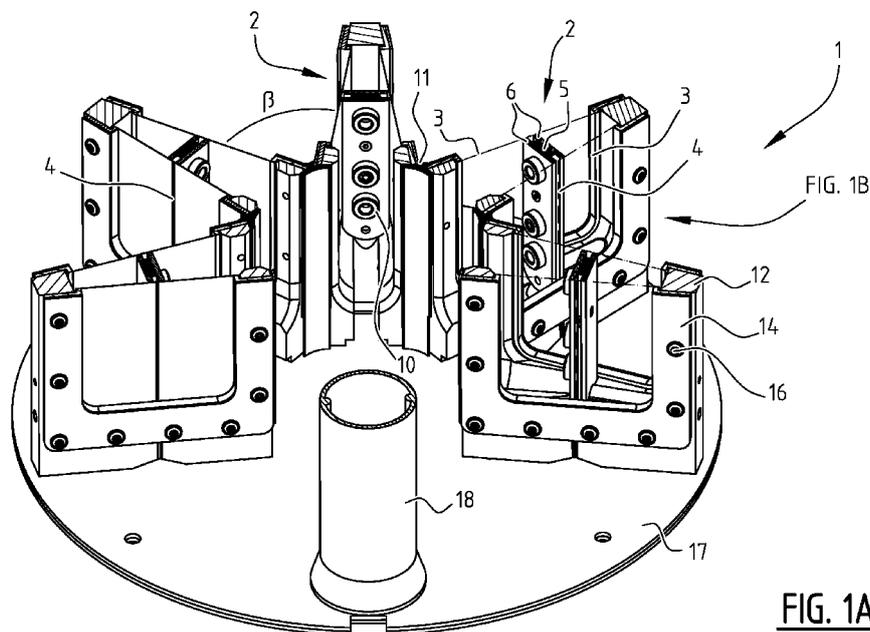




- (51) **International Patent Classification:**
H04R 9/06 (2006.01) *H04R 9/04* (2006.01)
H04R 7/04 (2006.01)
- (21) **International Application Number:**
PCT/NL2020/050528
- (22) **International Filing Date:**
27 August 2020 (27.08.2020)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
2023714 27 August 2019 (27.08.2019) NL
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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW,

(54) **Title:** SPEAKER-ELEMENT AND SPEAKER COMPRISING SUCH A SPEAKER-ELEMENT



(57) **Abstract:** The invention relates to a speaker-element for a speaker, comprising two substantially mutually opposing spaced apart membrane planes, wherein each membrane plane comprises at least one electromagnetic wire arranged for creating a magnetic field upon an electric current 5 passing through said electromagnetic wire, wherein at least one permanent magnet is arranged between the two membrane planes, wherein the electromagnetic wires of the two membrane planes are connectable to an electric power source in such a manner, that the electric current passes there trough in substantially mutually opposing directions and thereby creating substantially mutually opposing magnetic fields, such that upon passing an electric current through the electromagnetic 10 wire of each membrane plane said membrane planes are both either attracted towards or repulsed from the permanent magnet and thereby moved towards or away from each other, respectively, thereby producing a sound wave.



SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

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

SPEAKER-ELEMENT AND SPEAKER COMPRISING SUCH A SPEAKER-ELEMENT

The invention relates to a speaker-element for a speaker and speaker comprising such a speaker-element.

5 Speakers and speaker-elements thereof are known per se. Said known speakers and speaker-elements thereof are suitable for producing sound waves in a certain frequency range, and generally different speakers or different speaker-elements are provided for different frequency ranges. For example, a first speaker or speaker-element may be provided for a frequency range of about 100 Hz – 22 kHz, and a second speaker or speaker-element may be provided for a frequency
10 range having frequencies lower than about 150 Hz, also known as a subwoofer.

 It is an object of the invention to improve said known speaker and speaker-elements thereof. More in particular it is an object of the invention to provide one speaker and/or one speaker-element that is suitable for producing sound waves at a full frequency range, i.e. for example between about 0 – 22 kHz.

15 Said speaker-element comprises in accordance with the invention two substantially mutually opposing spaced apart membrane planes, wherein each membrane plane comprises at least one electromagnetic wire arranged for creating a magnetic field upon an electric current passing through said electromagnetic wire, wherein at least one permanent magnet is arranged between the two membrane planes, wherein the electromagnet wires of the two membrane planes
20 are connectable to an electric power source in such a manner, that the electric current passes there through in substantially mutually opposing directions and thereby creating substantially mutually opposing magnetic fields, such that upon passing an electric current through the electromagnetic wire of each membrane plane said membrane planes are both either attracted towards or repulsed from the permanent magnet and thereby moved towards or away from each other, respectively,
25 thereby producing a sound wave.

 The applicant has found that such a speaker-element is able to produce sound waves in a frequency range of about 0 – 22 kHz, thereby reducing the need for further speaker-elements having a different frequency range, i.e. no separate subwoofer is needed for low frequencies.

30 Said two membrane planes may be relatively light and/or relatively small, thereby being able to produce said sound waves in said large frequency range.

 By providing said two membrane planes the sound waves produced thereby are added.

 The membrane planes may be composed by one continuous membrane that is bent to form said two membrane planes, or by two separate membranes. Said “two substantially mutually opposing spaced apart membrane planes” may therefore alternatively be defined as “at least one
35 membrane comprising two substantially mutually opposing spaced apart planes” or “at least one membrane comprising two substantially mutually opposing spaced apart plane-like parts”.

The electromagnetic wires of the two membrane planes may be arranged substantially parallel to each other, wherein in the one wire the current passes in a first direction, and in the other wire the current passes in a second, opposite direction. Because the current passes through the wires in substantially opposing directions, the electrometric fields created by the wires are also substantially opposing. Therefore the wires, and thereby the membrane planes, are moved in substantially opposing directions, i.e. towards or away from each other.

Each electromagnetic wire may extend in plane with a respective one the two membrane planes.

The permanent magnet may be arranged symmetrically between the two membrane planes.

The permanent magnet may for example be a neodymium magnet.

The membrane plane may for example comprise a Polyethylene terephthalate (PET) membrane or foil, for example known as Mylar.

The membrane plane may for example be around 0.019 mm thick.

In an embodiment of the speaker-element according to the invention each electromagnetic wire is arranged substantially in a middle line of each membrane plane, such that substantially equal membrane parts are arranged on both sides of said electromagnetic wire.

By providing the electromagnetic wire in the middle line of each membrane plane, the membrane plane may be evenly moved.

In other, possibly less preferable embodiments, it is possible to arrange the electromagnetic wire in a different location with respect to each membrane plane. As an example, the electromagnetic wire may be arranged along a line bisecting a half of each membrane plane.

The middle line may for example either be the substantially vertical or substantially horizontal middle line of the membrane plane.

The electromagnetic wire may in particular extend over the whole length or whole width of said membrane plane.

It is noted that the electromagnetic wires may be arranged in the same middle lines of the two membrane planes, i.e. the middle lines of the membrane planes that extend substantially parallel to each other, such that the wires extend substantially parallel with respect to each other.

In another embodiment of the speaker-element according to the invention said permanent magnet extends substantially parallel to the at least two electromagnetic wires with a longitudinal length thereof in such a manner, that the at least two electromagnetic wires are arranged in front of two opposing longitudinal surfaces of the permanent magnet.

In this embodiment the permanent magnet extends longitudinally between the two membrane planes, wherein each of said two opposing longitudinal surfaces of the permanent magnet faces a respective one of the two membrane planes in the area of the electromagnetic wire

of that membrane plane, such that the electromagnetic wire is arranged in front of that longitudinal surface of the permanent magnet.

In yet another embodiment of the speaker-element according to the invention said two substantially mutually opposing membrane planes are arranged at an angle with respect to each other, said angle may be oblique, said angle may be chosen between 0° and 75° . Said angle may for example be chosen in correspondence with a desired direction of sound waves produced by the membrane planes and/or a desired setup of the speaker.

At an angle of 0° , said membrane planes extend parallel to each other. At an angle larger than 0° up to about for example 75° said membrane planes extend oblique with respect to each other. More in particular, at an angle larger than 0° up to about 75° said membrane planes may diverge from each other in a direction substantially orthogonal to the direction of the electromagnetic wires.

In yet another embodiment of the speaker-element according to the invention said two membrane planes together define a circumferential edge zone, which circumferential edge zone is closed over a first part thereof and open over a second part thereof.

Sound waves that are produced internally of the speaker-element are able to leave the speaker-element via the open circumferential edge zone part.

As an alternative, the open circumferential edge zone part could be closed by e.g. a fabric which allows the passage of sound waves relatively undistorted and/or undamped. As yet another alternative, the closed circumferential edge zone parts could be left open, in order to allow sound to exit in different directions.

Said circumferential edge zone may in particular have a substantially quadrangular shape as seen in a side view of the speaker-element, wherein three neighboring circumferential edge zone parts are closed, and the other, fourth circumferential edge zone part is open.

In particular, if said membrane planes diverge as described above, said circumferential edge zone part that is located at the diverging end of the speaker-element may be the open edge zone part.

Said closed circumferential edge zone parts may for example be closed by a frame.

In yet another embodiment of the speaker-element according to the invention each membrane plane comprises four of said electromagnetic wires, which four wires are arranged in parallel to each other with no or a small mutual distance. For example, said distance may be up to 2 mm, but preferably smaller.

The applicant has found that four of said electromagnetic wires are able to produce a magnetic field of sufficient strength.

It is noted that the direction of the electric current passing through the electromagnetic wires is the same for all electromagnetic wires of a said membrane plane.

Each electromagnetic wire may have a thickness of about 0.2 mm.

Each electromagnetic wire may be a copper wire.

The or each electromagnetic wire may be attached to the membrane plane in any desired way. Practically the or each electromagnetic wire may be attached to the membrane plane using a polyimide tape, for example known as Kapton.

In yet another embodiment of the speaker-element according to the invention said speaker-element comprises a frame for holding a circumferential edge of each membrane plane, wherein the circumferential edge of each membrane plane is arranged between two frame parts of said frame and held tight thereby.

Said frame may for example comprise four of said frame parts, wherein two frame parts are arranged for holding a respective membrane plane. Alternatively said frame may for example comprise three of said frame parts, wherein a central frame part is arranged between the two membrane planes and arranged for holding a respective membrane plane on opposite sides thereof.

Said speaker-element may further comprise two angular profiles made of a flexible and/or compressible material, such as rubber, said angular profiles being arranged between said frame parts in the area of said circumferential edge of the membrane plane, for tensioning said membrane plane.

Said membrane planes are preferably held in a tensioned manner. This may for example be achieved by said angular profiles.

The invention also relates to a speaker, comprising a plurality of speaker-elements as described above according to any of the described embodiments, alone or in any suitable combination, or having any one or more described feature, in any suitable combination.

Said plurality of speaker-elements may be arranged with respect to each other in any suitable way. For example, said plurality of speaker-elements may extend in a same plane in for example parallel rows.

In a preferred embodiment said speaker defines a central longitudinal line, wherein said plurality of speaker-elements are arranged in a radial direction with respect to said central longitudinal line and spaced apart by an angular distance.

Said angular distance may be chosen as desired, for example in accordance with a suitable sound angle and/or in accordance with a number of speaker-elements.

If said diverging membrane planes are provided, the converging ends of the speaker-elements may be the radially outward ends, and the, opposing, diverging ends of the speaker-elements may be the radially inward ends, i.e. the diverging ends may be arranged towards said central longitudinal line.

Practically five of said speaker-elements are provided which are spaced apart over an angular distance of about 60°.

In such an embodiment the five speaker-elements produce the sound waves over an angular range of about 300°.

Said part of the speaker where no speaker-element is provided may be for example used for passing through electrical wires or for arranging any other desired hardware. Said speaker may
5 for example be used in such a manner that said part of the speaker where no speaker-element is provided may be directed towards a wall.

Said speaker may comprise at least one further series of five of said speaker-elements which are spaced apart over an angular distance of about 60°, and wherein the at least one further series is arranged on top of said five speaker-elements in such a manner that the speaker-elements
10 are aligned.

In another preferred embodiment of the speaker according to the invention, the plurality of speaker elements are spaced along and aligned with each other along an imaginary line with one membrane plate of one speaker-element substantially facing a membrane plate of an adjacent speaker-element.

15 Such a speaker may be suitable for presenting sound to produce sound in a relatively large space or outside. The imaginary line may be straight.

In particular the imaginary line along which the speaker-elements are arranged may comprise a first section which is straight, and a second section which is curved. If the speaker-elements are of the above-described kind having membrane planes disposed at a non-zero angle
20 with respect to each other, the curved section of the imaginary line may curve in the opposite direction as the angle between the membrane planes of a single speaker element.

Such a speaker may be suitable for presenting sound to a relatively large audience, wherein the speaker-elements along the straight section of the imaginary line may be used to direct the produced sound further away at a relatively small angle with respect to the horizon, and the
25 speaker-elements along the curved section of the imaginary line may be used to direct sound closer to the speaker at a relatively large angle with respect to the horizon.

The invention will be further elucidated with reference to the attached schematic figures, in which:

Figure 1A is a schematic perspective transverse cross section through a speaker according
30 to a first embodiment of the invention;

Figure 1B is a detail of figure 1A;

Figure 2 is a schematic perspective view of a speaker according to a second embodiment of the invention; and

Figures 3A and 3B are schematic perspective views of other embodiments of the speaker
35 according to the invention.

In the figures, like elements are referred to by like reference numerals.

Figure 1A shows a speaker 1 according to a first embodiment of the invention having five speaker-elements 2 according to a first embodiment of the invention. Two of the speaker-elements 2 are shown transparently. Figure 1B shows one of the speaker-elements 2 in more detail.

As is clear from figures 1A and 1B each speaker-element 2 comprises two substantially
5 mutually opposing spaced apart membrane planes 3. In this embodiment each membrane plane 3 is formed by a separate membrane 3, for example made of Mylar. Each membrane plane 3 comprises in this embodiment four electromagnetic copper wires 4 arranged for creating a magnetic field upon an electric current passing through said electromagnetic wires 4. The wires 4 extend parallel to each other with no or a small distance there between and are attached to the membrane plane
10 using a kapton tape, such that in the figures the wires 4 appear to be one, rather thick wire. In this embodiment the wires 4 are arranged in the vertical middle line of the membrane plane 3. Between the membrane planes 3 a permanent magnet 5 is arranged, which is held by two holding plates 6, which are arranged on opposite front and back sides of the magnet 5 for holding the magnet 5 there between. Screws 10 are provided for connecting the plates 6 to each other. The magnet 5 extends
15 substantially parallel to the wires 4 and the wires 4 are arranged such that they are in front of the longitudinal side surfaces of the magnet 5. When a current passes through the wires 4 a magnetic field is created thereby. As is shown in figure 1B, the current passes through the wires 4 in opposite directions 7, 8 in view of the two membrane planes 3 of the speaker-element 2. As a result of the opposite directions 7, 8 the magnetic fields created by the wires 4 of the two membrane
20 planes 3 are opposite to each other, such that both membrane planes 3 are either attracted towards or repulsed from the magnet 5 and are thus moved in opposite directions. It will be clear for the skilled person that the upward direction 7 and downward direction 8 are shown by way of example only and may be reversed, as long as they are opposite to each other. More in particular, the current passing through wires 4 varies continuously between the upward and downward directions, such
25 that the membrane planes 3 are continuously attracted towards and repulsed from the magnet 5, thereby creating sound waves. External sound waves created on the outside of membrane planes 3 can travel outwards, as indicated by arrow 9. Insulator elements 11 are provided between neighboring speaker-elements 2 for preventing sound waves that are created internally of the speaker-elements 2 to leave the speaker between neighboring speaker-elements 2. The insulator
30 elements may for example be made of rubber or any other suitable material. The applicant has found that otherwise the internal sound waves interfere with the external sound waves. The applicant has found that the internal sound waves may leave the speaker 1 at a back of the speaker 1, but the effect thereof may be negligible. As is further clear from figures 1A and 1B, in this embodiment the membrane planes 3 are diverging under an angle α of 67.5° . As a result of this
35 angle the sound waves travel in a desired direction 9.

As is shown in figures 1A and 1B, the membrane planes 3 are held by a frame. Said frame comprises inner and outer circumferential frame parts 12 - 14, wherein the inner circumferential frame part 12, 13 comprises a central frame part 12 arranged at the converging, small end of the speaker element 2 to which both membrane planes 3 are attached, and which inner frame part splits into two frame parts 13 in the diverging direction of the speaker-element 2. Two outer circumferential frame parts 14 are attached to the inner circumferential frame part 12, 13, wherein the membrane planes 3 are arranged between the inner and outer circumferential frame parts 12 - 14 and therefore held tight thereby. Rubber angular profiles 15 extend between the membrane planes 3 and the outer circumferential frame parts 14, such that the membrane planes 3 are tensioned. The outer and inner frame parts 12 - 14 are attached to each other using screws 16. The inner circumferential frame parts 12, 13 close a circumferential edge zone of the speaker-element 2 at the upper, lower, and outer sides thereof, and only the inner side of the circumferential edge zone of the speaker-element is left open, such that sound waves can travel to the inner part of the speaker and then leave the speaker via elements 11 as described above.

Figure 1A further shows that the speaker-elements 2 are arranged on a substantially circular plate 17. The speaker-elements 2 extend radially with respect to the central longitudinal line of the speaker 2 and are spaced apart radially by an angular distance β of approximately 60° , such that the five speaker-elements 2 together extend over an angular range of the plate 17 of about 300° . In the area where no speaker-element 2 is provided a cable pipe 18 is provided.

Figure 2 shows a speaker 1 having two rows of speaker-elements 2. The speaker-elements 2 of the two rows are aligned with respect to each other. The speaker-elements 2 may be similar to the speaker-elements 2 of figures 1A and 1B and the reader is referred to the above description of figures 1A and 1B for a description thereof. The speaker 1 is shown in a front perspective view. The cables may be arranged at the back of the speaker 1 where no speaker-element 2 is provided. Other hardware of the speaker may for example be arranged under the two rows of speaker elements 2. The speaker 1 thus provided has a substantially cylindrical shape.

Figure 3A shows a speaker 102 with a plurality of speaker-elements 2, which are spaced along and aligned with each other along an imaginary line L. For each speaker-element a membrane plane 3 substantially faces a membrane plane 3 of an adjacent speaker-element 2, as shown by membrane planes 3-1 and 3-2. In this example the imaginary line L is straight. Figure 3B shows another embodiment of the speaker 201, which is similar to the speaker 102 of figure 3A, except for the line L which has a straight section L_s and a curved section L_c . The curve of the curved section L_c curves away from the non-zero angle between two membrane planes 3-3 and 3-4 of a single speaker-element 2. The speaker elements 2 of speakers 101, 102 of figures 3A and 3B comprise the above-described features, unless stated otherwise.

Although the invention has been described hereabove with reference to a number of specific examples and embodiments, the invention is not limited thereto. Instead, the invention also covers the subject matter defined by the claims, which now follow.

Claims

1. Speaker-element for a speaker, comprising two substantially mutually opposing spaced apart membrane planes, wherein each membrane plane comprises at least one electromagnetic wire
5 arranged for creating a magnetic field upon an electric current passing through said electromagnetic wire, wherein at least one permanent magnet is arranged between the two membrane planes, wherein the electromagnet wires of the two membrane planes are connectable to an electric power source in such a manner, that the electric current passes there through in substantially mutually opposing directions and thereby creating substantially mutually opposing
10 magnetic fields, such that upon passing an electric current through the electromagnetic wire of each membrane plane said membrane planes are both either attracted towards or repulsed from the permanent magnet and thereby moved towards or away from each other, respectively, thereby producing a sound wave.
- 15 2. Speaker-element according to claim 1, wherein each electromagnetic wire is arranged substantially in a middle line of each membrane plane, such that substantially equal membrane parts are arranged on both sides of said electromagnetic wire.
3. Speaker-element according to claim 1 or 2, wherein said permanent magnet extends
20 substantially parallel to the at least two electromagnetic wires with a longitudinal length thereof in such a manner, that the at least two electromagnetic wires are arranged in front of two opposing longitudinal surfaces of the permanent magnet.
4. Speaker-element according to any of claims 1 – 3, wherein said two substantially mutually
25 opposing membrane planes are arranged at an oblique angle with respect to each other, said angle preferably being chosen between 0° and 75° .
5. Speaker-element according to any of claims 1 – 4, wherein said two membrane planes together define a circumferential edge zone, which circumferential edge zone is closed over a first part
30 thereof and open over a second part thereof.
6. Speaker-element according any of claims 1 – 5, wherein each membrane plane comprises four of said electromagnetic wires, which four wires are arranged in parallel to each other with no or a small mutual distance.

7. Speaker-element according to any of claims 1 – 6, wherein each said electromagnetic wire is a copper wire.

8. Speaker-element according to any of claims 1 – 7, wherein each electromagnetic wire is attached
5 to the membrane plane using a polyimide tape.

9. Speaker-element according to any of claims 1 – 8, comprising a frame for holding a circumferential edge of each membrane plane, wherein the circumferential edge of each membrane plane is arranged between two frame parts of said frame and held tight thereby.

10

10. Speaker-element according to claim 9, comprising two angular profiles made of a flexible and/or compressible material, such as rubber, said angular profiles being arranged between said frame parts in the area of said circumferential edge of the membrane plane, for tensioning said membrane plane.

15

11. Speaker, comprising a plurality of speaker-elements according to any of claims 1 – 10.

12. Speaker according to claim 11, said speaker defining a central longitudinal line, wherein said plurality of speaker-elements are arranged in a radial direction with respect to said central

20

longitudinal line and spaced apart by an angular distance.

13. Speaker according to claim 12, wherein five of said speaker-elements are provided which are spaced apart over an angular distance of about 60°.

25

14. Speaker according to claim 13, wherein at least one further series of five of said speaker-elements is provided which are spaced apart over an angular distance of about 60°, and wherein the at least one further series is arranged on top of said five speaker-elements in such a manner that the speaker-elements are aligned.

30

15. Speaker according to claim 11, wherein the plurality of speaker elements are spaced along and aligned with each other along an imaginary line with one membrane plane of one speaker-element substantially facing a membrane plane of an adjacent speaker-element, thereby forming a column of speaker elements.

35

16. Speaker according to claim 15, wherein the imaginary line along which the speaker-elements are arranged may comprise a first section which is straight, and a second section which is curved,

wherein if the speaker-elements are according to at least claim 4, the curved section of the imaginary line preferably curves in a direction opposite to the angle between the opposing membrane planes of a single speaker element.

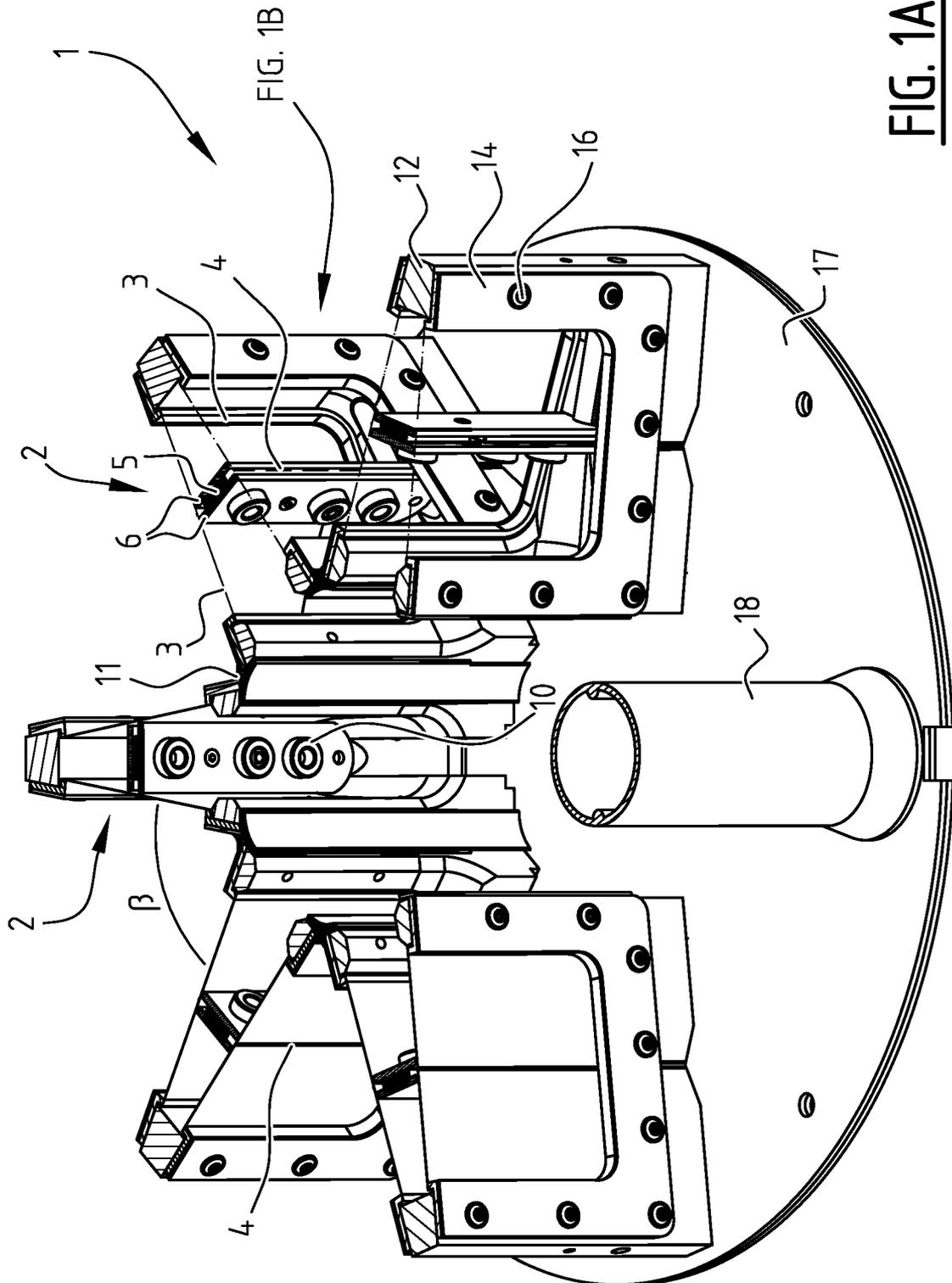
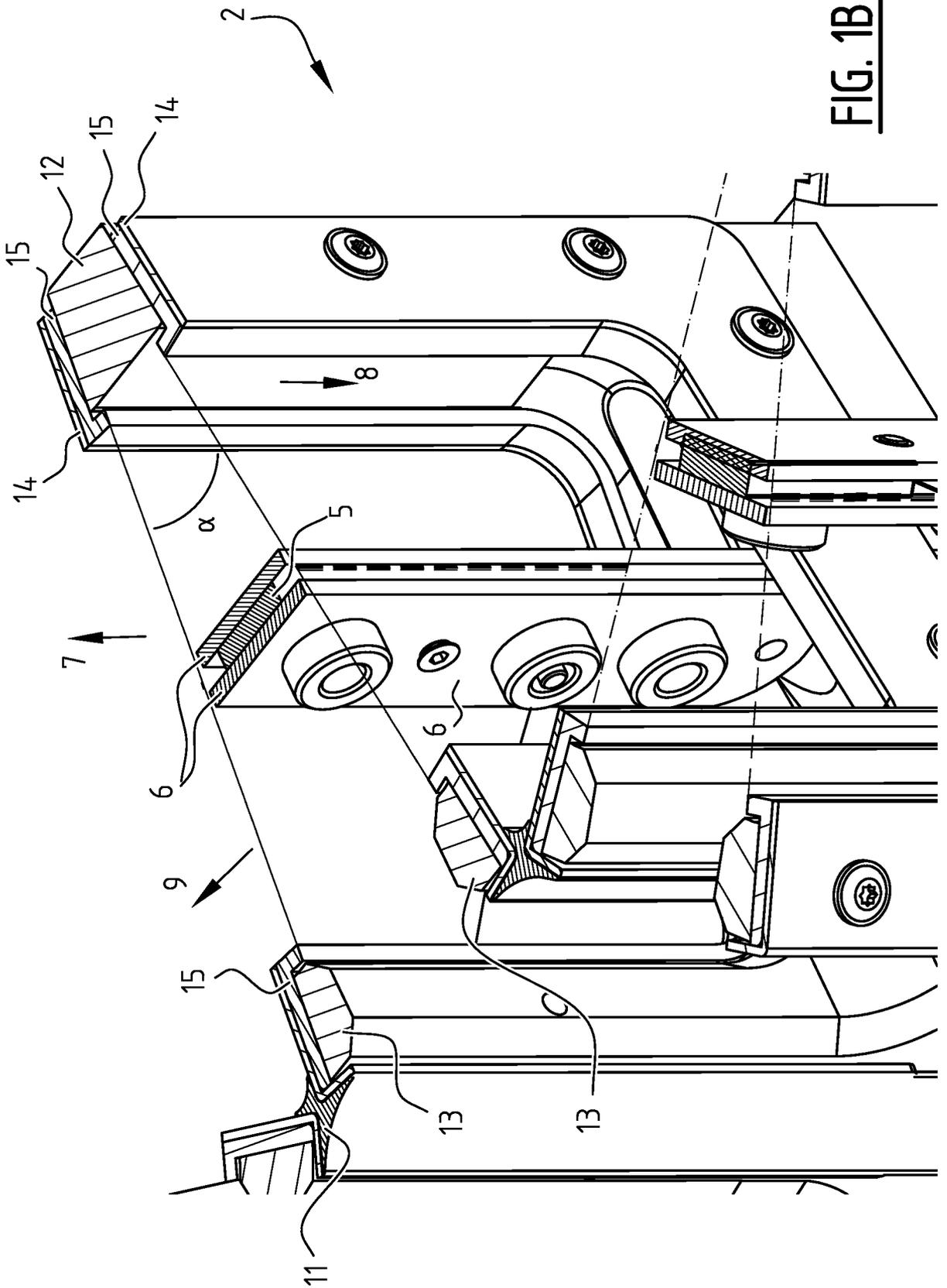


FIG. 1A



3/5

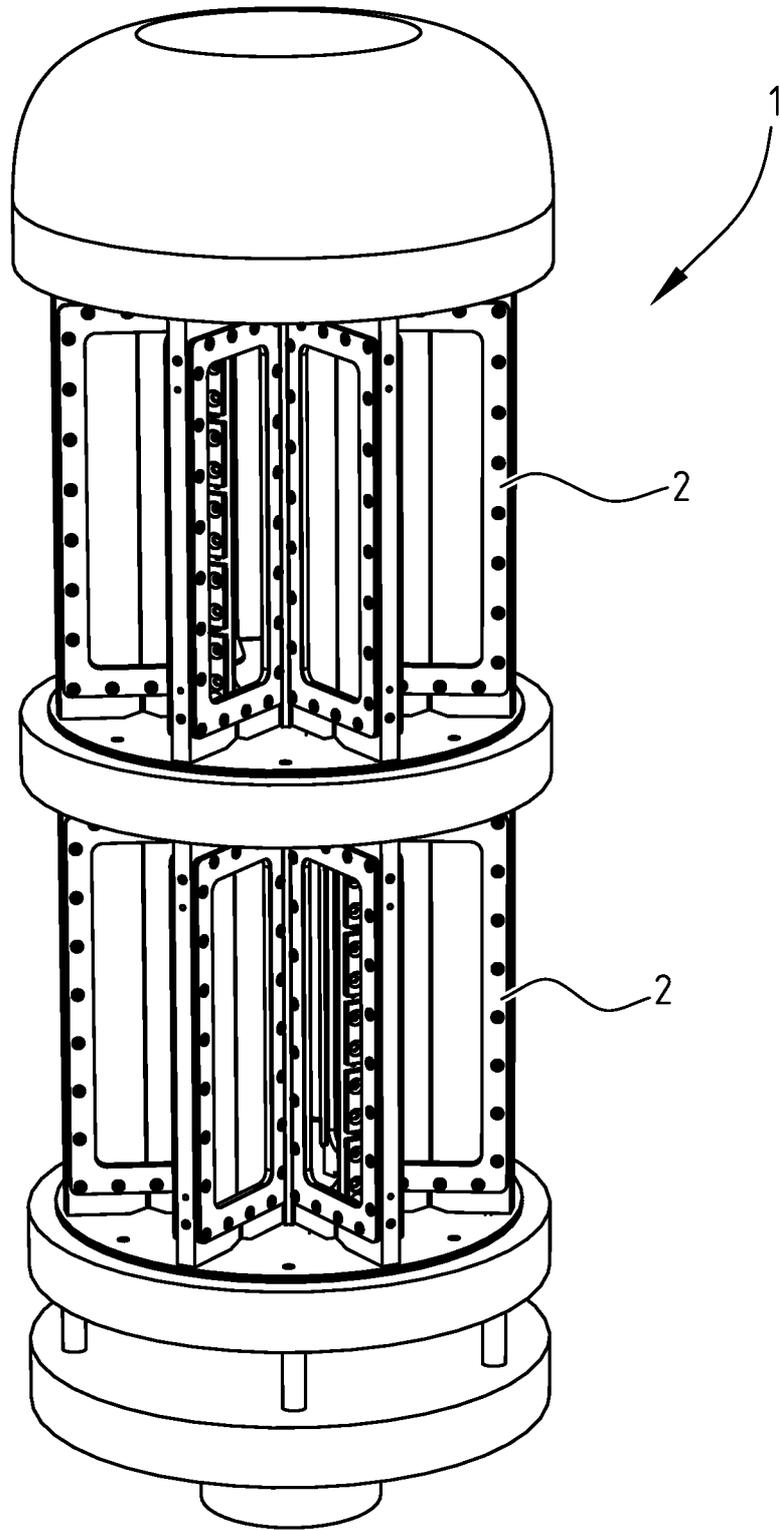


FIG. 2

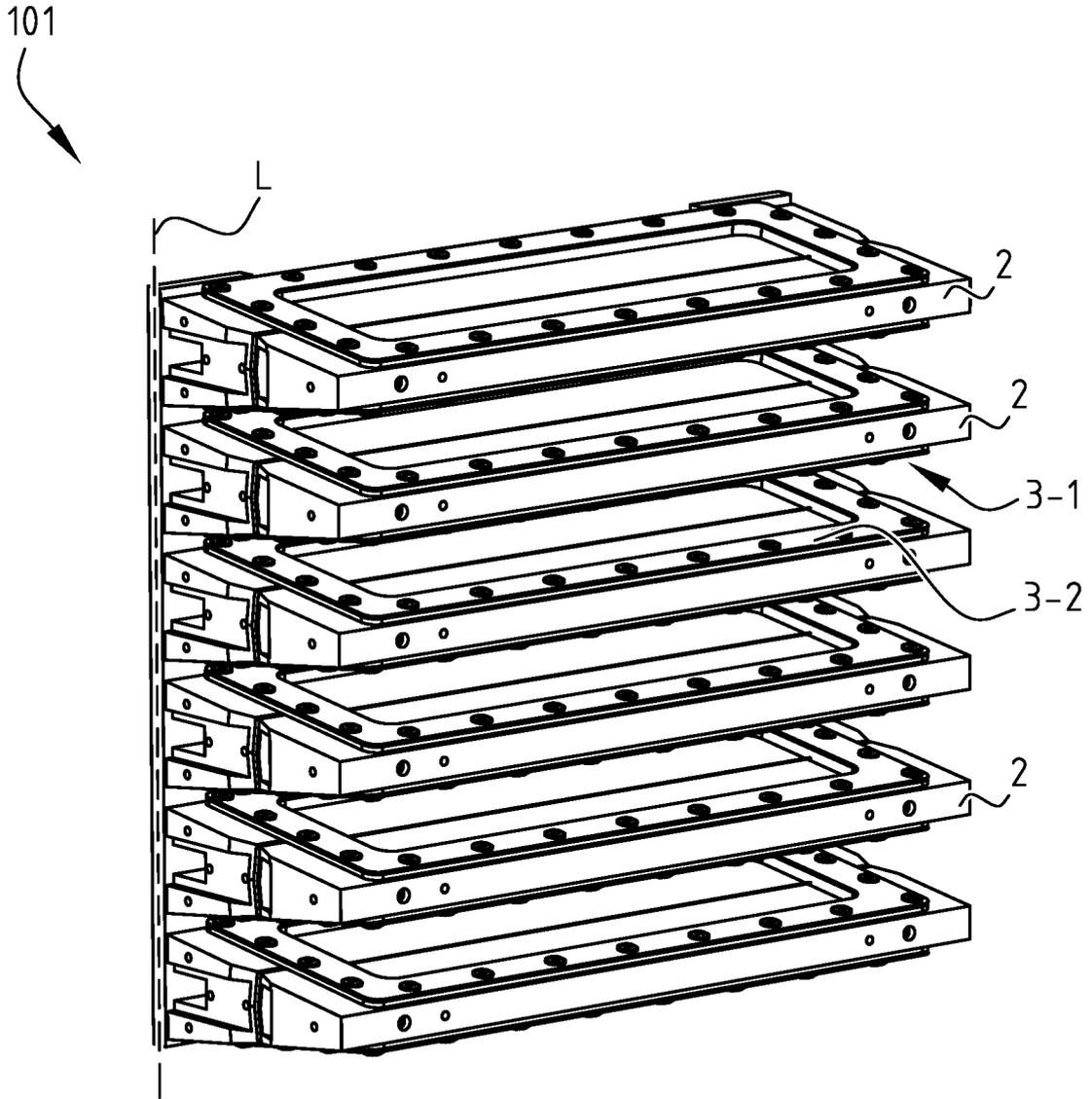


FIG. 3A

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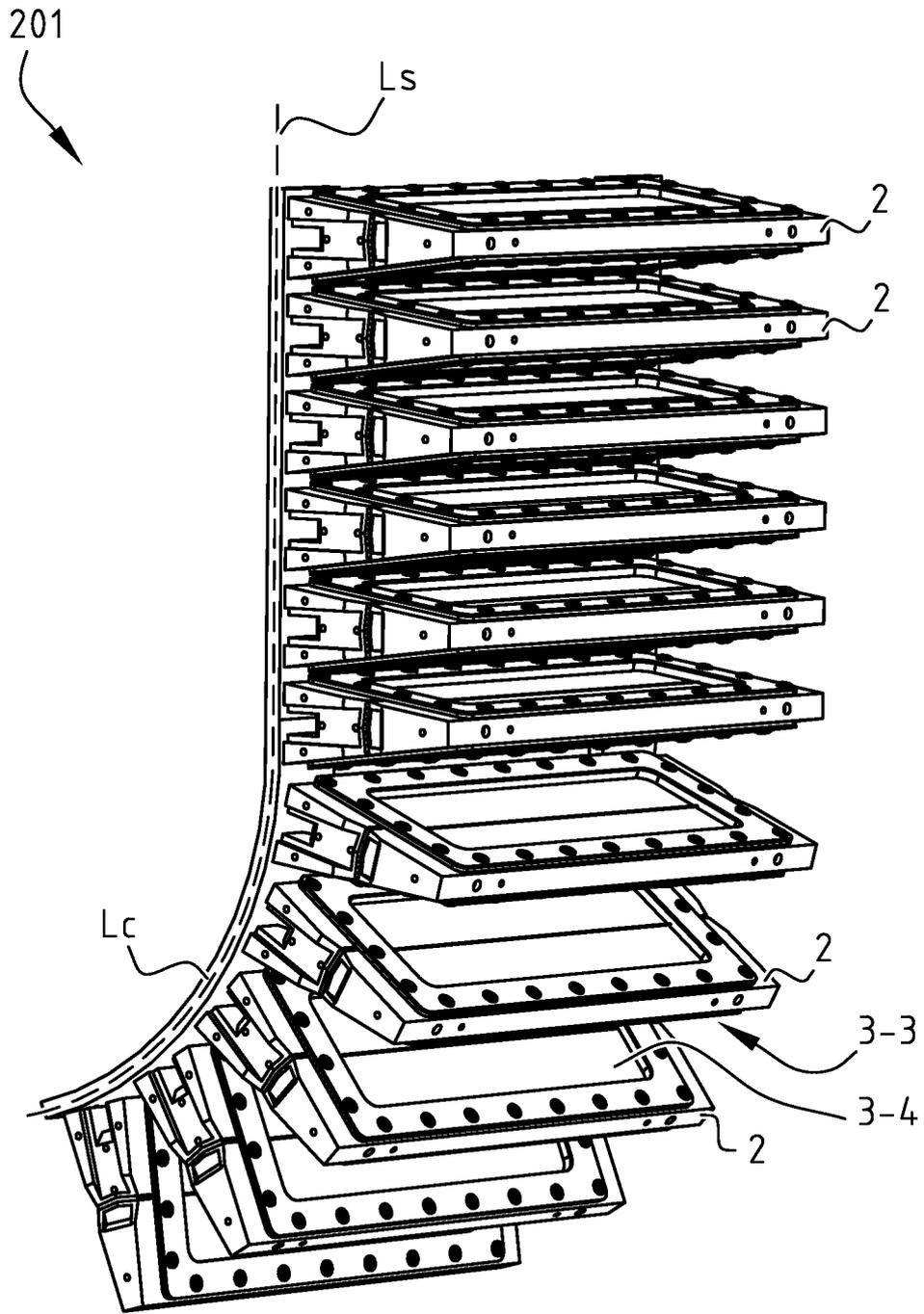


FIG. 3B

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2020/050528

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R9/06 H04R7/04 H04R9/04
ADD.
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)
H04R
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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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	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 20 October 2020	Date of mailing of the international search report 12/11/2020
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Pigniez, Thierry
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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2020/050528

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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