(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 667 038 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.06.2020 Bulletin 2020/25

(51) Int Cl.:
F01M 13/04 *(2006.01)*

(21) Application number: **19215033.2**

(22) Date of filing: **10.12.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **10.12.2018 IT 201800010913**

(71) Applicant: **FPT Industrial S.p.A.**
10156 Torino (IT)

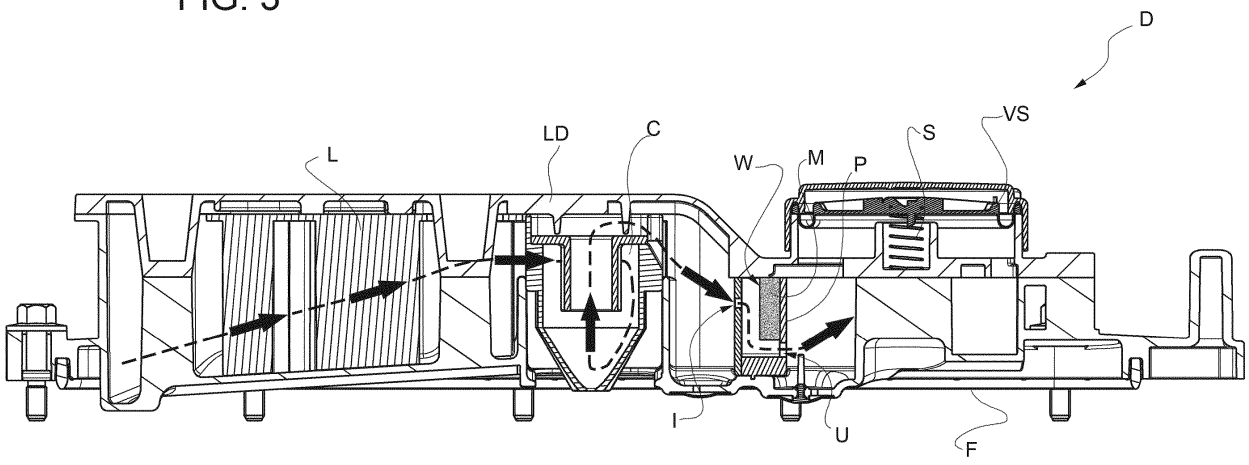
(72) Inventor: **CAPUTO, Giovanni**
10147 TORINO (IT)

(74) Representative: **Bongiovanni, Simone et al**
Studio Torta S.p.A.
Via Viotti, 9
10121 Torino (IT)

(54) **DEVICE AND METHOD FOR SEPARATION OF LUBRICANT OIL MIST OF AN INTERNAL COMBUSTION ENGINE**

(57) An oil mist separation device (D) of an internal combustion engine, the device comprising a filtering assembly consisting of a labyrinth filter (L), a cyclone filter (C) and an impactor separator (W) arranged in sequence to be flown through by a gas in which the oil mist is dispersed.

FIG. 3



EP 3 667 038 A1

Description

Cross-reference to related applications

[0001] This patent application claims priority from Italian patent application no. 102018000010913 filed on 10/12/2018.

Technical field of the invention

[0002] The invention relates to a device and a method for the separation of oil mist of an internal combustion engine, according to the preamble of claim 1, which corresponds to document DE10127817A1.

State of the art

[0003] As it is known, endothermic engines are provided with a crankcase ventilation circuit, which is designed to release to the outside of the crankcase itself the so-called "blow-by" gases, namely those gases that leak from the cylinders into the crankcase past the sealing segments of the pistons. The ventilation is necessary both to prevent the pressure on the inside of the crankcase from increasing and to make up for volume changes due to the motion of the pistons. Blow-by gases contain atomized oil drops as well as other impurities, such as for example unburnt particles of a carbon nature (particulate matter). The ventilation circuit can be of an open type, namely it releases blow-by gases into the atmosphere, or it can be of a closed type, namely it is connected to the intake duct of the internal combustion engine in order to ensure the complete combustion of the particulate matter. In this case, there is a blow-by gas "recirculation".

[0004] Whereas in the first case the oil and the particulate matter need to be separated from the gases for evident environment and health protection reasons (the particulate matter has carcinogenic effects), in the second case the oil and the particular matter need to be eliminated in order not to deteriorate the components of engine coming into contact with the recirculated flow up to the combustion chamber. Indeed, oil residues and particulate matter have a tendency to form residual sediments. These residues settle on the intake valves and, in case of supercharged engines, also in the compressor and in the intercooler, thus jeopardizing the efficiency thereof due to an aerodynamic disturbance in the first case and to an increased thermal resistance in the second case. Furthermore, in catalytic vehicles, the combustion of the lubricant oil possibly recirculated in the intake has harmful effects on the exhaust gas after-treatment device. Some oils, indeed, generate residues which cannot be burnt and, therefore, the particulate filter cannot dispose of them even through active regenerations.

[0005] The oil dragged in the blow-by gases, both recirculated and not recirculated, represents a consumption which, given the same volume of the tanks used to contain it, typically oil pans, reduces the top-up interval. In order to obtain the separation of the lubricant oil from the blow-by gases, it is known to use separation or purification systems of different types, for example impactor separators, in which the gas flow is directed, by one or more nozzles, against a wall, which causes sudden changes in the direction thereof; separators of this type have a very high filtering power and/or efficiency compared to other filtering devices, so that they manage to almost entirely purify the oil mist dispersed in the blow-by gases; however, they suffer from the drawback of generally having a relative small duration, since they are subjected to conditions in which they quickly get dirty. Impactor separators can also be relatively large-sized and have high load losses when they are flown through by the gases to be filtered.

[0006] The use of a traditional filtering element, generally a labyrinth filter, combined with an impactor separator as proved to be unsatisfactory. Indeed, when the filter, as a whole, needs to reach a filtering power exceeding 80%, the impactor separator has to sort out more than 80% of the total oil dispersed in the form of mist in the blow-by gases. Therefore, even in this case, significant load losses occur and the impactor separator quickly gets dirty. The cyclone filter, on the other hand, does not even exceed 50% in terms of filtering power and, therefore, its use has been long abandoned.

[0007] If not specifically excluded by the detailed description below, the information contained in this part should be considered as an integral part of the detailed description itself.

Summary of the invention

[0008] The object of the invention is to offer a lubricant oil mist separation device for the separation of lubricant drops from the blow-by gases of the crankcase, said separation device allowing manufacturers to overcome, in a simple and economic fashion, the drawbacks arising from the known purifying devices mentioned above.

[0009] The idea on which the invention is based in that of implementing a succession of a labyrinth filter, a cyclone filter and an impactor separator, which leads to a corresponding filtering sequence.

[0010] The cyclone filter and the impactor separator are sized so as to obtain a moderate separation of the oil mist. This implies that one single cyclone filter is implemented, which is large-sized. In other words, no high tangential speeds need to be obtained, because only middle-sized drops need to be recovered. Hence, one single cyclone filter with low tangential speeds allows for a limitation of the load loss offered by the separation device as a whole. Consequently, as far as the impactor separator following the cyclone filter is concerned, it does not need to have a filtering power exceeding 70%, so that low load losses of the filtering assembly, as a whole, are ensured.

[0011] Therefore, the filtering assembly only includes

the aforesaid three filters, strictly in this succession.

[0012] The separation device preferably comprises one single casing, in which three distinct housings are obtained, which house, respectively, the aforesaid filters; in particular, said housings can be accessed through one single common lid.

[0013] The casing comprises at least one inlet and at least one outlet and comprises a pneumatic path, which establishes a communication between said at least one inlet and said at least one outlet and crosses the aforesaid three housings, so that the gases flow through the aforesaid filters according to the sequence described above.

[0014] The pneumatic path preferably is such as to lead the gas flow along an oscillatory motion towards and away from a bottom wall of the casing.

[0015] According to another preferred aspect of the invention, which can be combined with the previous ones, the gas covers, in the separation device, a U-shaped path: a first part of the path entails flowing through the aforesaid three filters, whereas the remaining part of the path is approximately straight.

[0016] According to another preferred aspect of the invention, which can be combined with the previous ones, the gas covers, in the separation device, a U-shaped path having an inversion of motion, which is accomplished inside a valve body used to adjust the pressure established inside the crankcase of the internal combustion engine.

[0017] The aforesaid object is reached by the invention according to the features set forth in claim 1.

[0018] The dependant claims describe preferred embodiments of the invention, thus forming an integral part of the description.

Brief description of the figures

[0019] Further objects and advantages of the invention will be best understood upon perusal of the following detailed description of an embodiment thereof (and of relative variants) and of the accompanying drawings offered as mere way of non-limiting examples, wherein:

figure 1 shows an example of a device for the separation of lubricant oil mist in an internal combustion engine, shown in an exploded view, according to the invention;

figure 2 is a view from the top of the example of figure 1, with a removed lid;

figure 3 is a longitudinal section according to a section plane identified by line III-III of figure 2, perpendicular to the aforesaid lid;

figure 4 is a view from the top, with a transparent lid, of the example of figure 1;

figure 5 shows, on a larger scale, a detail of figure 3.

[0020] In the figures, the same numbers and the same reference letters indicate the same elements or components.

[0021] For the purposes of the invention, the term "second" component does not imply the presence of a "first" component. As a matter of fact, these terms are only used as labels to improve clarity and should not be interpreted in a limiting manner.

[0022] The elements and features contained in the different preferred embodiments, drawings included, can be combined with one another, without for this reason going beyond the scope of protection of this patent application, as described hereinafter.

Detailed description of embodiments

[0023] Figure 1 shows an exploded view of an example of separation device D according to the invention, according to a perspective view with exploded parts.

[0024] The separation device D comprises a casing H with side walls LW projecting perpendicular to a substantially flat bottom wall F, therefore the casing H substantially is a right and hollow prism.

[0025] The casing H further comprises a lid LD, which is distinct from the remaining parts and is designed to operatively come into contact with the side walls so as to close the casing H, thus preventing the gas to be filtered from leaking into the atmosphere before the dispersed oil mist is recovered by means of the filtering assembly contained in the casing H.

[0026] The casing H has a substantially oblong shape along an axis Z; the filtering assembly consists of a labyrinth filter L, a cyclone filter C and an impactor separator W, in the same order as listed, arranged along the axis Z. Therefore, the gas flowing through the separation device D, at first, is purified from large-sized oil drops by means of the labyrinth filter and, then, it is further purified by means of the cyclone filter C, which, as it is known, uses a centrifugal acceleration to force the remaining drops of oil towards and along the walls of the filter. Finally, the gas is led through the impactor separator W.

[0027] The axis Z of the separation device D is parallel to the bottom wall F.

[0028] Advantageously, the coexistence of the cyclone filter C and of the impactor separator W, downstream of the labyrinth filter L, allows for low load losses of the filtering assembly as a whole.

[0029] The labyrinth filter L is preferably designed so as to only eliminate macro-drops and to offer, for example, a filtering power up to 5%. However, generally speaking, labyrinth filters can offer a filtering power or efficiency up to 40%.

[0030] The cyclone filter C is preferably designed so as to have a filtering power up to 30%. However, generally speaking, cyclone filters C can offer a filtering power or efficiency up to 60%.

[0031] Finally, the impactor separator W is designed so as to have a filtering power of 70% - 75%. However, generally speaking, impactor separators can reach a filtering power or efficiency up to 90%.

[0032] Therefore, the overall filtering power exceeds

80%; indeed, in the example indicated above: 1 x 0.95 x 0.7 x 0.25 = 0.166, wherein 0.166 represents the fraction of oil mist flowing through.

[0033] Hence, the solution suggested herein consists of three filtering stages in series, the first stage to which the flow is subjected being defined by the labyrinth filter L, second stage by the cyclone filter C and the third stage by the impactor separator W. This arrangement allows for a progressive reduction of the oil drops, namely for a reduction of the number and/or dimensions of the drops, stage after stage. Indeed, the filtering power increases from the first to the second stage and, then, from the second to the third stage.

[0034] Therefore, the quantity of oil reaching the third filtering stage, which is defined by the impactor separator, is progressively reduced by the two preceding filtering stages, so that the degree of dirt of the impactor separator W is significantly more limited compared to known solutions, in which this last type of filter is used alone, without previous filtering stages.

[0035] Thanks to this relatively low degree of dirt, the solution suggested herein has a relatively long duration, for example a duration corresponding to approximately 300,000 km covered by the vehicle, so that it basically needs no maintenance or replacements.

[0036] At the same time, the overall efficiency of the filtering assembly is extremely high, especially thanks to the third stage defined by the impactor separator W.

[0037] Furthermore, the solution suggested herein is relative compact, despite the presence of three filtering stages in series.

[0038] The impactor separator W comprises a chamber, preferably with a parallelepiped shape flattened along the axis Z, having an inlet I and an outlet U arranged in opposite points of the chamber so as that the gas flowing through it is subjected to two relevant deflections of approximately 90°.

[0039] According to figure 5, the inlet I is defined by at least one nozzle arranged in a position such as to direct a corresponding flow along an axis A towards an impact wall P, which is arranged orthogonally to the axis A. The axis A preferably is parallel to the axis Z. In particular, the outlet U is obtained on the wall P and has an axis B, which is parallel to and spaced apart from the axis A. In other words, the inlet I and the outlet U are spaced apart from one another along the axis A and along an axis Y, which is orthogonal to the axes A and B. Specifically, the axis Y is orthogonal to the bottom wall F.

[0040] In particular, according to figure 1, the inlet I is defined by two nozzles spaced apart from one another along a direction, which is orthogonal to the axis A and to the direction Y.

[0041] The nozzles defining the inlet I are preferably shaped so as to accelerate the flow, namely the converge towards the wall P.

[0042] Inside the chamber and axially in front of the inlet I there preferably is a coalescent material mat M. The mat M is supported in a fixed position by the wall P, so that it is axially spaced apart from the nozzles.

[0043] Therefore, the flow is directed by the nozzles towards the mat M, so that the oil drops hit the mat M (or the wall P, if there is no mat M) and merge through coalescence, while the gases are deflected by approximately 90° along the axis Y so as to reach the outlet U, which is also indicated by the flow line shown in figure 3.

[0044] In the specific example, the outlet U is obtained on the outside of the perimeter of the mat M. According to a variant which is not shown herein, the outlet U is obtained on the inside of the perimeter of the mat M.

[0045] The oil recovered by the three filters slides downwards, namely towards the bottom F, due to the weight force and is collected in a recovery duct (not shown), which leads the oil back to the oil pan of the internal combustion engine through a return pipe (not shown).

[0046] If necessary, a non-return valve is arranged along the return pipe.

[0047] The separation device D preferably further comprises a regulating valve V. It is arranged downstream of the filtering assembly so as to allow the gas to be drained to the outside in case of overpressure or so as to choke the recirculation of the blow-by gases, in order to maintain a pressure, in the crankcase of the internal combustion engine, within a predetermined pressure range. It is evident that the possibly released gas is purified from oil mist.

[0048] The housings, which respectively house the three filters of the filtering assembly, and the regulating valve V are aligned along the axis Z of the casing H.

[0049] In the valve body of the regulating valve V, the gas reverses its motion, thus flowing back in an opposite direction compared to the one used to flow through the filtering assembly.

[0050] Therefore, the gas follows a U-shaped path having a first portion, upstream of said inversion, and a second portion, downstream of said motion inversion; the first portion entails the crossing of the filtering assembly, while the second portion is approximately straight.

[0051] This U-shaped path is particularly clear with reference to figure 2, which shows the pneumatic path of the gas to be filtered by means of thick arrows, wherein the pneumatic path preferably starts from a first inlet IN1, which is obtained in a side wall of said casing H, and from a second inlet IN2, which is obtained in said bottom wall F, towards one single outlet OUT, which is arranged on the other side wall of the casing H, opposite the side wall where the first inlet IN1 is obtained.

[0052] Figure 3 shows, in a longitudinal section, the separation device D, perpendicular to the bottom wall F and to the lid LD. The lid LD is parallel to the bottom wall F at least over a relative portion. Figure 3 shows the first portion of the U-shaped path, which entails the crossing of the filtering assembly.

[0053] With reference to figure 3, the first portion of the U-shaped path has an oscillatory motion towards and away from a bottom wall F of the casing.

[0054] With reference to figure 5, the heights Q1 and Q2, according to a direction that is perpendicular to the bottom wall F, namely parallel to the axis Y, of the cyclone filter C and of the impactor separator W, respectively, are different from one another and, in particular, Q1 is greater than Q2.

[0055] This fact forces the gas to make the aforesaid movement towards the bottom wall F, in an area between the filters C and W.

[0056] The separation device D described herein is designed to be associated with an internal combustion engine with one or two banks. Therefore, the inlet IN2 obtained in the bottom wall F of the casing H can be absent.

[0057] The bottom wall F is going to be operatively horizontal, namely parallel to the ground, so as to operatively convey the collected oil in a return pipe (not shown), which is connected to the oil pan of the internal combustion engine. The regulating valve V comprises a movable fan Vs, which is kept in position by a helical retaining spring S, which is arranged perpendicular to the bottom wall F, as it is shown in figure 3. In case of overpressure of the blow-by gas, the movable fan Vs moves against the effect of the retaining spring S and, hence, allows the gas to flow through an outlet Vout of the valve (figure 1), which is obtained in the lid LD. Vice versa, in case of depression, the movable spring VS moves in an opposite direction so as to adjust the flow of blow-by gas, thus adjusting the pressure on the inside of the crankcase of the internal combustion engine.

[0058] Therefore, the lid LD forms a portion of the valve body V.

[0059] Figure 4 shows a view from the top of the separation device D, namely a view that is perpendicular to the bottom wall F, where, though, the lid is transparent.

[0060] Another aspect of the invention that plays a significant role is the modular character of the separation device D. Indeed, the three filters define respective modules engaging the respective housings in the casing H and distinct from one another, so that they can be mounted independently of one another. The three filters can preferably be removed from their housings and, hence, be replaced independently of one another. Furthermore, the U-shaped pneumatic path is accomplished regardless of the presence, in the relative housings, of all three filters.

[0061] The non-limiting example described above can be subjected to variations, without for this reason going beyond the scope of protection of the invention, comprising all embodiments that, for a person skilled in the art, are equivalent to the content of the claims.

[0062] When reading the description above, a skilled person can carry out the subject-matter of the invention without introducing further manufacturing details.

Claims

1. An oil mist separation device (D) of an internal combustion engine, said device comprising a filtering assembly consisting of a preliminary filter, a cyclone filter (C) and a further filter to be flown through by a gas in which said oil mist is dispersed; said cyclone filter (C) being arranged in sequence after said preliminary filter; said further filter being arranged in sequence after said cyclone filter;
characterized in that said preliminary filter is a labyrinth filter (L) and said further filter is an impactor separator.

2. The device according to claim 1, comprising one single casing (H), in which three housings are provided, the housings being engaged, respectively, by said filters, and wherein the casing has at least one inlet (IN; IN1, IN2) and one single outlet (OUT) and a pneumatic path, which interconnects said at least one inlet to said one single outlet through said three housings.

3. The device according to claim 2, wherein said casing has the shape of a right prism with respect to a bottom wall (F), and wherein said pneumatic path is such as to induce the gas flow along an oscillatory motion towards and away from said bottom wall.

4. The device according to any one of the preceding claims, comprising a regulating valve (V) suitable to maintain a pressure in the crankcase of the internal combustion engine within a predefined pressure range; wherein said valve is arranged downstream of said filtering assembly.

5. The device according to claim 4, wherein said pneumatic path, according to a projection on said bottom wall (F), has a U shape, and wherein an inversion of direction is accomplished within a valve body of said regulating valve (V).

6. The device according to claim 5, wherein said U shaped path comprises a first portion, upstream of said inversion, and a second portion, downstream of said inversion, and wherein said first portion of the path entails the crossing of said filtering assembly, while the second portion is approximately rectilinear.

7. The device according to any one of the claims 3 to 6, wherein a first inlet (IN1) is provided in a side wall of said casing and a second inlet (IN2) is provided in said bottom wall.

8. An internal combustion engine comprising an oil mist separation device (D) according to any one of the preceding claims 1 to 7.

9. A method for separation of oil mist of an internal combustion engine, comprising a filtering procedure consisting in sequence of a first filtering by means of

labyrinth filter (L), a second filtering by means of cyclone filter (C) and a third filtering by means of an impactor separator (W).

10. A land vehicle comprising an internal combustion engine according to claim 8.

FIG. 1

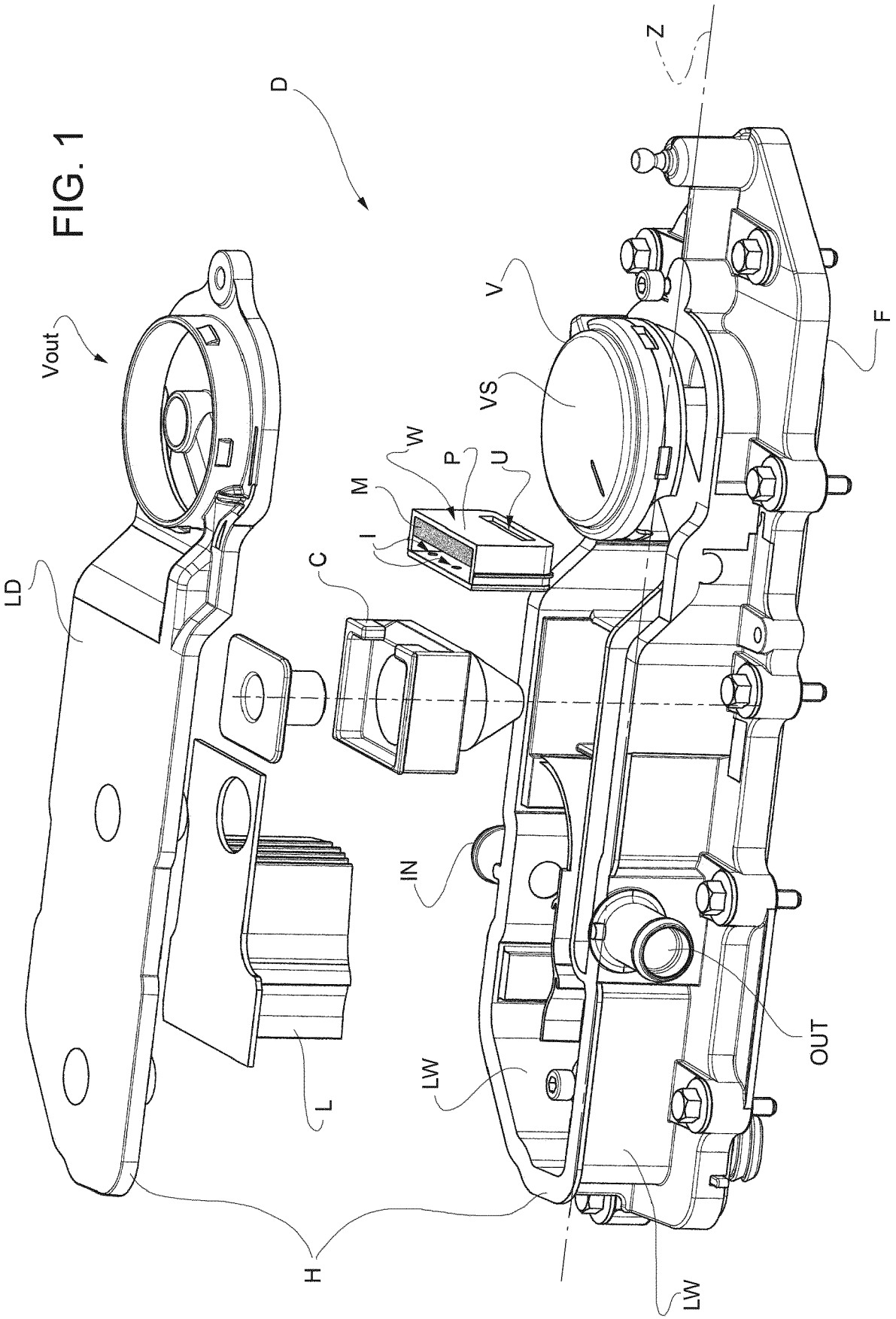
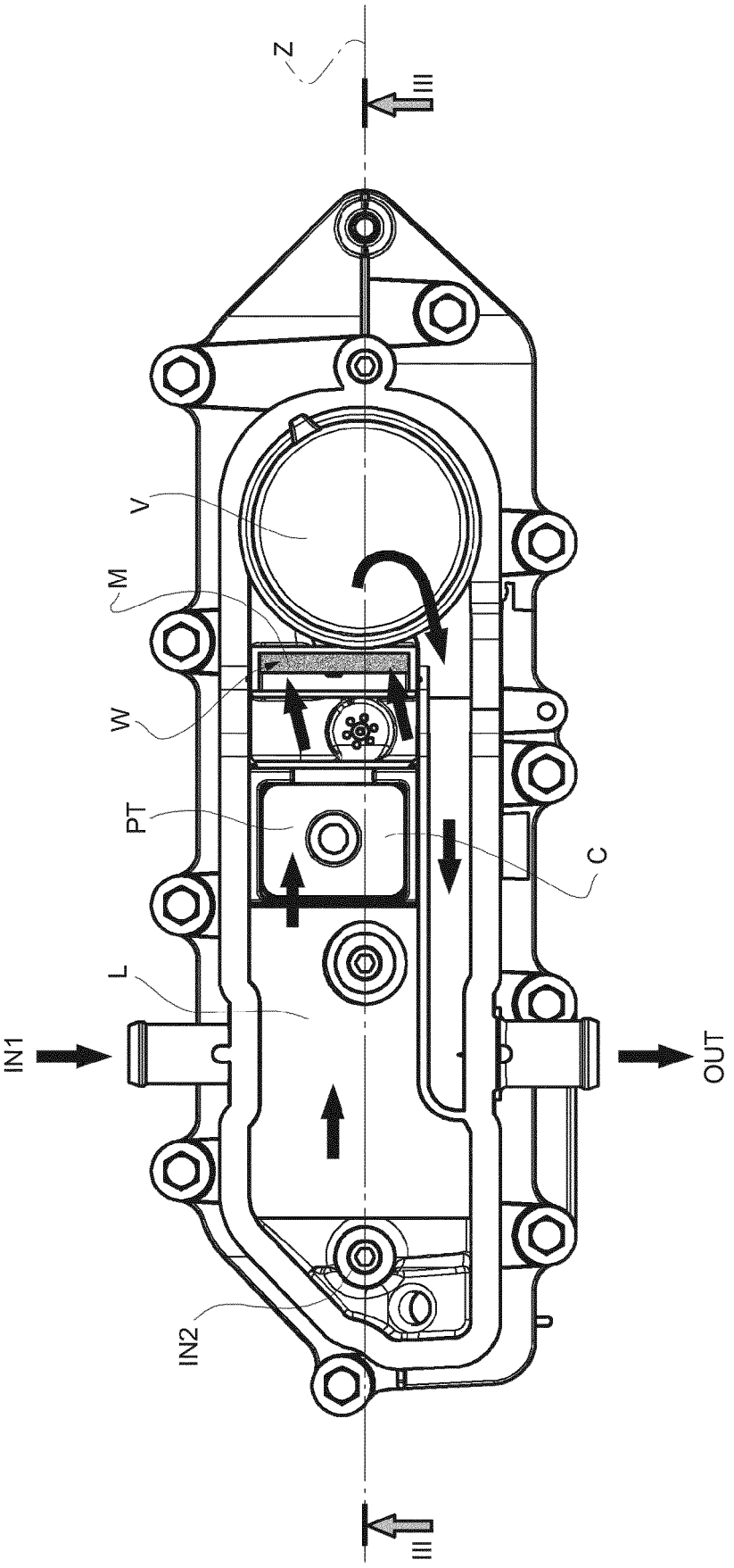


FIG. 2



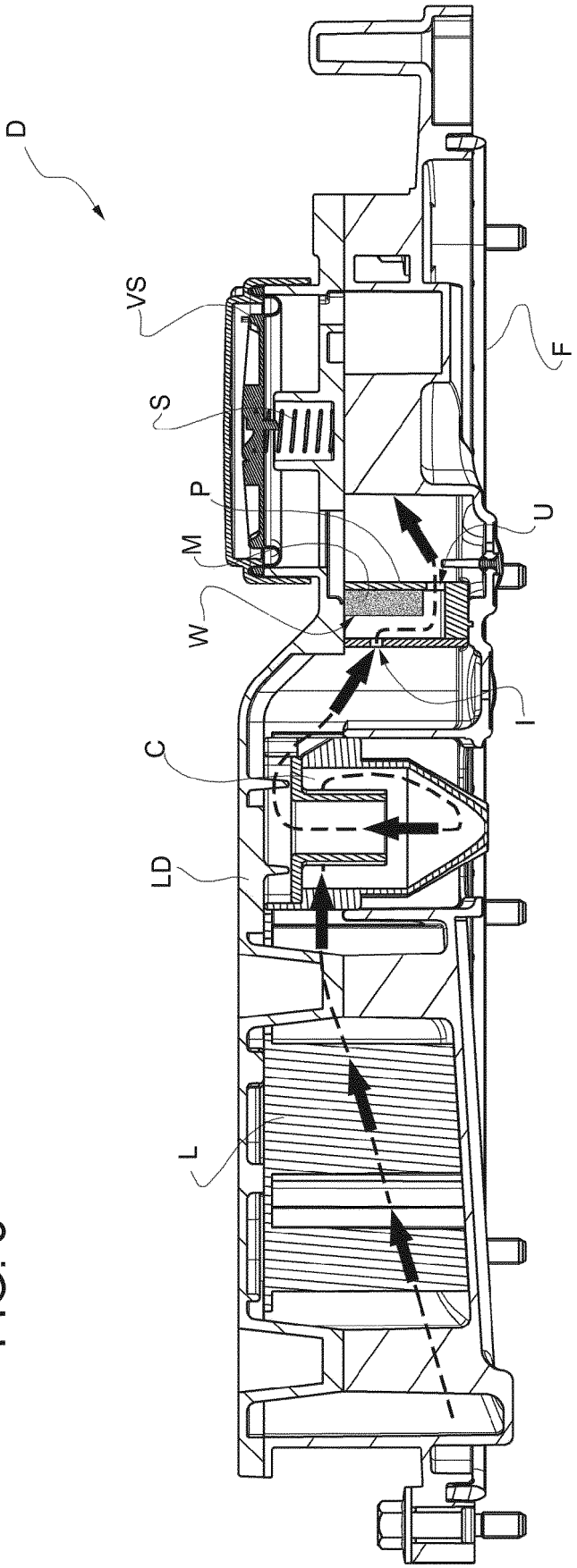


FIG. 3

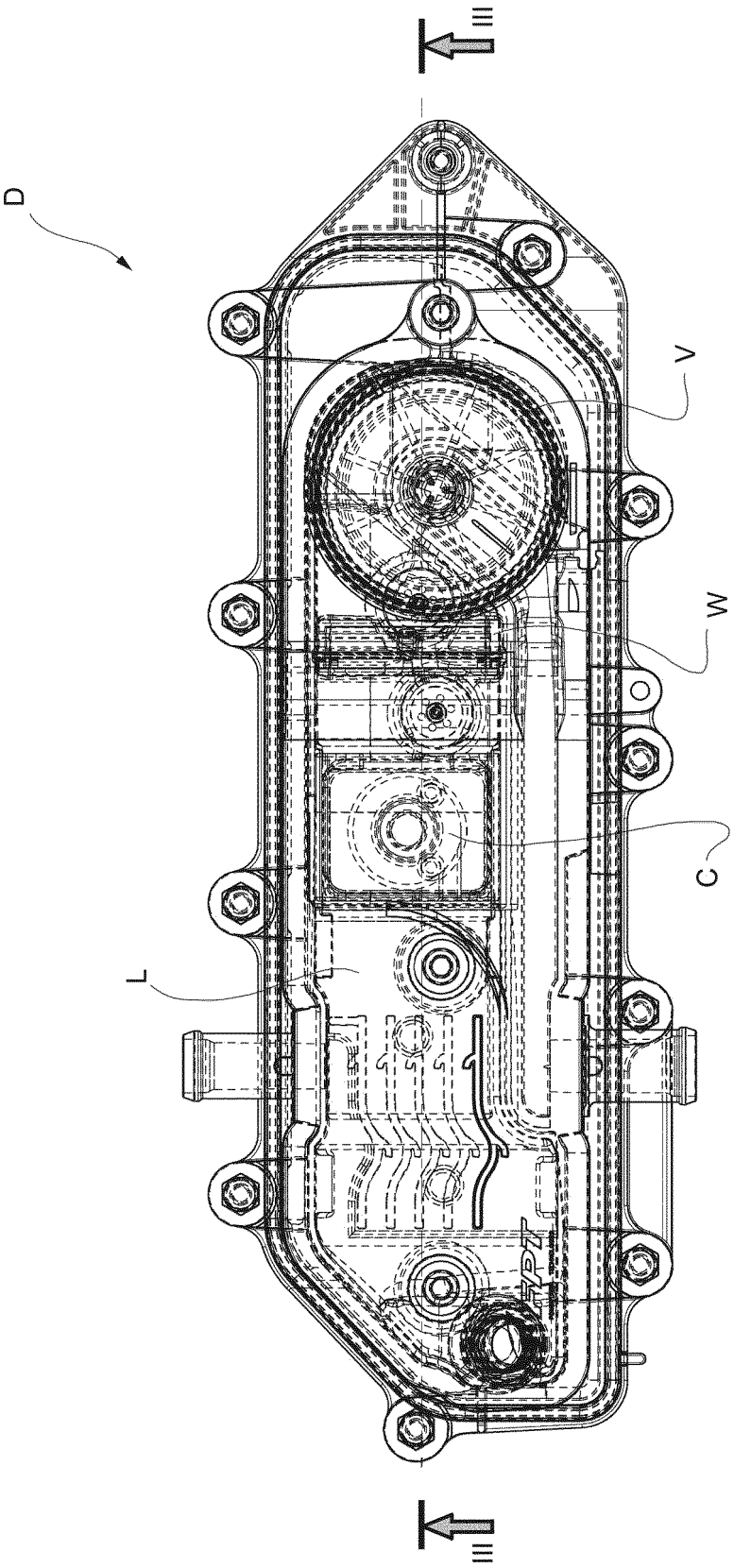


FIG. 4

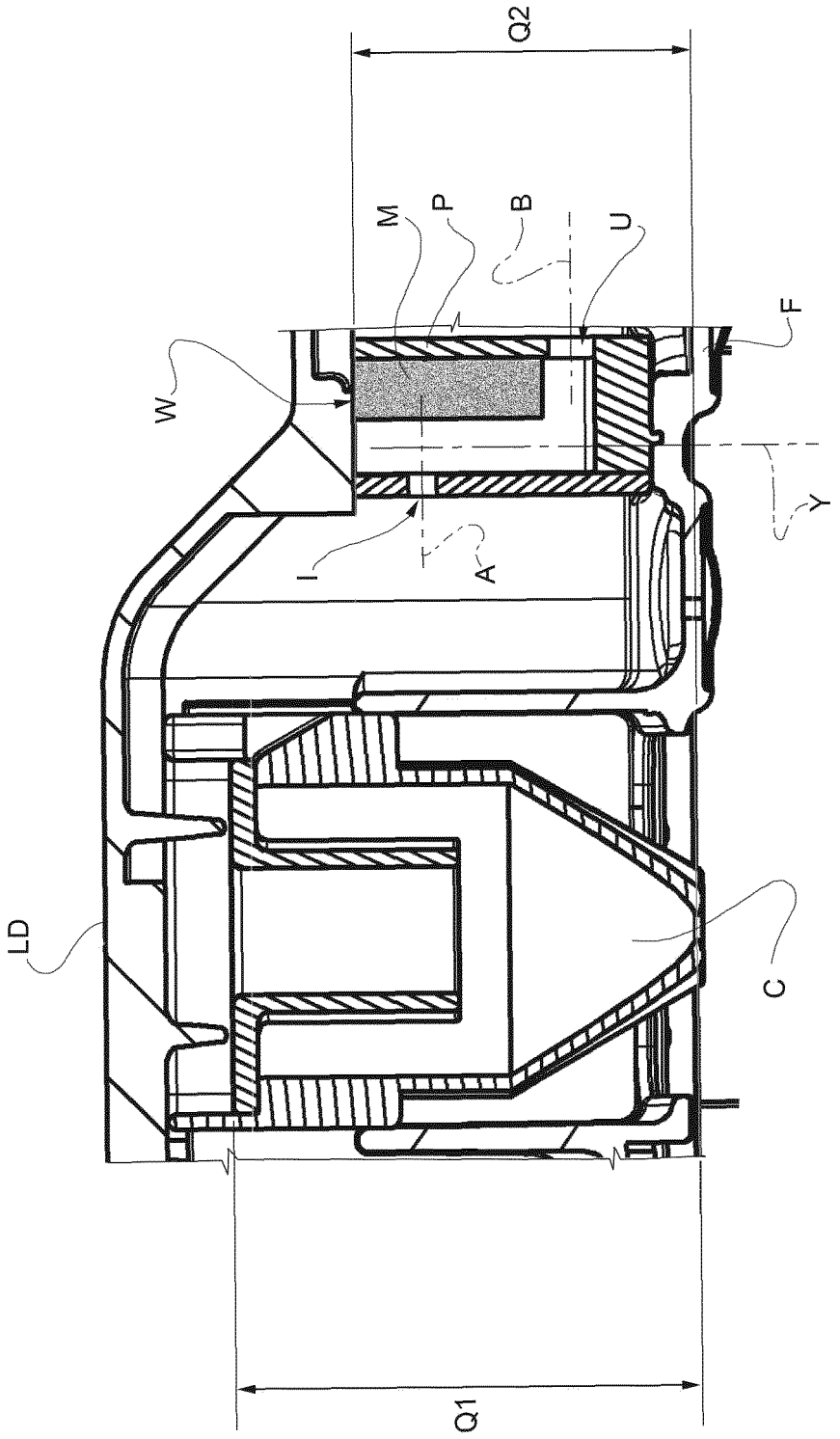


FIG. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 21 5033

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 101 27 817 A1 (BOSCH GMBH ROBERT [DE]) 12 December 2002 (2002-12-12) * abstract * * column 3, paragraph 21 - column 5, paragraph 28; figures 1-5 *	1-6,8-10 7	INV. F01M13/04
X	DE 10 2015 016283 A1 (AISIN SEIKI [JP]) 23 June 2016 (2016-06-23) * abstract * * page 4, paragraph 32 - paragraph 36 *	1,9,10	
A	KR 2013 0053887 A (INZI CONTROLS CO LTD [KR]) 24 May 2013 (2013-05-24) * the whole document *	1-3,8-10	
A	DE 197 00 733 A1 (BOSCH GMBH ROBERT [DE]) 23 July 1998 (1998-07-23) * abstract * * column 2, line 51 - column 4, line 30; figures 1,2 *	1,8-10	
Y	US 2005/005921 A1 (IKEDA EIJI [JP] ET AL) 13 January 2005 (2005-01-13) * abstract; figures 1,4,8 *	7	TECHNICAL FIELDS SEARCHED (IPC) F01M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 February 2020	Van Zoest, Peter

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 21 5033

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-02-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10127817 A1	12-12-2002	DE 10127817 A1	12-12-2002
		EP 1402156 A1	31-03-2004
		JP 4138644 B2	27-08-2008
		JP 2004521238 A	15-07-2004
		US 2003110743 A1	19-06-2003
		WO 02099257 A1	12-12-2002
DE 102015016283 A1	23-06-2016	DE 102015016283 A1	23-06-2016
		JP 2016113999 A	23-06-2016
		US 2016177791 A1	23-06-2016
KR 20130053887 A	24-05-2013	NONE	
DE 19700733 A1	23-07-1998	DE 19700733 A1	23-07-1998
		FR 2758365 A3	17-07-1998
		IT MI970929 U1	13-07-1998
US 2005005921 A1	13-01-2005	CN 1576527 A	09-02-2005
		JP 4075714 B2	16-04-2008
		JP 2005030292 A	03-02-2005
		US 2005005921 A1	13-01-2005

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- IT 102018000010913 **[0001]**
- DE 10127817 A1 **[0002]**