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Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

(54) **Title:** DISINFECTING RESPIRATOR MASK CARTRIDGE WITH ULTRAVIOLET LIGHT

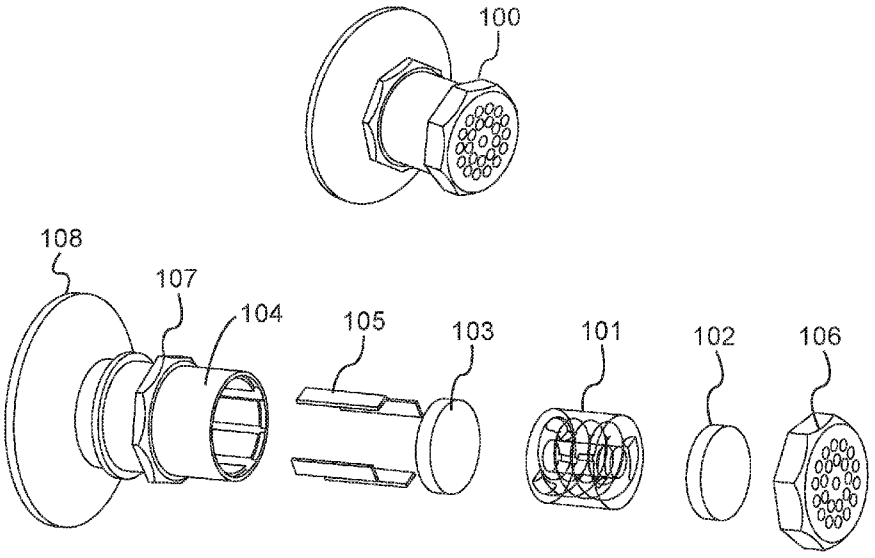


FIG. 1

(57) **Abstract:** According to one example embodiment, an apparatus may include at least one solid cylinder comprising at least one helicoidal channel passing through the at least one cylinder along a y-axis of the at least one cylinder, at least one cartridge enclosure configured to house the at least one solid cylinder, and at least one light source disposed between the at least one solid cylinder and at least one cartridge enclosure and configured to emit ultraviolet light.

WO 2022/003401 A1

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— *with international search report (Art. 21(3))*

DISINFECTING RESPIRATOR MASK CARTRIDGE WITH ULTRAVIOLET LIGHT

TECHNICAL FIELD:

[0001] Some example embodiments may generally relate to face-worn respirators, such as those configured to prevent exposure to airborne pathogens.

BACKGROUND:

[0002] Pathogens such as influenza viruses, rhinoviruses, mycobacterium tuberculosis, ebolaviruses, and severe acute respiratory syndrome coronaviruses, such as SARS-CoV, SARS-CoV-1, and more recently SARS-CoV-2, have increased the need for sufficient and effective personal protective equipment (PPE). Far-ultraviolet C light has been demonstrated to successfully inactivate and disinfect drinking water, wastewater, air, pharmaceutical products, and surfaces from these types of pathogens.

SUMMARY:

[0003] In accordance with some embodiments, an apparatus may include at least one solid cylinder comprising at least one helicoidal channel passing through the at least one cylinder along a y-axis of the at least one cylinder, at least one cartridge enclosure configured to house the at least one solid cylinder, and at least one light source disposed between the at least one solid cylinder and at least one cartridge enclosure and configured to emit ultraviolet light.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0004] For the proper understanding of example embodiments, reference should be made to the accompanying drawings, wherein:

[0005] FIG. 1 illustrates an example of a respirator mask cartridge design according to certain embodiments.

[0006] FIG. 2 illustrates an example of a structure of a transparent helicoidal air channel according to various embodiments.

[0007] FIG. 3 illustrates an example of multiple internal details of a cartridge enclosure according to some embodiments.

DETAILED DESCRIPTION:

[0008] It will be readily understood that the components of certain example embodiments, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of some example embodiments of apparatuses related to a respirator mask cartridge design is not intended to limit the scope of certain embodiments but is instead representative of selected example embodiments.

[0009] Current respirator masks, both full-face and half-face, typically utilize filter cartridges to protect the human respiratory system from inhaling hazardous particles, gases, and vapors. These filter cartridges generally treat inhaled air only, leaving unsanitized exhaled air as a risk for spreading airborne diseases. Moreover, while filter cartridges are generally capable of removing most microorganisms, including bacteria and viruses, filter cartridges have limited use before cleaning, maintenance, and replacement are necessary.

[0010] Far-ultraviolet C (UVC) light, having a wavelength in the range of 100–280 nanometers (nm) and photon energy of 4.43–12.4 electronvolts (eV), has been shown to efficiently inactivate airborne-mediated microbial diseases carried by aerosols, even at very low doses. For example, more than 95% of airborne influenza A virus subtype H1N1 (A/H1N1) can be inactivated when exposed to 222nm light at a UV intensity (fluence) of 2 mJ/cm^2. Thus, a user

may use far-UVC light to disinfect inhaled and exhaled air, protecting both the user and other people.

[0011] Some embodiments of the respirator mask cartridge described herein allow its user to breathe cleaned and sanitized air using a series of mechanisms. As the user inhales, unfiltered air first passes through a particle filter, which captures or otherwise prevents larger particles from passing more in-depth into the respirator mask cartridge. After passing through the particle filter, the air travels through a transparent cylinder via a plurality of helicoidal air channels inside the cylinder. As the air moves through the helicoidal air channels, the air is exposed to far-UVC light, disinfecting the air of any microorganisms. Finally, the air passes through a carbon filter which captures ozone (O_3) generated by the UVC light, protecting the user from the ozone.

[0012] When the user exhales, the air once again passes through the carbon filter, where there is no significant ozone for removal since the exhaled air has not yet passed through the helicoidal air channels. Any exhaled ozone is negligible, and will quickly mix with outside air. As the exhaled air moves through the helicoidal air channels, microorganisms trapped in water vapor exhaled by the user are exposed to the UVC light, sanitizing the air and protecting other people from contagions exhaled by the user.

[0013] As noted above, FIG. 1 illustrates an assembled view and an exploded view of an example embodiment of a respirator mask cartridge 100. Respirator mask cartridge 100 may include a cylinder 101 with at least one helicoidal air channel passing through cylinder 101, which may be centered on the y-axis of cylinder 101, and run from an interior end of cylinder 101 to an exterior end of cylinder 101. Cylinder 101 may be made of any combination of transparent material, including glass, plastic, acrylic, polycarbonate, polypropylene, and other polymers.

[0014] In various embodiments, respirator mask cartridge 100 may include at least one particle filter 102 configured to cover the exterior end of cylinder

101, including exterior-end entries of the helicoidal air channels in cylinder 101. Particle filter 102 may be configured to capture airborne particles, such as smoke, mold, dust, fungus, bacteria, and viruses. Particle filter 102 may also be any combination of cotton, fiberglass, polyester, high-efficiency particulate air (HEPA), ultra-low particulate air (ULPA), and electrostatic non-woven polypropylene fiber filters. Additionally or alternatively, particle filter 102 may also be a cupper filter, such as a cuprous oxide (Cu_2O)-impregnated filter configured to provide more protection against microbes and viruses.

[0015] In some embodiments, respirator mask cartridge 100 may also include at least one carbon filter 103 configured to cover the interior end of cylinder 101, opposite from particle filter 102, including interior-end entries of the helicoidal air channels in cylinder 101. Carbon filter 103 may include activated carbon and/or activated charcoal. Carbon filter 103 may also be configured to capture hazardous gases, such as ozone, tetrachloroethene ($Cl_2C=CCl_2$), chlorofluorocarbons, methylene chloride (CH_2Cl_2), formaldehyde (CH_2O), chlorocarbons, benzene (C_6H_6), and other volatile organic compounds (VOCs).

[0016] Certain embodiments of respirator mask cartridge 100 may further include a cartridge enclosure 104 configured to enclose and secure the aforementioned features. Cartridge enclosure 104 may be a cylindrical shell having an interior volume suitable to house cylinder 101, particle filter 102, and carbon filter 103. As will be illustrated later in FIG. 3, the interior face of cartridge enclosure 104 may include reflective material, such as glass mirrors, acrylic mirrors, paint, polished anodized aluminum, and biaxially-oriented polyethylene terephthalate (BoPET). The reflective material of cartridge enclosure 104 may be configured to amplify and focus light within cartridge enclosure 104 towards air moving through the helicoidal air channels in cylinder 101.

[0017] As will be discussed in further detail below, the interior face of cartridge enclosure 104 may have multiple surfaces, wherein the interior face may include at least one indentation extending longitudinally from an interior end of cartridge enclosure 104 to an exterior end of cartridge enclosure 104. At least one indentation may be configured to secure at least one strip of lights 105, such as far-UVC light-emitting diode (LED) lights, to the interior face of cartridge enclosure 104. Any number of indentations and lights 105 may be accommodated by cartridge enclosure 104.

[0018] In some embodiments, lights 105 may be powered by batteries (not shown), which may be disposed outside of the respirator mask cartridge. As a result, the respirator mask cartridge may remain lightweight and maintenance-free. Additionally or alternatively, the batteries may be charged using, for example, a universal serial bus (USB) cable. Furthermore, lights 105 may be directly powered by other sources, such as a battery pack used for charging mobile devices or cell phones.

[0019] In order to secure the aforementioned features, an interior end of a nut 106 may be configured to screw, snap, or otherwise lock onto the exterior end of cartridge enclosure 104, thereby sealing elements 101-103 and 105 from air leaking with the outside environment. Nut 106 may include a plurality of holes extending from its interior to exterior end, allowing an exchange of air between the outside environment and particle filter 102. The outside surface of cartridge enclosure 104 may include nut 107 configured to affix cartridge enclosure 104 to article 108, which may be a respiratory mask. While a single respirator mask cartridge has been described as affixing to article 108, any number of respirator mask cartridges may be used. For example, two respirator mask cartridges may be affixed to article 108, and extend away from article 108 at the same angle. In this way, a variety of respirator mask designs, including full-face and half-face masks, may be accommodated, and

additional safety may be provided with a backup respirator mask cartridge in place if one respirator mask cartridge fails.

[0020] As noted above, cylinder 101 shown in FIG. 1 may have at least one helicoidal air channel, more closely detailed at 201 in FIG. 2. When a user inhales through the interior end of the assembled respirator mask cartridge 100, air begins to pass through helicoidal air channel 201 from the exterior end of cylinder 101 to the interior end of cylinder 101. Air exhaled by the user again flows through helicoidal air channel 201 inversely. In this way, exposing the air to UVC light while passing through helicoidal air channel 201 protects both the user and other people. It is noted that the length and/or angle of helicoidal air channel 201 may be adjusted to increase or decrease the distance of helicoidal air channel 201, and thus the time that air is exposed to UVC light.

[0021] Furthermore, cylinder 101 may include an electronic communication system, allowing the user to speak to others without the need to remove respirator mask cartridge 100 and risk contamination. For example, channel 202 may run through the center of cylinder 101 and may house a microphone configured to detect voice communications from the user. The microphone may transmit signals to an electroacoustic transducer (speaker) via a wireless connection, such as with BLUETOOTH and/or ZIGBEE technology, and/or with a wired connection passing through wire channel 204. Cylinder 101 may also have a tongue 203 configured to align cylinder 101 with carbon filter 103 and/or cartridge enclosure 104.

[0022] In various embodiments, any number of sensors may be integrated with respirator mask cartridge 100, such as light, pressure, temperature, and humidity sensors. Such sensors may communicate with an electronic device, such as a mobile phone, via a wired connection passing through channel 202 and/or a wireless connection, such as with BLUETOOTH and/or ZIGBEE technology. By communicating with an electronic device, the user may

monitor the performance of respirator mask cartridge 100 and may receive notifications on required preventative maintenance when respirator mask cartridge 100, using the variety of sensors, detects abnormalities in the functioning of respirator mask cartridge 100.

[0023] FIG. 3 illustrates a detailed view of cartridge enclosure 104. As noted above, the interior face of cartridge enclosure 104 may include a plurality of reflective surfaces 301, which may reflect and focus UVC light towards helicoidal air channel 201. Lights 105 may be positioned at any of indentations 302, which may run along the longitudinal axis of cartridge enclosure 104. As noted above, a microphone in channel 202 requiring a wired connection may use wire port 304 to allow communication from the microphone to a speaker positioned outside of respirator mask cartridge 100, with the wire passing through wire channel 303.

[0024] Certain embodiments described herein may have various benefits and/or advantages to overcome the disadvantages described above. For example, certain embodiments may sanitize air inhaled and exhaled by a user, as well as allow verbal communication without removal of the respirator mask cartridge.

[0025] The features, structures, or characteristics of example embodiments described throughout this specification may be combined in any suitable manner in one or more example embodiments. For example, the usage of the phrases "various embodiments," "certain embodiments," "some embodiments," or other similar languages throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with an example embodiment may be included in at least one example embodiment. Thus, appearances of the phrases "in various embodiments," "in certain embodiments," "in some embodiments," or other similar languages throughout this specification do not necessarily all refer to the same group of example embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more example embodiments.

[0026] Additionally, if desired, the different functions or procedures discussed above may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the described functions or procedures may be optional or may be combined. As such, the description above should be considered as illustrative of the principles and teachings of certain example embodiments, and not in limitation thereof.

[0027] One having ordinary skill in the art will readily understand that the example embodiments discussed above may be practiced with procedures in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although some embodiments have been described based upon these example embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent while remaining within the spirit and scope of the example embodiments.

[0028] Partial Glossary

[0029]	BoPET	Biaxially-oriented Polyethylene Terephthalate
[0030]	CoV	Coronavirus
[0031]	eV	Electronvolt
[0032]	HEPA	High-efficiency Particulate Air
[0033]	LED	Light-emitting Diode
[0034]	nm	Nanometers
[0035]	PPE	Personal Protective Equipment
[0036]	SARS	Severe Acute Respiratory Syndrome
[0037]	ULPA	Ultra-low Particulate Air
[0038]	USB	Universal Serial Bus
[0039]	UVC	Ultraviolet C
[0040]	VOC	Volatile Organic Compound

WE CLAIM:

1. An apparatus, comprising:

at least one solid cylinder (101) comprising at least one helicoidal channel (201) passing through the at least one cylinder along a y-axis of the at least one cylinder;

at least one cartridge enclosure (104) configured to house the at least one solid cylinder; and

at least one light source (105) disposed between the at least one solid cylinder and at least one cartridge enclosure and configured to emit ultraviolet light.

2. The apparatus of claim 1, wherein the at least one light source is configured to emit far ultraviolet C light.

3. The apparatus of any preceding claim, further comprising:

at least one particle filter (102) disposed on an exterior end of the at least one solid cylinder and configured to capture airborne particles.

4. The apparatus of any preceding claim, further comprising:

at least one carbon filter (103) disposed on an interior end of the at least one solid cylinder and configured to capture ozone.

5. The apparatus of any preceding claim, wherein the at least one light source is configured to affix with at least one indentation of the at least one cartridge

enclosure along the longitudinal axis of the at least one cartridge enclosure.

6. The apparatus of any preceding claim, further comprising:

at least one nut (106) configured to attach to an exterior end of the at least one cartridge enclosure.

7. The apparatus of any preceding claim, further comprising:

at least one nut (107) configured to couple the at least one cartridge enclosure with at least one article.

8. The apparatus of any preceding claim, wherein the at least one solid cylinder further comprises:

a channel (202) through the at least one solid cylinder configured to house a microphone for detection of voice communications from a user.

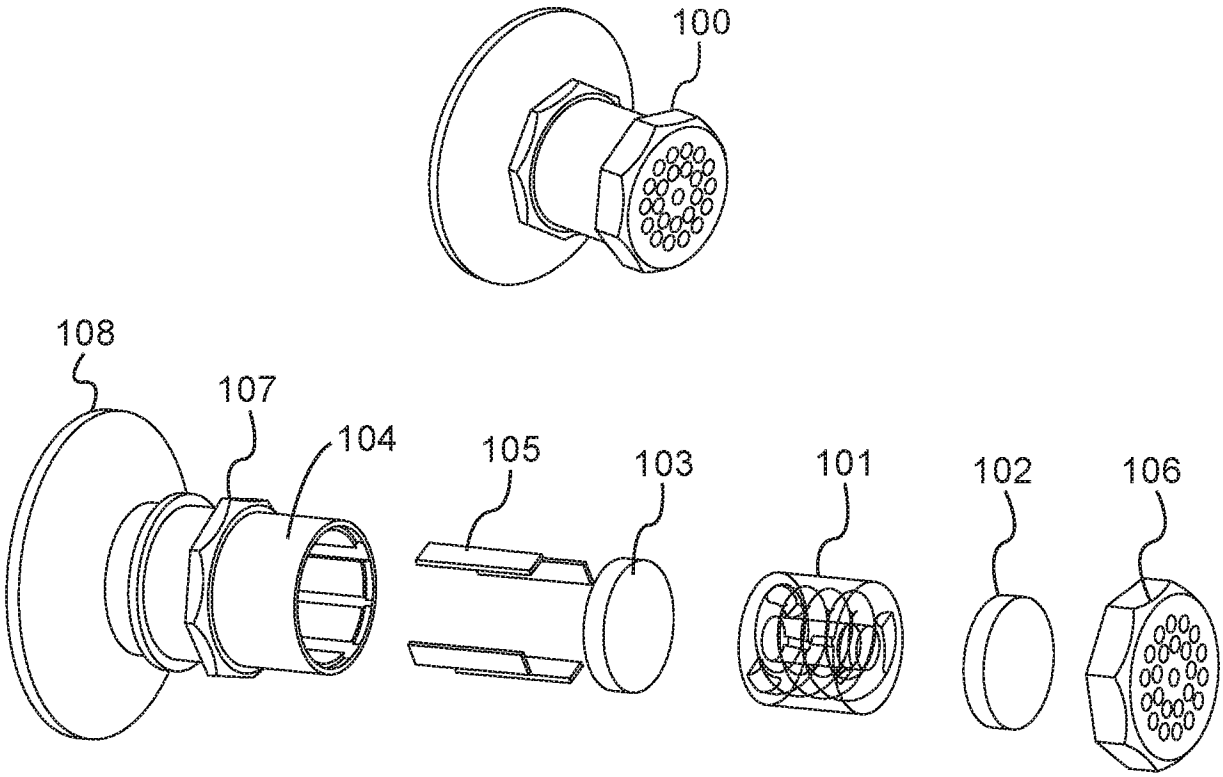


FIG. 1

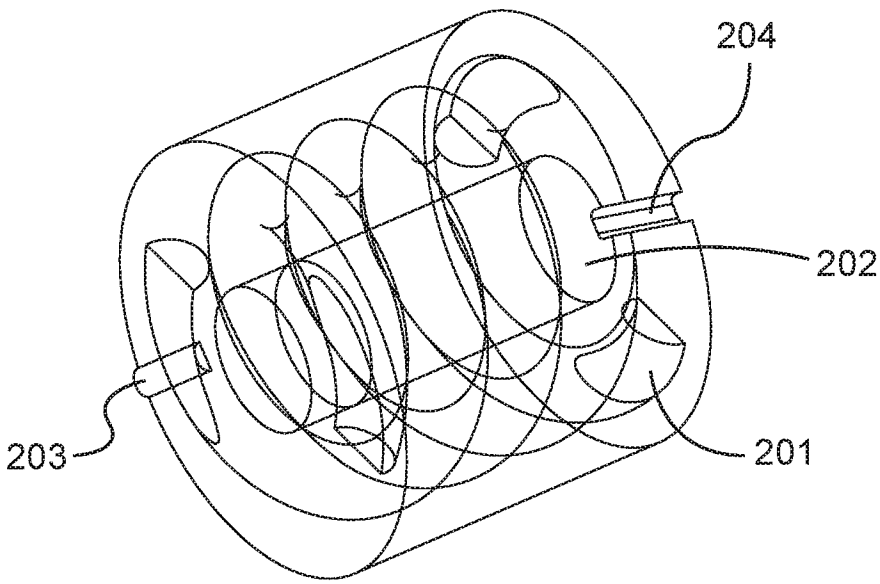


FIG. 2

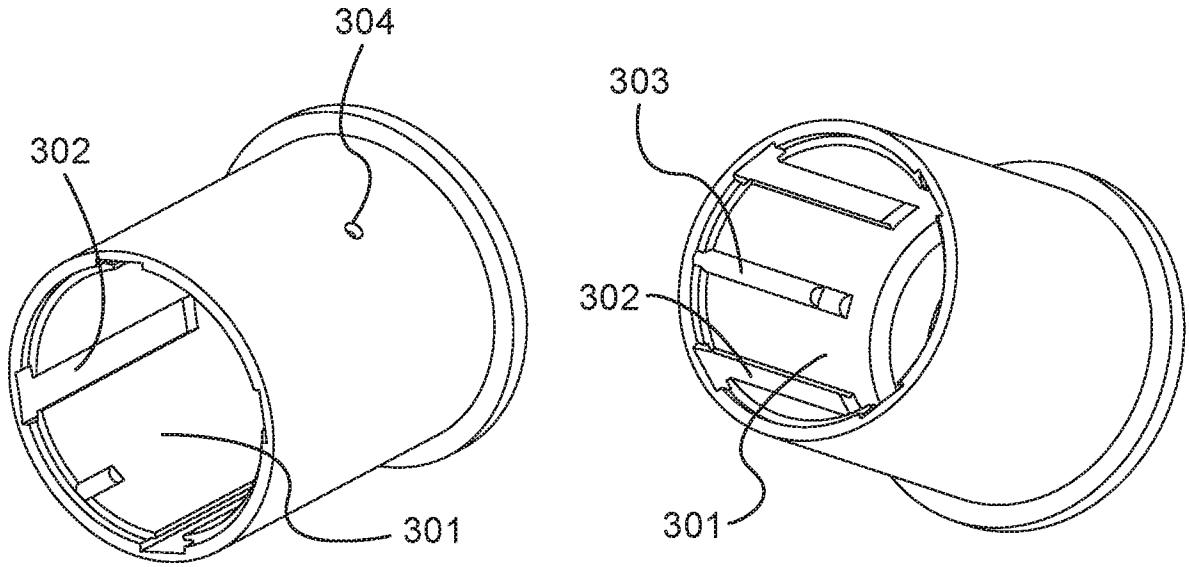


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB20/56232

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A62B 23/02, 7/10; A61L 9/20; B01D 46/00 (2020.01)

CPC - A62B 23/02, 7/10; A61L 9/20; B01D 46/0027, 46/00; A61L 2209/14, 2209/133; B01D 2259/4541

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)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	CN 209985209 U (HENAN AIWEIKANG BIOTECHNOLOGY) 24 January 2020 (24.01.2020); see machine translation; entire document.	1 & 3/1 --------- 2 & 3/2
Y	US 2019/0255201 A1 (FREESTYLE PARTNERS, LLC) 22 August 2019 (22.08.2019); abstract; figure 1; paragraph [0005].	2 & 3/2
A	US 2018/0264161 A1 (WELCH, G) 20 September 2018 (20.09.2018); entire document.	1-3
A	CN 104824877 A (XIE, A et al.) 12 August 2015 (12.08.2015); see machine translation; entire document.	1-3

☐ 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
"D" document cited by the applicant in the international application
"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	Date of mailing of the international search report
05 October 2020 (05.10.2020)	20 OCT 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB20/56232

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.: 4-8
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.