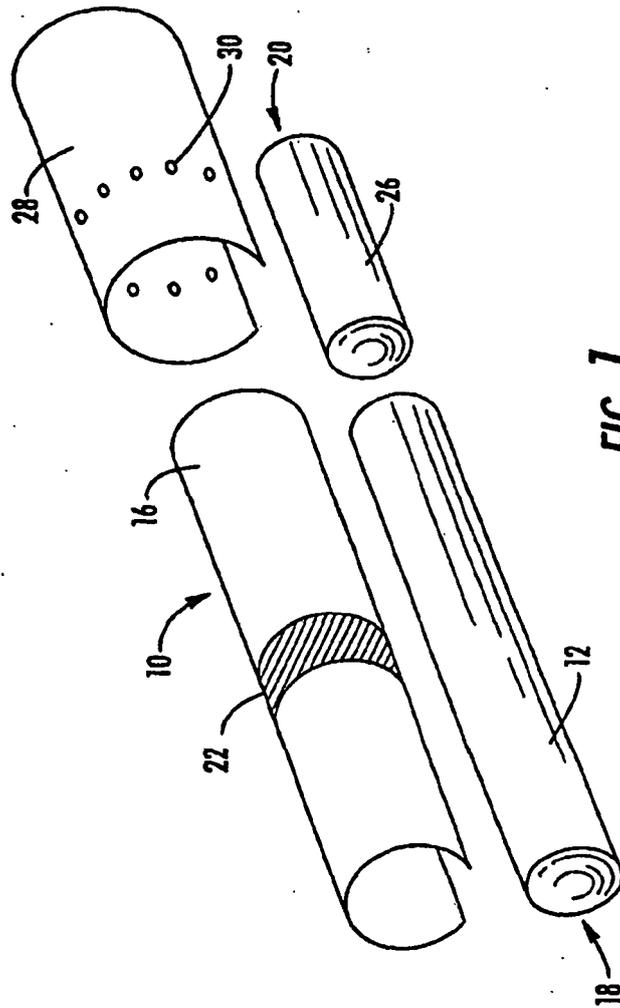


FIG. 1

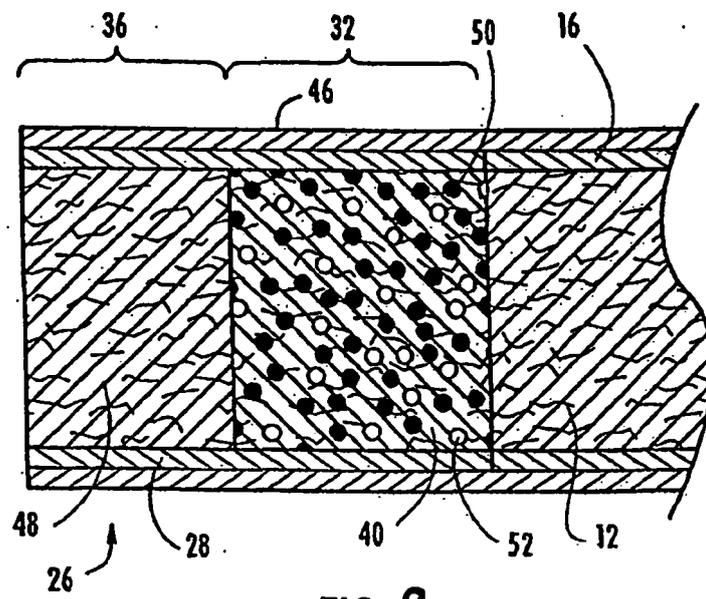


FIG. 2

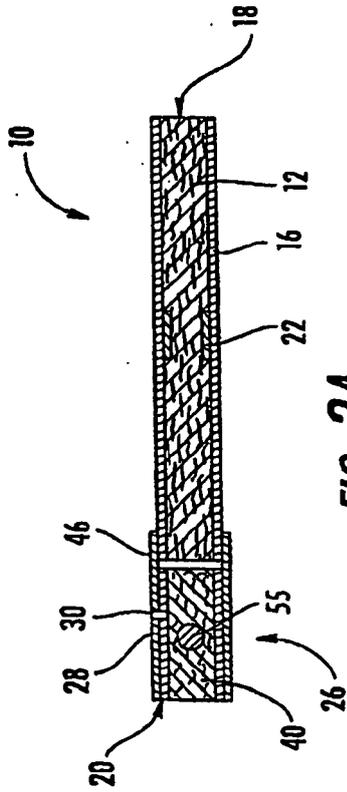


FIG. 3A

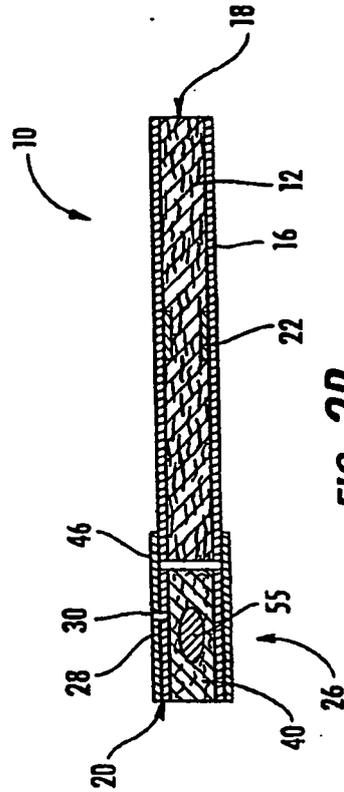


FIG. 3B

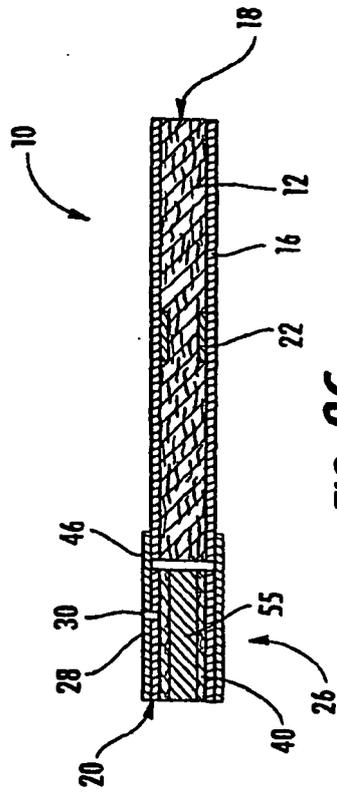


FIG. 3C

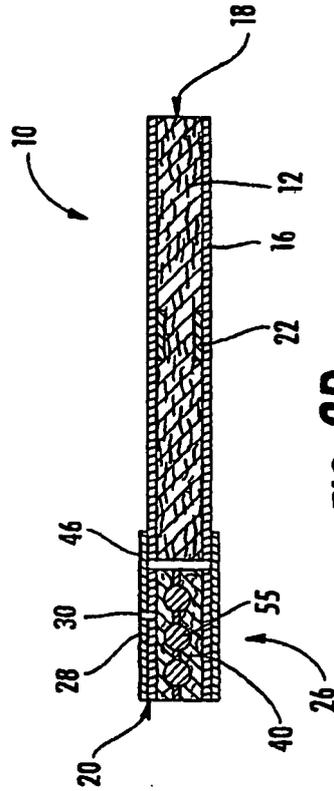


FIG. 3D

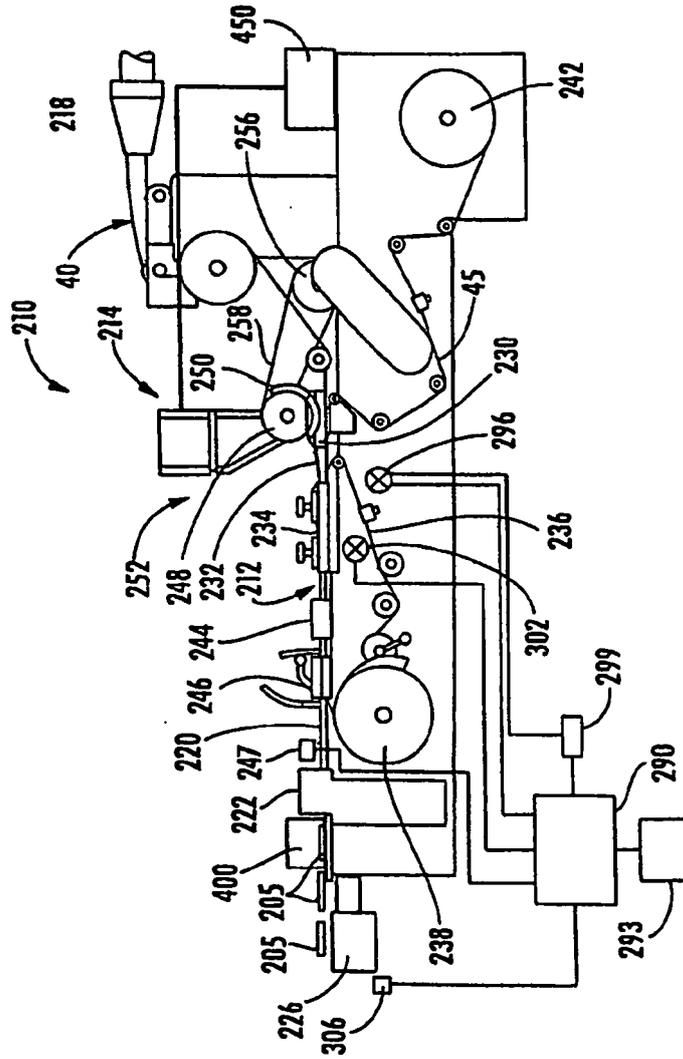


FIG. 4

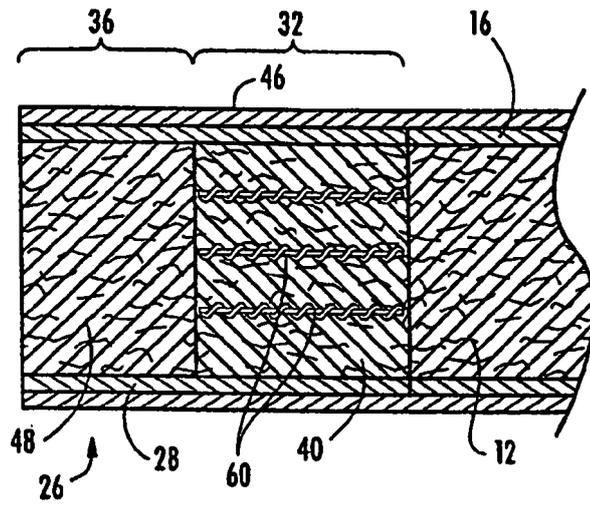


FIG. 5

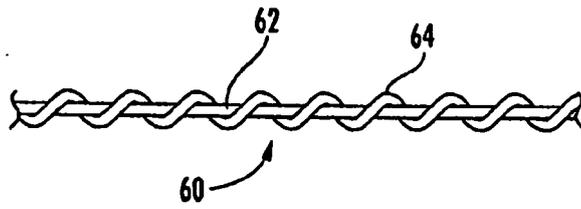


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2881770 A, Touey [0003]
- US 3101723 A, Seligman [0003]
- US 3236244 A, Irby [0003]
- US 3311519 A, Touey [0003]
- US 3347247 A, Lloyd [0003]
- US 3349780 A, Sublett [0003]
- US 3370595 A, Davis [0003]
- US 3413982 A, Sublett [0003] [0076]
- US 3602231 A, Dock [0003]
- US 3972335 A, Tiggelbeck [0003]
- US 5360023 A, Blakley [0003] [0036]
- US 6537186 B, Veluz [0003] [0036]
- US 20070056600 A, Coleman, III [0003] [0035] [0036] [0052]
- WO 2006064371 A, Banerjea [0003] [0036]
- WO 2006051422 A, Jupe [0003]
- US 20070068540 A1, Thomas [0006] [0053] [0064]
- US 4862905 A [0006] [0064] [0067]
- US GREENJR A [0006]
- US 461941 A, Nelson [0006] [0053] [0064] [0065]
- US 760983 A, Stokes [0006] [0053] [0065]
- US 7074170 B, Lanier, Jr. [0006]
- US 20040237984 A, Figlar [0019] [0036]
- US 20050268925 A, Schluter [0019]
- US 20060130861 A, Luan [0019]
- US 20060174899 A, Luan [0019]
- US 20080029111 A, Dube [0022]
- WO 2007104908 A, White [0031]
- WO 2007093757 A, Awty [0031]
- WO 2007010249 A, Fiebelkorn [0031]
- WO 2007028957 A, Lee [0031]
- WO 2006136950 A, Nunziata [0031]
- WO 2006103404 A, Cashmore [0031]
- WO 2005118133 A, Branton [0031]
- WO 2005112670 A, Bhattacharyya [0031]
- WO 2005082180 A, Sampson [0031]
- WO 2005023026 A, Branton [0031]
- WO 2004095957 A, Bray [0031]
- WO 2004014161 A, Grzonka [0031]
- WO 2003092416 A, Dittrich [0031]
- WO 2003034847 A, Abhulimen [0031]
- WO 2003051144 A, Schlüter [0031]
- WO 2003034848 A, Abhulimen [0031]
- WO 2001041590 A, Bushby [0031]
- US 7370657 B, Zhuang [0031]
- US 4771795 A, White [0033] [0049]
- US 5027837 A, Clearman [0033]
- EP 236922 A [0033]
- EP 419733 A [0033]
- EP 419981 A [0033]
- US 7049382 B, Haftka [0035]
- US 20080092912 A, Robinson [0035]
- US 3217715 A, Berger [0036]
- US 3648711 A, Berger [0036]
- US 3957563 A, Sexstone [0036]
- US 4174720 A, Hall [0036]
- US 4201234 A, Neukomm [0036]
- US 4223597 A, Lebert [0036]
- US 5137034 A, Perfetti [0036]
- US 5568819 A, Gentry [0036]
- US 5622190 A, Arterbery [0036] [0076]
- US 6584979 B, Xue [0036]
- US 6761174 B, Jupe [0036]
- US 6789547 B, Paine III [0036]
- US 6789548 B, Bereman [0036]
- US 20020166563 A, Jupe [0036]
- US 20020020420 A, Xue [0036]
- US 20030200973 A, Xue [0036]
- US 20030154993 A, Paine [0036]
- US 20030168070 A, Xue [0036]
- US 20040194792 A, Zhuang [0036]
- US 20040226569 A, Yang [0036]
- US 20050133051 A, Luan [0036]
- US 20050049128 A, Buhl [0036]
- US 20050066984 A, Crooks [0036]
- US 20060144410 A, Luan [0036]
- US 20060180164 A, Paine, III [0036]
- EP 579410 A, White [0036]
- US 4821749 A, Toft [0041]
- US 4756318 A, Clearman [0049]
- US 4714082 A, Banerjea [0049]
- US 4793365 A, Sensabaugh [0049]
- US 4989619 A, Clearman [0049]
- US 4917128 A, Clearman [0049]
- US 4961438 A, Korte [0049]
- US 4966171 A, Serrano [0049]
- US 4969476 A, Bale [0049]
- US 4991606 A, Serrano [0049]
- US 5020548 A, Farrier [0049]
- US 5027836 A, Shannon [0049]
- US 5033483 A, Clearman [0049]
- US 5040551 A, Schlatter [0049]
- US 5050621 A, Creighton [0049]
- US 5052413 A, Baker [0049]
- US 5065776 A, Lawson [0049]
- US 5076296 A, Nystrom [0049]
- US 5076297 A, Farrier [0049]
- US 5099861 A, Clearman [0049]

EP 2 323 506 B2

- US 5105835 A, Drewett [0049]
- US 5105837 A, Barnes [0049]
- US 5115820 A, Hauser [0049]
- US 5148821 A, Best [0049]
- US 5159940 A, Hayward [0049]
- US 5178167 A, Riggs [0049]
- US 5183062 A, Clearman [0049]
- US 5211684 A, Shannon [0049]
- US 5240014 A, Deevi [0049]
- US 5240016 A, Nichols [0049]
- US 5345955 A, Clearman [0049]
- US 5396911 A, Casey, III [0049]
- US 5551451 A [0049]
- US RIGGS A [0049]
- US 5595577 A, Bensalem [0049]
- US 5727571 A, Meiring [0049]
- US 5819751 A, Barnes [0049]
- US 6089857 A, Matsuuru [0049]
- US 6095152 A, Beven [0049]
- US 6578584 B, Beven [0049]
- US 20070215167 A, Crooks [0049]
- US 200800092912 A, Robinson [0049]
- US 4474190 A [0050]
- US 4781203 A, La Hue [0050]
- US 4844100 A, Holznagel [0050]
- US 5131416 A, Gentry [0050]
- US 5156169 A, Holmes [0050]
- US 5191906 A, Myracle, Jr. [0050]
- US 6647870 B, Blau [0050]
- US 6848449 B, Kitao [0050]
- US 6904917 B, Kitao [0050]
- US 20030145866 A, Hartman [0050]
- US 20040129281 A, Hancock [0050]
- US 20050039764 A, Barnes [0050]
- US 20050076929 A, Fitzgerald [0050] [0052]
- US 3288147 A, Molins [0051]
- US 3915176 A, Heitmann [0051]
- US 4291713 A, Frank [0051]
- US 4574816 A, Rudszinat [0051]
- US 4736754 A, Heitmann [0051]
- US 4878506 A, Pinck [0051]
- US 5060665 A, Heitmann [0051]
- US 5012823 A, Keritsis [0051]
- US 6360751 B, Fagg [0051]
- US 20030136419 A, Muller [0051]
- US 5101839 A, Jakob [0052]
- US 5159944 A, Arzonico [0052]
- US 5220930 A, Gentry [0052]
- US 6779530 B, Kraker [0052]
- US 20050016556 A, Ashcraftet [0052]
- US 20050066986 A, Nestor [0052]
- US 11375700 B, Thomas [0052]
- US 11408625 B, Oglesby [0052]
- US 7115085 B, Deal [0053] [0064]
- US 20080029118 A1 [0053]
- US 3424172 A, Neurath [0057]
- US 4811745 A, Cohen [0057]
- US 4925602 A, Hill [0057]
- US 5225277 A, Takegawa [0057]
- US 5271419 A, Arzonico [0057]
- US 5387285 A, Rivers [0058]
- US 111760983 A, Stokes [0064]
- US 3319629 A, Chamberlain [0076]
- US 3904577 A, Buisson [0076]
- US 4281671 A, Bynre [0076]
- US 4876078 A, Arakawa [0076]
- US 4947874 A, Brooks [0076]
- US 5230960 A, Iizuka [0076]
- US 5268158 A, Paul, Jr. [0076]
- US 5338605 A, Noland [0076]
- US 5446005 A, Endo [0076]
- US 5482773 A, Bair [0076]
- US 5536486 A, Nagata [0076]
- US 7223376 B, Panter [0076]
- US 20060201524 A, Zhang [0076]
- US 2006023111 A, Newbery [0076]
- US 7313906 B, Zhou [0080]
- US 7445841 B, Kaijiyama [0080]
- US 7407922 B, Leskowitz [0083]
- US 7434586 B, Higashi [0083]

Non-patent literature cited in the description

- Tobacco Production, Chemistry and Technology. 1999 [0002]
- *J. Amer. Chem. Soc.*, 1938, vol. 60 (2), 309-319 [0031]
- Activated Carbon Compendium. 2001 [0034]
- R. J. REYNOLDS. Chemical and Biological Studies on New Cigarette Prototypes that Heat Instead of Burn Tobacco. *Tobacco Company Monograph*, 1988 [0049]
- *Inhalation Toxicology*, 2000, vol. 12 (5), 1-58 [0049]
- JOHNSON. Development of Cigarette Components to Meet Industry Needs. T.S.R.C, September 1998 [0052]
- LEFFINGWELL et al. Tobacco Flavoring for Smoking Products. R. J. Reynolds Tobacco Company, 1972 [0083]