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(54) Title: AIR FILTER CONFIGURED IN A ROLL

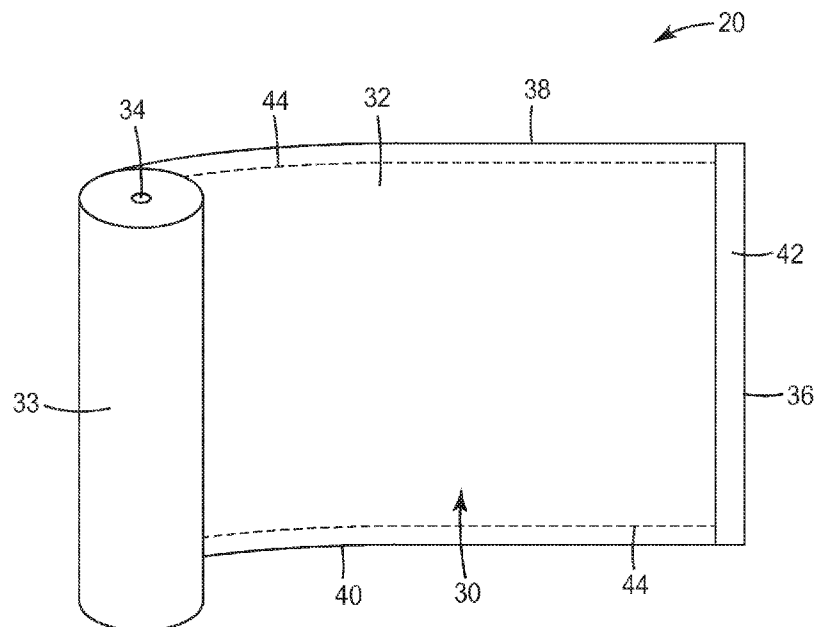


FIG. 1

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(57) Abstract: The present disclosure relates to air filters. More particularly, it relates to adjustably sized air filter systems capable of use in a window opening. Some embodiments relate to a filter media assembly configured in a roll. In some embodiments, the filter media assembly includes a filter media having a leading end opposite a trailing end and first and second opposed side edges extending between the leading end and the trailing end.

AIR FILTER CONFIGURED IN A ROLL

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Technical Field

The present disclosure relates to air filters. More particularly, it relates to adjustably sized air filter systems capable of use in a window opening.

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Background

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Windows are available in a large variety of sizes and can include vertically or horizontally operable sashes to provide air flow between an exterior and an interior of a building structure. Occupants of a building structure often desire opening windows to let fresh air into an interior of a home, business, or otherwise enclosed space. However, in many locations, such as highly populated areas of China, the outside air is more contaminated than the indoor air. Novel filtering solutions are needed to let the fresh aspects of the outdoor air in without letting in the pollution or contaminants. Outdoor contaminants may include larger particles such as pollen, dust, and mold spores and smaller particles such as those forming PM_{2.5}, bacteria, and viruses. Gaseous outdoor pollutants such as odors, NO_x, SO₂, ozone, and others may also be of concern in some locations.

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Summary

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The inventors of the present disclosure recognized that, in light of the above, a need exists for an air filter that protects users from air quality contaminants, allows fresh air get into the home through windows, can be easily installed and used by consumers, is versatile to fit in most locations, and/or has minimal impact on lighting and visibility. In some embodiments, the filter is a window air filter.

The inventors of the present disclosure invented various embodiments of air filters, methods of making air filters, and methods of using air filters.

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Some embodiments relate to an air filter comprising filter media assembly configured in a roll, the filter media assembly including filter media having a leading end opposite a trailing end and first and second opposed side edges extending between the leading end and the trailing end.

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In some embodiments, the air filter further comprises a housing for containing the filter media assembly. In some embodiments, the leading edge can be releasably retained on at least one of the exterior or interior of the housing. In some embodiments, the filter media assembly is replaceable within the housing. In some embodiments, at least one of the leading edge and the trailing edge includes a looped structure, a hooked structure, and/or a fastening device. In some embodiments, the first end includes a handle. In some embodiments, the filter media assembly is retractable on the roll. In some

embodiments, the roll includes a central member that is under spring tension. In some embodiments, the central member provides stopping points. In some embodiments, the filter media assembly includes sufficient filter media for multiple uses. In some embodiments, the filter media assembly includes separation and/or perforation lines or points.

5 Some embodiments further include a hinged attachment mechanism. In some embodiments, the hinged attachment mechanism is combined with the housing or attached to the central member. In some embodiments, the hinged attachment mechanism is rotatable.

10 In some embodiments, the filter media is at least one of moisture-resistant, moisture-repellant, electrostatically charged, an electret nonwoven web, and/or not electrostatically charged. In some embodiments, the filter media includes at least one of carbon, activated carbon, a nonwoven, a thermoplastic, a thermosetting material, a porous foam, fiberglass, paper, a high loft spunbound web, a low loft spunbound web, a meltblown web, and/or bi-modal fiber diameter meltblown media. In some embodiments, the filter media is pleated. In some embodiments, the filter media is at least one of self-supporting and non-self-supporting.

15 Some embodiments further include a cutting device capable of cutting the filter media to a desired size. In some embodiments, the cutting device is integrated into the housing.

In some embodiments, the air filter is a window air filter.

20 Some embodiments relate to a kit comprising an air filter as described above or herein and a cutting device capable of cutting the filter media to a desired size. In some embodiments, the cutting device is integrated into the housing.

25 Some embodiments relate to a kit comprising an filter as described above or herein and an attachment device capable of permanently or semi-permanently attaching the air filter to a window. In some embodiments, the attachment device is at least one of a nail, a screw, a hook, an adhesive, and/or an adhesive backed interlocking strip.

Brief Description of the Drawings

FIG. 1 is a perspective view of an exemplary retractable air filter in accordance with principles of the present disclosure;

30 FIG. 2A is a perspective view of an exemplary retractable air filter in a retracted state in accordance with principles of the present disclosure;

FIG. 2B is a perspective view of an exemplary retractable air filter in a un-retracted state in accordance with principles of the present disclosure;

35 FIG. 3 is a perspective view of an exemplary retractable air filter in accordance with principles of the present disclosure;

FIGS. 4A-4C are perspective views of an exemplary retractable air filter for use in, for example, a vertically opening window in accordance with principles of the present disclosure; and

FIG. 5 is a side view of an exemplary retractable air filter installed in, for example, a horizontally opening window in accordance with principles of the present disclosure.

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Detailed Description

Various embodiments and implementations will be described in detail. These embodiments should not be construed as limiting the scope of the present application in any manner, and changes and modifications may be made without departing from the spirit and scope of the embodiments and implementations. For example, many of the embodiments, implementations, and examples are discussed with specific reference to window air filters, but these should not be construed to limit the application scope to this one exemplary implementation. Further, only some end uses have been discussed herein, but end uses not specifically described herein are included within the scope of the present application. As such, the scope of the present application should be determined by the claims.

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One embodiment of a retractable filter 20 useable in a window in accordance with principles of the present disclosure is illustrated in FIG. 1. The retractable filter 20 includes a filter media assembly 30 having a filter media 32. In some embodiments, the filter media assembly 30 can be in the form of a roll 33. In some embodiments, the filter media 32 is wound on a central member 34 and can be easily expanded and retracted (*i.e.* unrolled and rolled back up). Details on the various components are provided below.

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In general terms, the adjustable length of the filter media assembly 30, due to the retractable nature, allows it to fit in a wide variety of window sizes. The retractable filter 20 can be attached to a partially opened window. The retractable filter 20 can fit a wide variety of window sizes. The retractable filter 20 can be employed in a partially open window, where only 10-30% of the window area is blocked, for example, leaving a large percentage of the window area still open for light passage and visibility.

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In some embodiments, a roll of filter media assembly 30 has a first, or leading, end 36 and a second, or trailing, end (not shown) opposite the first end 36 adjacent to a central member 34. First and second side edges 38, 40 extend between the first end 36 and the second end. In some embodiments, the filter media assembly 30 is generally rectangular when extended. In some embodiments, the first end 36 can include a handle 42 for increased usability. In some embodiments, one or both of the first and second side edges 38, 40 can include a looped structure (generally indicated by dashed line 44) or other fastening device, as is discussed in more detail below.

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As illustrated in FIGS. 2A-2B, in some embodiments, the central member 34 may be contained within a housing 50. The housing 50 can be any suitable shape for containing the roll 33 and/or providing expansion and retraction of the filter media assembly 30. Some exemplary shaped include rectangular or tubular. In some embodiments, the housing 50 includes at least one side 52 and, optionally, top and

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bottom ends 54, 56. In some embodiments, the leading end 36 of the filter media assembly 30 is easily accessible to a user and/or can be releasably retained on an exterior or interior of the housing 50. In some embodiments, the filter media assembly 30 is replaceable within the housing 50. In some embodiments, the filter media assembly 30 can be user replaceable without replacing the housing 50 and/or mounting components (see, *e.g.*, FIG. 3). In some embodiments, the filter media assembly 30 may also be replaceable without requiring replacement of internal winding (*e.g.* spring) components. For example, a refill filter media assembly 30 may slidably engage the central member 34 containing the winding components. The housing 50 can provide several benefits, such as, for example, improved seal between the filter media 32 and the window frame, improved aesthetic design, and/or enhanced locations and surface area for mounting the retractable filter 20 to the window structure. In some embodiments, the housing 50 provides a further benefit by firmly defining and fixing the distance between the mounting members for the two ends of the media central roll 34, which aids in assembly versus requiring the user to measure and install separate brackets.

In some embodiments, the filter media assembly 30 is retractable onto the roll 33 and unwound, or expanded, from the roll 33, as indicated by arrow "A" of FIG. 2B. In some embodiments, the central member 34 can be a spring-wound inner shaft or similar structure to provide retractability of the filter media assembly 30. In some embodiments, when the user desires to use the retractable filter 20 in the window, the filter media assembly 30 is unrolled by pulling on the handle 42 of the leading end 36. In some embodiments, the filter media assembly 30 unwinds from the central shaft member 34, which is under a spring tension, as the user continues to pull. In one embodiment, the central member 34 and spring mechanism (not shown) can provide stopping points, where the length of the unwound filter media assembly 30 can be temporarily fixed, until the spring mechanism is re-engaged. When the user wants to return the filter media assembly 30 to within the housing 50 or otherwise retract the filter media assembly 30, for example to close the window, the user re-engages the spring mechanism, which re-winds the filter media assembly 30 back into the housing 50.

In some embodiments, the filter media assembly 30 includes filter media 32 of suitable size to fit a wide variety of window dimensions. In some embodiments, the filter media assembly 30 may be longer than needed for a single use. In some embodiments, the filter media assembly 30 has a length suitable to provide for one or more filter media 32 changes, for example, wherein the dirty filter media 32 is discarded, and a clean segment of filter media 32 is unwound from the next section on the filter media assembly 30. In some embodiments, the filter media assembly 30 can be cut to expose a new length of clean filter media 32, providing for multiple filter changes from a single filter media assembly 30. With particular reference to FIG. 2B, in some embodiments, the filter media assembly 30 includes a plurality of separation lines 60 to divide the filter media assembly 30 into discrete filter lengths. In some embodiments, each separation line 60 can be formed from any number of through-cuts suitable to provide separation. In one embodiment, the separations lines 60 are perforated lines formed at positions along the

filter media assembly 30 corresponding to common window widths. The separation lines 60 can be at varying (*e.g.*, increasing or decreasing) distances from one another or uniform distances. Additionally, or alternately, a cutting device (not shown) may be integrated into the housing 50. Any cutting device may be used. In some embodiments, the cutting device can, for example, be a thin metal strip having a serrated edge.

In some embodiments, the filter media assembly 30 may incorporate looped structures 44, for example, either integrally or by addition, such as lamination, into one or both of the first and second side edges 38, 40. The loop structure 44 may be mated to a hook structure (see, *e.g.*, FIG. 4A) which is applied to the window frame and/or sash members. In some embodiments, the combined hook/loop structure holds in the filter media assembly 30 in place and reasonably seals the side edges 38, 40 from air bypassing the filter media assembly 30. In some embodiments, low-profile hooks, such as used in diapers, may be used, preferably with an adhesive back-side coating. In some embodiments, the hook and loop may be reversed in attachment orientation. In some embodiments, for example, where the retractable filter 20 is mounted in a recessed window, where a good mating edge for hook and loop attachment may not be available, the retractable filter 20 may include secondary strips or structures that can be attached to the window frame and/or sash to help facilitate the engagement. In some embodiments, the filter media 32 may also or alternatively be conformable, which will allow the filter media 32 to attach to hook structures in multiple planes.

FIG. 3 illustrates an exemplary retractable filter 20 including a hinged attachment mechanism 62, which may be combined with the housing 50 or which may be attached directly to the central member 34 at the roll 33 and the window. In one embodiment, the hinge 62, or similar mechanism, is rotatable to allow the filter media assembly 30 to pivot away from the window when the filter media assembly 30 is not in use and swing into the window when in use. This motion could allow for easier user interface and help enable better sealing of the filter media assembly 30 to the window cavity. In some embodiments, a locking mechanism (not shown) may be included to help retain the housing 50 in one or more rotated positions.

The particular filter media 32 selected for the filter media assembly 30 can be particularly suited have any of the particular desired characteristics described herein. In some embodiments, the filter media assembly 30 is constructed from moisture-resistant materials. In some embodiments, the filter media may include additional layers or features to specifically block or repel water, such as rain. In some embodiments, an electrostatic charge is optionally imparted into or onto material(s) of the filter media 32. In some embodiments, an electrostatically charged media 32 may be used, of which many grades are available, and many of which offer high efficiency with low pressure drop. In some embodiments, the filter media 32 can be an electret nonwoven web. Electric charge can be imparted to the filter media 32 in a variety of ways as is well known in the art, for example by hydrocharging, corona charging, etc. (*e.g.*, as described in U.S. Patent No. 7,947,142, the entirety of which is incorporated by reference herein).

In other embodiments, the filter media 32 is not electrostatically charged. In some embodiments, additional multi-functional media grades, which incorporate activated carbon or other materials for purifying gas-phase pollutants, may also or alternatively be incorporated into the filter structure. In some embodiments, the filter media 32 can be constructed, for example, from nonwoven fibrous media formed of thermoplastics or thermosetting materials such as polypropylene, linear polyethylene and polyvinyl chloride. Other suitable, non-limiting materials for the filter media include porous foams, nonwovens, papers, fiberglass, or the like. In some embodiments, the filter media 32 comprises a filter media that attracts and captures dust, allergens (such as pollen and mold spores), and/or fine particle pollution from the outdoor air.

Other nonwoven webs useful with the filter media 32 can be a high loft spunbond webs, such as described, for example, in U.S. Patent No. 8,162,153 to Fox et al., the entirety of which is incorporated herein. In other embodiments, the filter media 32 can be a low loft spunbond web, such as is described in U.S. Patent No. 7,947,142 to Fox et al., the entirety of which is incorporated herein. In yet other embodiments, nonwoven webs useful with the filter media 32 are generated by other techniques and/or have other characteristics, such as the meltblown nonwoven webs disclosed in U.S. Patent No. 6,858,297 to Shah et al., the entirety of which is incorporated herein. Other non-limiting example of useful nonwoven web formats include bi-modal fiber diameter meltblown media such as those described in U.S. Patent No. 7,858,163, , the entirety of which is incorporated herein.

In some embodiments, the filter media 32 is an electrostatically charged nonwoven type of media. In some embodiments, the filter media 32 can be a pleated filter media including at least a portion that has been folded to form a configuration comprising rows of generally parallel, oppositely oriented folds. In some embodiments, pleats can be formed in the filter media 32 (or in the pleated filter media assembly 30) using various methods and components as are well known in the art, *e.g.*, to form a pleated filter for use in applications such as air filtration., for example those described in U.S. Patent No. 6,740,137 to Kubokawa et al. and U.S. Patent No. 7,622,063 to Sundet et al., the entire teachings of both of which are incorporated herein by reference.

In some embodiments, the filter media 32 can consist of the filter media or web alone or can include one or more additional components or structures applied or assembled to the filter media 32 so long as the resultant filter media assembly 30 can at least be transitioned from the rolled condition to the unrolled condition without significantly damaging the structural integrity of the filter media assembly 30. In some embodiments, the filter media can be repeatedly transitioned between the rolled and unrolled conditions without significantly damaging the structural integrity of the filter media assembly 30. The filter media 32 of the assembly 30 can be self-supporting or non-self-supporting. For example, where the filter media assembly 30 consists of the filter media 32 alone, the filter media or web can be self-supporting or non-self-supporting. In some embodiments, where the filter media assembly 30 consists of the filter media or web 32 and a support structure, the filter media 32 can be non-self-supporting with an

additional supporting structure rendering the filter media assembly 30, as a whole, to be self-supporting. For example, the filter media 32 can be wire-backed. As used herein, the term “self-supporting filter media or web” can describe at least one of the following conditions: (1) a filter media or web that is deformation resistant without requiring stiffening layers, adhesive or other reinforcement in the filter media web; or (2) the filter media generally maintains its shape when subjected to an airstream as described, for example, in U.S. Patent No. 7,169,202 to Kubokawa, the entire teachings of which are incorporated herein by reference; or (3) a web or media having sufficient coherency and strength so as to be drapable and handleable without substantial tearing or rupture. As used herein, the term “non-self-supporting” can denote an air filter media that is not capable, in the absence of a support frame and/or a support grill, of withstanding the forces encountered due to typical air flow.

In some embodiments, the retractable air filters 20 are useful in protecting users from outside air quality contaminants. As discussed above, an electrostatically charged media 32 may be used. Additional multi-functional media grades, which incorporate activated carbon or other materials for purifying gas-phase pollutants, may also be incorporated into the filter media assembly 30. By incorporating an extended surface area and by covering moderate portion of the window, in combination with using a low pressure drop web enabled by the electrostatic charging, a reasonably low pressure drop can be achieved for the filter, which may help provide moderate airflow through the filter.

FIGS. 4A-4C illustrate aspects of the materials and construction of an exemplary retractable filter 120, similar to retractable filter 20, installed in a sliding-type window 180, which can be either single or double hung. Sliding windows are predominant in North America and China. Attachment of the retractable filter 120 to a window 180, with or without housing 150, may be either permanent or semi-permanent. In some embodiments, attachment mechanisms 190, 192 provide secure holding of the retractable filter 120 to the window 180 because the attachment point may undergo moderate stress from the inner spring forces as the filter media assembly 130 is extended and retracted. Some exemplary permanent fixation options include nails, screws, and certain types of adhesives. In some embodiments, the attachment is semi-permanent, such as using Command™ strips, adhesively backed interlocking hooks, rare earth magnets, etc. The housing 150 may be attached to the window frame 182 (or surrounding structures) in the major plane of the window, or it may be attached to the window frame 182 (or surrounding structures) perpendicular to the major plane of the window 180. In another embodiment, the housing 150 may not be mounted to the window frame 182 at all, and may rather be pinched between the window sash 184 and the window frame 182. When expanded, the side edges 138, 140 of the filter media assembly 130 can be attached to the window frame/sill members with mechanical or adhesive components.

Finally, similar to the vertical sliding window 180 of FIGS. 4A-4C discussed above, FIG. 5 illustrates an exemplary retractable filter 220 installed in a horizontal sliding window 280. In some embodiments, the housing 250 of the retractable filter 220 is attached at one end of the window 280, the

5 window 280 is partially opened, and the filter media assembly 230 is expanded to cover the window gap. It is noted that a small gap may be created between the two window segments, allowing air to flow from the outside between the two window segments and bypassing the filter media assembly 230 to gain entry to the indoors. In some embodiments, this bypass may be avoided by the use of a piece of foam, weather-stripping, etc. (not shown).

10 The air filters of the present disclosure can be placed in any desired frame or housing. Some exemplary frames are described in, for example, US Patent Application No. 62/041496 and 62/041499, both of which are incorporated in their entirety herein. The air filter assembly of the present disclosure can be used in a powered air filtration system such as, for example, that described in U.S. Patent Application No. 62/041501, incorporated herein in its entirety. The air filter assembly or media of U.S. Patent No. 62/206,928 can be used in the air filters of the present disclosure.

15 The terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

All references mentioned herein are incorporated by reference in their entirety.

20 Moreover, the terms top, bottom, over, under and the like in the description and the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other orientations than described or illustrated herein.

The recitation of all numerical ranges by endpoint is meant to include all numbers subsumed within the range (*i.e.*, the range 1 to 10 includes, for example, 1, 1.5, 3.33, and 10).

25 Those having skill in the art will appreciate that many changes may be made to the details of the above-described embodiments and implementations without departing from the underlying principles thereof. Further, various modifications and alterations of the present invention will become apparent to those skilled in the art without departing from the spirit and scope of the invention. The scope of the present application should, therefore, be determined only by the following claims and equivalents thereof.

What is claimed is:

1. An air filter comprising:

filter media assembly configured in a roll, the filter media assembly including filter media having a leading end opposite a trailing end and first and second opposed side edges extending
5 between the leading end and the trailing end.

2. The air filter of claim 1, further comprising:

a housing for containing the filter media assembly.

10 3. The air filter of claim 2, wherein the leading edge can be releasably retained on at least one of the exterior or interior of the housing.

4. The air filter of either claim 2 or 3, wherein the filter media assembly is replaceable within the housing.
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5. The air filter of any of the preceding claims, wherein at least one of the leading edge and the trailing edge includes a looped structure, a hooked structure, and/or a fastening device.

6. The air filter of any of the preceding claims, wherein the first end includes a handle.
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7. The air filter of any of the preceding claims, wherein the filter media assembly is retractable on the roll.

8. The air filter of any of the preceding claims, wherein the roll includes a central member that is under spring tension.
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9. The air filter of claim 8, wherein the central member provides stopping points.

10. The air filter of any of the preceding claims, wherein the filter media assembly includes sufficient filter media for multiple uses.
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11. The air filter of any of the preceding claims, wherein the filter media assembly includes separation and/or perforation lines or points.

12. The air filter of any of the preceding claims, further including a hinged attachment mechanism.
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13. The air filter of claim 12, wherein the hinged attachment mechanism is combined with the housing or attached to the central member.

14. The air filter of claim 13, wherein the hinged attachment mechanism is rotatable.

15. The air filter of any of the preceding claims, wherein the filter media is at least one of moisture-resistant, moisture-repellant, electrostatically charged, an electret nonwoven web, and/or not electrostatically charged.

16. The air filter of any of the preceding claims, wherein the filter media includes at least one of carbon, activated carbon, a nonwoven, a thermoplastic, a thermosetting material, a porous foam, fiberglass, paper, a high loft spunbound web, a low loft spunbound web, a meltblown web, and/or bi-modal fiber diameter meltblown media.

17. The air filter of any of the preceding claims, wherein the filter media is pleated.

18. The air filter of any of the preceding claims, wherein the filter media is at least one of self-supporting and non-self-supporting.

19. The air filter of any of the preceding claims, further including a cutting device capable of cutting the filter media to a desired size.

20. The air filter of claim 19, wherein the cutting device is integrated into the housing.

21. The air filter of any of the preceding claims, wherein the air filter is a window air filter.

22. A kit, comprising:

an air filter of any of claims 1-21; and

a cutting device capable of cutting the filter media to a desired size.

23. The kit of claim 22, wherein the cutting device is integrated into the housing.

24. A kit, comprising:

an air filter of any of claims 1-21; and

an attachment device capable of permanently or semi-permanently attaching the air filter

to a window.

25. The kit of claim 21, wherein the attachment device is at least one of a nail, a screw, a hook, an adhesive, and/or an adhesive backed interlocking strip.

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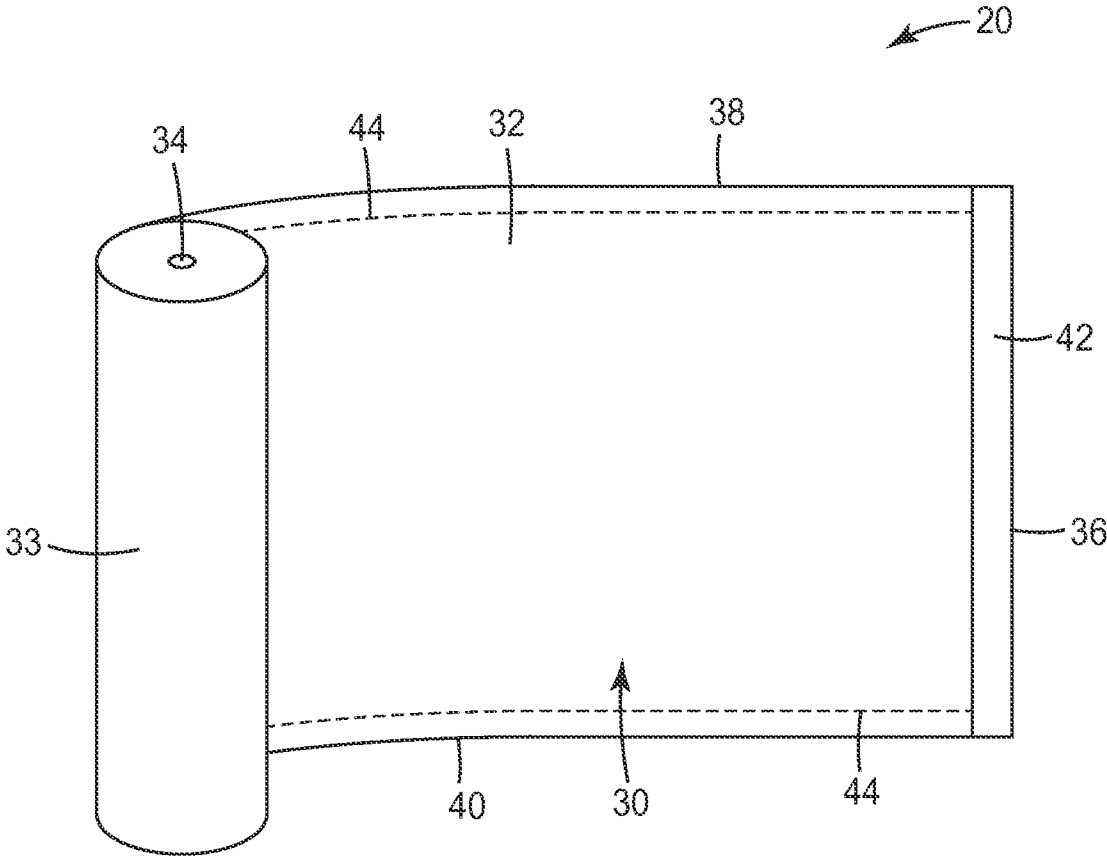
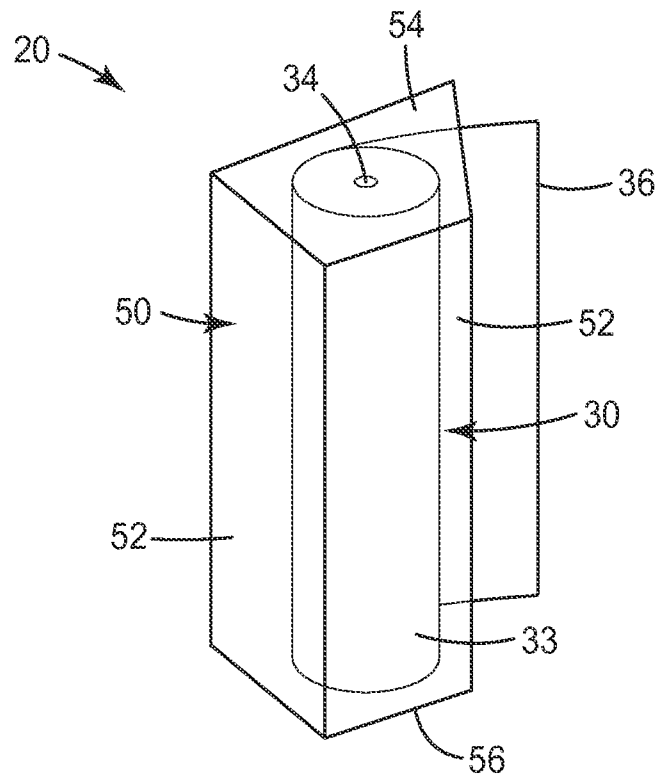
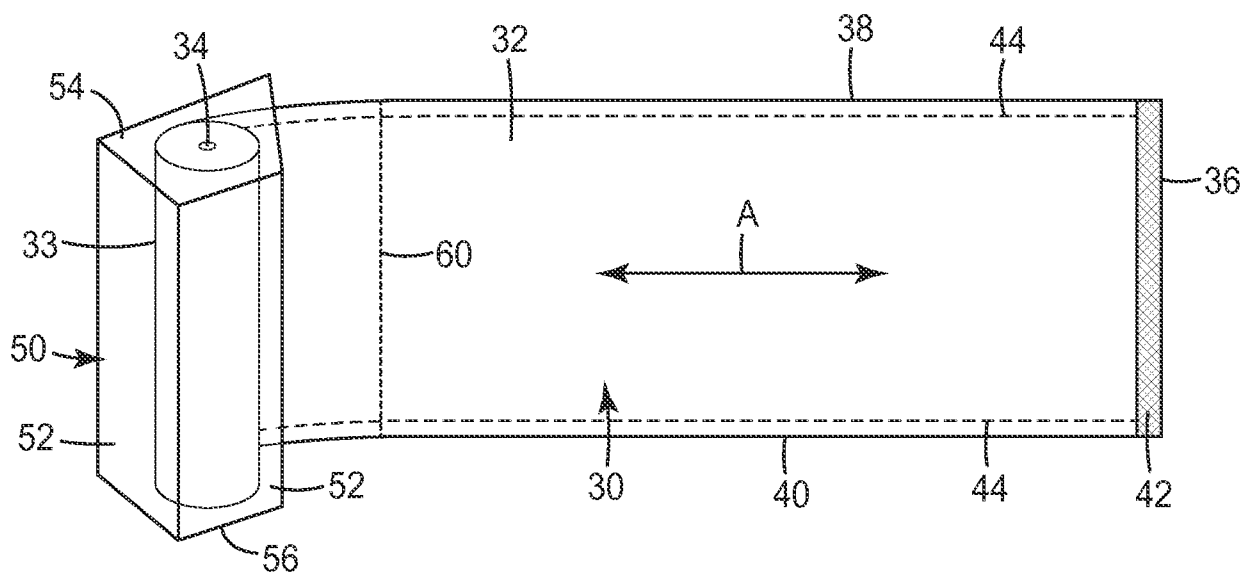


FIG. 1

*FIG. 2A**FIG. 2B*

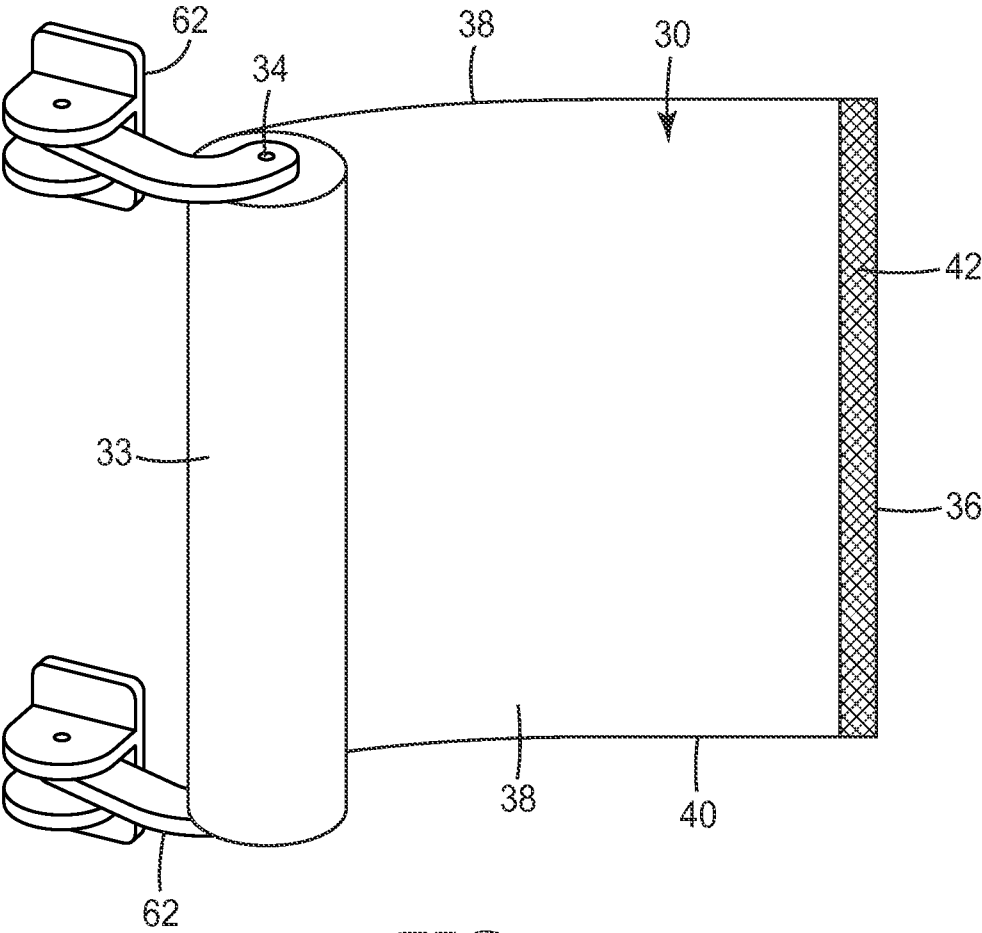
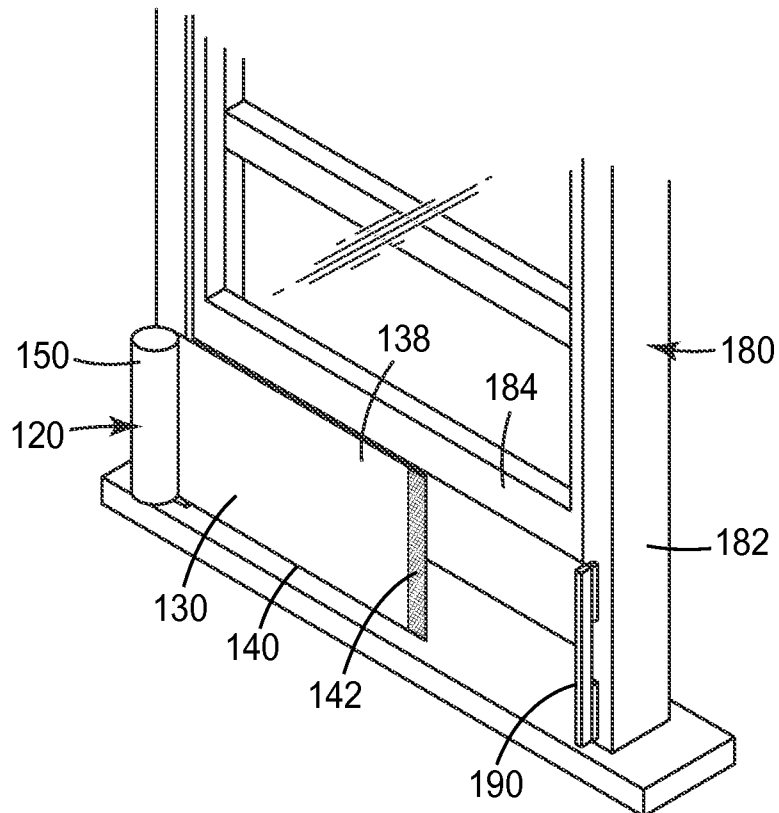
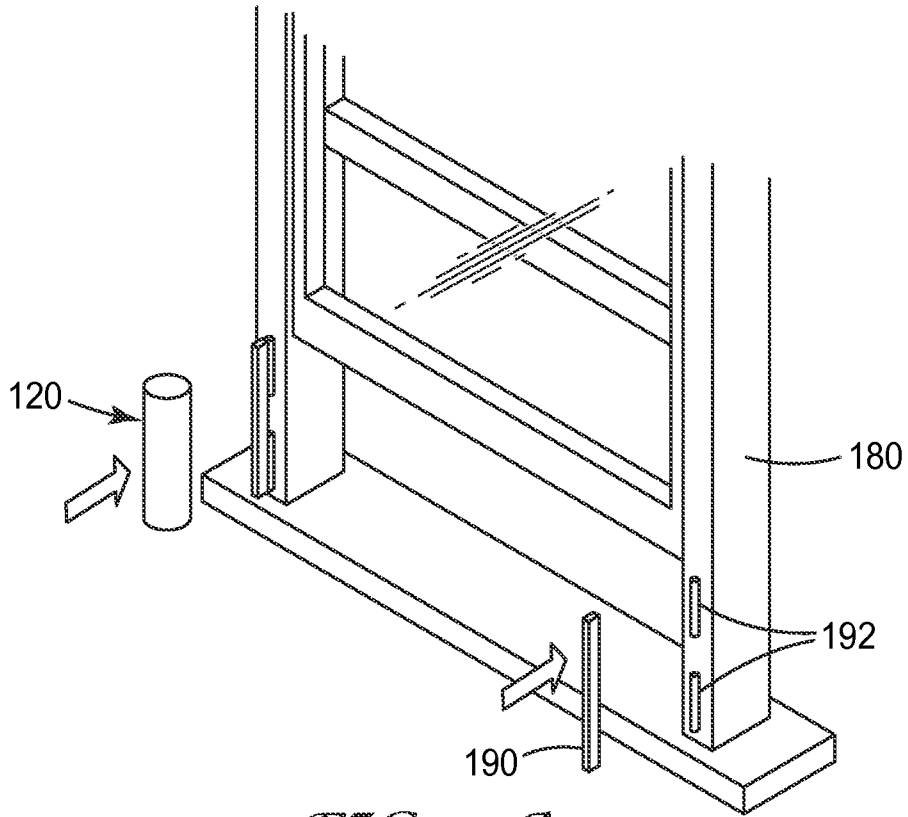
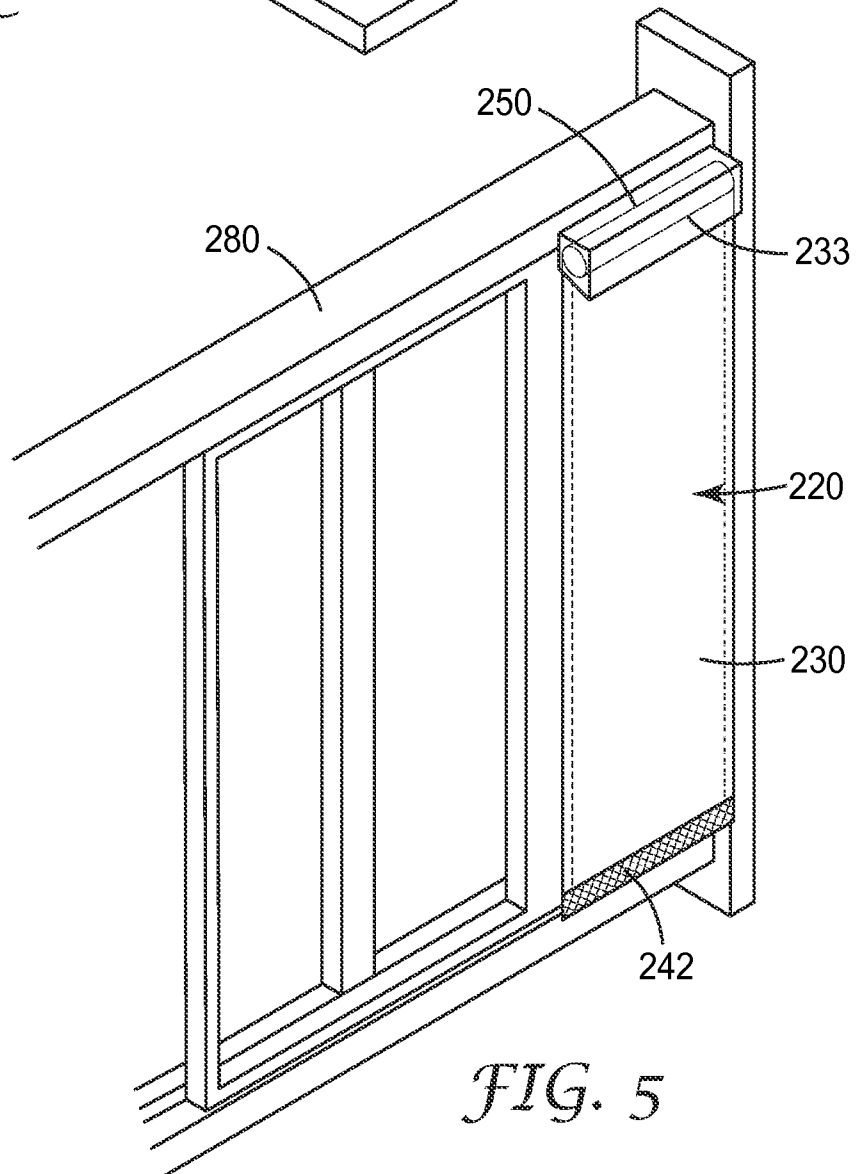
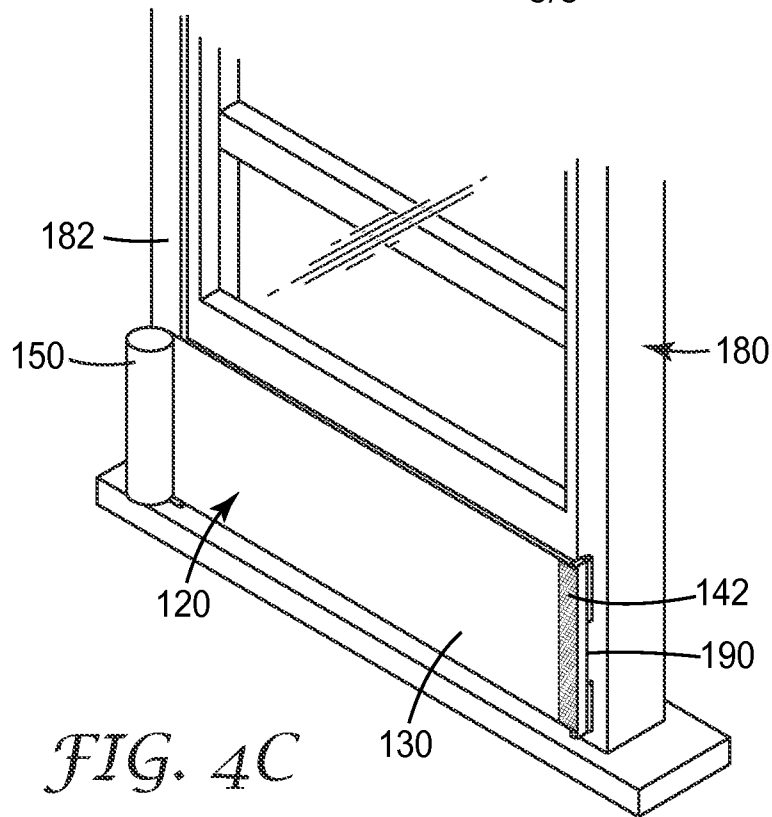


FIG. 3

4/5



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/046490

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A47H 23/08 (2015.01)

CPC - A47H 23/08 (2015.10)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A47H 23/08; E06B 9/52, 9/54; F24F 13/28 (2015.01)

CPC - A47H 23/08; E06B 9/54; F24F 13/28; Y10S 160/07 (2015.10)

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

USPC - 55/354; 160/239, 273.1 (keyword delimited)

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

PatBase, Google Patents, YouTube, Google.

Search terms used: rolling, air, filter, media, housing, window.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2,521,455 A (GORGUN) 05 September 1950 (05.09.1950) entire document	1-4
X	US 1,795,087 A (HIGGINS) 03 March 1931 (03.03.1931) entire document	1-3
A	US 3,695,008 A (NEUMANN) 03 October 1972 (03.10.1972) entire document	1-4
A	US 3,364,662 A (REVELL) 23 January 1968 (23.01.1968) entire document	1-4
A	US 6,197,077 B1 (SIMMONS et al) 06 March 2001 (06.03.2001) entire document	1-4

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

12 October 2015

Date of mailing of the international search report

13 NOV 2015

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/046490

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5-25
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

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