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A filter element for a liquid filter arrangement in a vehicle

TECHNICAL FIELD

The invention relates to a filter element for a liquid filter arrangement used to filter a liquid
5 such as an oil or fuel flowing in a liquid circuit of an engine system. The invention further
relates to a liquid filter arrangement comprising a removable filter element.

The invention can be applied in passenger car vehicles, light commercial vehicles or
heavy-duty vehicles, such as trucks, buses and construction equipment.

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BACKGROUND

In passenger car vehicles, light commercial vehicles and in heavy-duty vehicles, different
liquid circuits can feed or pass through engines such as, for instance, fuel and oil circuits
15 that need to be filtered in order to remove particulates from the liquid which can reduce
performances or damage the engine.

In this aim, liquid filters are provided in the liquid circuits. A liquid filter 101 of prior art is
represented on figure 7. It conventionally comprises a filter housing 102, a filter cover 103
that closes the filter housing 102 and that delimits with the filter housing 102 a filtering
20 chamber 104. A tubular filter element 103 is located in the filtering chamber 104 to filter
the liquid entering into the filter chamber 104. The tubular filter element 105 is made of
filtering medium 106 that is generally folded into a star shape configuration around a
central axis X of the filter element 105. Conventionally in operating conditions, the liquid to
be filtered radially crosses the filter medium 106 from outside to inside of the filter element
25 105. At its axial ends 107, 108 the filter element usually comprises sealing end plates 109,
110 generally made of thermoplastic material and having an annular or a disk shape. The
sealing end plates 109, 110 are attached to the axial ends in sealing manner and are also
used to maintain pleats of the filter element 105 in a folded configuration. Traditionally,
when liquid is flowing from outside to inside the a filter element, the filter element 105 also
30 comprises a rigid perforated central tube 111 that supports the folded filter medium 106 in
the radial direction in order to avoid, in operating conditions, collapsing of the filter medium
106 due to the difference of pressure between outside and inside of the filter element 105.
The filter elements are generally removable from the filter housing in order to be replaced
by a new one. They are replaced at regular intervals during the life of a vehicle.

Replacements of filter elements constitute a significant cost center for the user due to the time of immobilization of the vehicle and due to the cost of the filter element itself. For convenience and in order to limit cost impacts of filter element replacements, it is known from manufacturers to modify capacity of filter elements in order to increase maintenance interval based. From the applicant view there is still a room for improvement in order to limit cost impact due to the replacements of filter elements in a vehicle.

SUMMARY

An object of the invention is to provide a filter element, which overcomes the drawback of the prior filter elements. More precisely, an object of the invention is to provide a cheaper filter element. Another object of the invention is to provide a filter element that is more environmentally friendly.

The object is achieved by a filter element adapted to fit in a filter housing. Said filter element has a filtrating part that is made of a sheet of filtering medium. Said sheet of filtering medium is folded into a star shape configuration around a central axis of the filter element. The filter element is hollow along its central axis and has two axial ends. The filter element is characterized by the fact that it has no central perforated tube and no sealing end plate on its axial ends.

In the absence of central perforated tube and in the absence of sealing end plates, each axial end of the filter element has therefore a star shape when looked from outside the filter element in the direction of the central axis.

In common filter elements adapted for liquid filter arrangement provided for instance in a vehicle, the central perforated tube and the sealing end plates constitute parts of the filter element which have no direct contribution for the filtration of particulates and that represent a significant cost in the global price of the filter element. That's why cancelling central perforated tube and the sealing end plates significantly lowers the cost to manufacture the filter element and so the associated cost of maintenance for the user. A filter element according to the invention is also more environmentally friendly because the central perforated tube and the sealing end plates are generally made of thermoplastic rigid material that are more difficult to recycle than filter medium itself.

Preferably, the filter element has a generally tubular shape or a generally truncated cone shape.

In the absence of central perforated tube and in the absence of sealing end plates fixed on the axial ends of a filter element, a generally truncated cone shape of the filter element is preferred because it allows several filter elements according to the invention to be inserted one inside the other in order to create piles of filter elements. This possible
5 arrangement provides a packaging advantage because it allows several filter elements to be packaged together in order to save space. The generally truncated cone shape of the filter element makes also easier insertion and positioning of the filter element in the filter housing of a liquid filter arrangement.

10 According to an embodiment of the invention, the filter element is only made of deformable material such as the filter medium. Preferably, the filter element is elastically deformable by compression in at least one direction that is transverse to the central axis such that its size can be reduced in the transverse direction.

15 In a preferred embodiment of the invention, the filter element is only made of a filter constituent material that constitutes the filter medium and of one or of several materials chosen among the followings : glue material and/or elastomer material and/or unwoven material.

Indeed, glue material can be needed to glue together two generating edges of the folded
20 sheet of the filter medium in order to close the tubular or truncated cone shape of the filter element. Glue material can also be used to attach on the filter element a sealing element that is preferably made of an elastomer material or of unwoven material in order to keep the filter element deformable.

25 If glue material is needed, the glue material is preferably of the flexible type in order to keep deformable the filter element.

In a more preferred embodiment of the invention, the filter element is only made of a filter constituent material that constitutes the filter medium.

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Preferably, the filter constituent material is a cellulose or a synthetic material or a combination of cellulose and synthetic materials.

The filter element is preferably designed such that several pleats formed by the folded
35 filtering medium can be bended and re-grouped together in order to reduce the dimension of the filter element in a direction that is transverse to the central axis. This is made possible by the absence of sealing end plates at the axial ends of the filter element.

More precisely, the sheet of filtering medium folded into a star shape configuration defines, inside the filter element, an inside peripheral star shape profile and defines, outside the filter element, an outside peripheral star shape profile.

- 5 According to an embodiment of the invention wherein, at least one sealing zone is formed on at least one axial end or in the vicinity of at least one axial end of the filter element. Said sealing zone is arranged outside the filter element and follows the outside peripheral star shape profile of the filter element.
- 10 In a variant or in addition said sealing zone is arranged inside the filter element and follows the inside peripheral star shape profile of the filter element.

It results from the above configuration that said sealing zone has also a star shape when viewed in the direction of the central axis.

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Preferably, a sealing zone is realized on both axial ends or in the vicinity of both axial ends of the filter element.

- Preferably, the sealing zone is realized by a back fold of the sheet of the filtering medium
- 20 at the axial end of the filter element. The back fold of the filtering medium forms an extra thickness around the folded filtering medium.

- In a variant, the sealing zone is realized by a glue bead, a rubber gasket or a gasket made of unwoven fabric having, when viewed in the direction of the central axis, a star
- 25 shape and that is preferably glued around the folded filtering medium.

According to a further aspect, the invention also relates to a liquid filter arrangement comprising :

- a filter housing,
- 30 • a filter cover that closes the filter housing and that delimits with the filter housing a filtering chamber, and
- a filter element according to one of the preceding claims that is located in the filtering chamber.

- According to this further aspect, the sheet of the filter medium that is folded into a star
- 35 shape configuration, defines, inside the filter element, an inside peripheral star shape profile and defines, outside the filter element, an outside peripheral star shape profile. Still according to this further aspect, the liquid filter arrangement further comprises a housing

peripheral wall that is attached to the filter housing or that is part of the filter housing and that has an inside star shape profile that is complementary to the outside peripheral star shape profile of the filter element. In other words, the housing peripheral wall has an inside shape profile that follows the outside peripheral star shape profile of the filter
5 element.

In addition or in a variant, the liquid filter arrangement may comprise a cover peripheral wall that is attached to the filter cover or part of the filter cover and that has an outside star shape profile that is complementary to the inside peripheral star shape profile of the filter element. In other words, the cover peripheral wall has an outside shape profile that
10 follows the inside peripheral star shape profile of the filter element.

More precisely, the the star shape profile of said housing peripheral wall and/or of said cover peripheral wall forms radial ends which penetrate radially between the pleats of the filter element.
15

The housing peripheral wall, the cover peripheral wall or each of the housing peripheral wall and the cover peripheral wall has a generally cylindrical or truncated cone shape around the central axis.

20 In an embodiment, the housing peripheral wall is made in one piece with the filter housing.

In a variant or in addition, the peripheral wall is formed by a tubular or a truncated cone extension attached to the filter cover and that extends inside the filter element.

25 Preferably, the filter cover is screwed onto the filter housing and the tubular or truncated cone extension is attached to the filter cover via a pivot connection such that the tubular or truncated cone extension is able to rotate with respect to the filter cover and around said central axis .

30 Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

35 With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Fig. 1 is an axial section of a liquid filter arrangement according to an embodiment of the invention.

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Fig. 2 is a three dimensional view of a filter element according to the invention that can be fitted in the filter housing of the liquid filter arrangement of figure 1.

Fig. 3 is a cross section of the filter element of figure 2.

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Fig. 4a, 4b, 4c, 4d shows different variants of sealing zones formed on or in the vicinity of an axial end of the filter element of figure 2.

Fig. 4a represents a sealing zone realized by a back fold of the filtering medium.

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Fig. 4b represents a sealing zone realized by a gasket made of unwoven fabric that glued on the filter medium.

Fig. 4c represents a sealing zone realized by a rubber gasket that glued on the filter medium.

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Fig. 4d represents a sealing zone realized by the filter medium itself.

Fig. 5 is a three dimensional view of a filter housing according to the invention and having an inside peripheral wall with a star shape.

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Fig. 6 is a view of a filter cover and a truncated cone extension attached to the filter cover according to the invention.

30 Fig. 7 is a view of a liquid filter arrangement according to prior art.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

It is to be understood that the present invention is not limited to the embodiments
5 described below and illustrated in the drawings; rather, the skilled person will recognize
that many changes and modifications may be made within the scope of the appended
claims.

Also, well-known functions or constructions are not described in detail since they would
obscure the application with unnecessary detail.

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In order to facilitate understanding, same elements and steps in the figures will be
denoted by the same reference numerals, and redundant descriptions thereof will be
omitted.

15 Figure 1 represents a liquid filter arrangement 1 according to an embodiment of the
invention. The liquid filter arrangement 1 is adapted to filter a liquid such as fuel or oil
flowing through an engine, for instance, in a vehicle. When assembled in a vehicle, the
liquid filter arrangement 1 is preferably located upstream from the engine of the vehicle.
The liquid filter arrangement 1 also comprises a filter housing 2 and a filter cover 3 that
20 closes the filter housing 2. The filter housing 2 and the filter cover 3 delimit together a
filtering chamber 4. A filter element 5 is located in the filtering chamber 4. The filter
element 5 divides the filtering chamber 4 into two parts : a dirty side 41 upstream from the
filter element 5 and a clean side 42 downstream from the filter element 5. The filter
element 5 has preferably a generally truncated cone shape around a central axis X such
25 as represented on figures 1 and 2. However, the filter element 5 may adopt some different
other shapes such as a tubular shape (not represented).

At least one liquid inlet 6 is arranged in the liquid filter arrangement 1 to feed in liquid the
filtering chamber 4. The liquid inlet 6 opens into the dirty side 41. On figure 1, two liquid
30 inlets 6 are represented and extend from the bottom of the filter housing 2 up to the dirty
side 41. The liquid filter arrangement 1 may alternatively comprises only one liquid inlet or
more than two liquid inlets that can also in a variant be formed in the filter cover 3.

At least one liquid outlet 7 is arranged in the liquid filter arrangement 1 to allow filtered
35 liquid (clean liquid) to exit the filtering chamber 4 from the clean side 42. In the example of

figure 1, the liquid outlet 7 is in a central position and extends axially from the clean side 42 to the bottom of the filter housing 2.

The liquid filter arrangement 1 according to the invention preferably comprises a central
5 supporting member 8 that can be attached to the filter cover 3 and that extends axially
from the filter cover 3 up to the inside of the hollow filter element 5. The central supporting
member 8 has a generally truncated cone shape to fit with the generally truncated cone
shape of the filter element 5. Depending on the general shape of the filter element 5 it
may adopt some other different shapes such as a tubular shape when the filter element is
10 also tubular. The central supporting member 8 provides a radial support to the filter
element 5 to avoid collapsing of the filter element 5 due to, in operating conditions, the
difference of pressure between dirty side 41 and clean side 42.

In operating conditions, that is to say when the filter element 5 is mounted into the filter
15 housing 2 closed by the filter cover 3 and the engine of the vehicle is started, the liquid to
be filtered enters into the dirty side 41 of the filtering chamber 4 via the liquid inlet 6, then
it flows radially across the filter element 5 through which some particulates are retained by
the filter medium 51 of the filter element 5. Finally, the filtered liquid exits the filtering
chamber 4 by flowing through the liquid outlet 7 from the clean side 42.

20

A filter element 5 according to the invention and adapted to fit in a filter housing 2 such as
previously described is represented on figure 2.

As previously explained, a filter element 5 according to the invention comprises a filtrating
part that is realized by a sheet of filtering medium 51 that is folded into a star shape
25 configuration 54 around a central axis X of the filter element 5. In other words, a cross
section 53 of the filter element 5, such as represented on figure 3 has a star shape 54. In
the embodiment of figure 2, the filter element 5 is designed to adopt a generally truncated
cone shape. However and such as previously mentioned it may also have some different
other general shapes such as a tubular shape (not represented).

30 The filter medium 51 can be made, for instance, of cellulose and/or synthetic material.

The filter element 5 is hollow along its central axis X and has two axial ends 55, 56.
According to a specificity of the present invention, the filter element 5 has no central
perforated tube and has no sealing end plate attached to its axial ends 55, 56. Therefore,
when viewed in the direction of the central axis X from outside the filter element, axial
35 ends 55, 56 have also a star shape 54.

Preferably, the filter element 5 is only made of deformable material. The deformable material comprises at least the filter medium 51.

Preferably, the filter element 5 is only made of a filter constituent material that constitutes the filter medium 51. Therefore the filter element 51 can only be made of cellulose or synthetic material or can only be made of a mix of cellulose and synthetic material.

The filter medium 51 can comprise several type of filtering layers. For instance, at least one layer is made of cellulose material and another is made of synthetic material.

10 The filter element 5 may also comprise some other material such as elastomer material and/or unwoven material to realize, for instance, some sealing zones. The filter element 5 may also comprise glue to stick, for instance, together two generating edges of the folded sheet of the filter medium 51 in order to close the tubular or truncated cone shape of the filter element or to attach on the filtering medium 51 rubber gasket or gasket made of
15 unwoven fabric. Said other material is chosen to be of the deformable or flexible type.

The use of only deformable material to manufacture the filter element 5, allows the filter element to be elastically deformable that is to say to be reversibly deformable.

20 More precisely, the filter element 5 is made elastically deformable by compression in at least one direction Y, Z that is transverse to its central axis X such that the size of the filter element 5 can be reduced according to this transverse direction Y,Z.

Preferably, several pleats 57 formed by the filtering medium can be bended and re-
25 grouped together in order to reduce the size of the filter element 5 in a direction Y, Z that is transverse to its central axis X.

An elastically deformable filter element 5 according to the invention improves a bit more the packaging of several filter elements. Indeed, having a filter element 5 that is
30 deformable by compression in at least one direction Y, Z allows, for instance, to stack up more filter elements in the same amount of space. A packaging method to package elastic filter elements 5 may comprises the following steps :

- compressing each filter element 5 in a direction X,Y that is transverse to its central axis X,
- 35 • bending several pleats 37 of each filter element 5 and re-grouping them in at least one packet,
- superposing several filter elements 5 in the transverse direction X,Y.

According to another packaging method, the absence of central perforated tube and the absence of end plates on the axial ends of a filter element 5 according to the invention allow also several filter elements to be inserted one inside the other in order to create piles of filter elements and thus to save space when several filter elements 5 are
5 packaged together.

The filter element 5 comprises at least one sealing zone 60 that is formed on at least one axial end of the filter element or in the vicinity of at least one axial end 55, 56 of the filter element. The sheet of filtering medium 51 folded into a star shape configuration 54 forms,
10 inside the hollow filter element 5, an inside peripheral star shape profile 58 and, outside the hollow filter element 5, an outside peripheral star shape profile 59.

Such as represented on figure 2, two sealing zones 60 formed at the top axial end 55 and at the bottom axial end 56 of the filter element may follow the outside peripheral star
15 shape profile 59 of the filter element 5.

In a variant, such as represented on figure 1, the sealing zone(s) 60 may follow the inside peripheral star shape profile 58 of the filter element 5.

In another variant, such as illustrated by figure 4b, two sealing zones can be arranged at
20 each axial end 55, 56, a first one is arranged inside the filter element 5 and follows the inside peripheral star shape profile 58 of the filter element and a second one is arranged outside the filter element and follows the outside peripheral star shape profile 59 of the filter element.

In operating conditions, the sealing zone 60 avoids the liquid to be filtered to by-pass the
25 filtering medium 51. In operating conditions, the seal is realized by radially and/or axially compressing (such as represented on figure 1, 4a, 4b, 4c, 4d) the sealing zone 60 between the outside of the filter element 5 and an inside peripheral wall 81 of the housing 2 and/or between the inside of the filter element 5 and an axial extension, that can be the central supporting member 8 previously described, that penetrates inside the hollow filter
30 element 5 and that is attached to or part of the filter cover 3 or that is attached to or part of the filter housing 2.

Such as illustrated on figure 4a, the sealing zone 60 can be realized by a back fold 61 of the filtering paper that forms an extra thickness around the folded filtering medium 51.
35

In a first variant such as represented on figure 4b, the sealing zone 60 is realized by at least one gasket 62 made of unwoven fabric having, when viewed in the direction of the

central axis X, a star shape and that is preferably glued around the folded filtering medium 51.

In a second variant such as represented on figure 4c, the sealing zone 60 is realized by a rubber gasket or a glue bead 63 having, when viewed in the direction of the central axis X, a star shape and that is preferably glued around the folded filtering medium 51.

In first and second variants the gasket 62 made of unwoven fabric, the rubber gasket or the glue bead 63 can be arranged inside 58 or outside 59 the filter element 5.

On figure 4b, two gaskets 62 are arranged on both sides 58, 59 of the filter element 5. On figure 1 they the rubber gasket is arranged outside 59 the filter element 5.

If the filter medium 51 is chosen with a sufficient medium thickness t_h , for instance, above 0,5 mm, the sealing zone 60 can be realized, such as represented on figure 4d, by the filter medium 51 itself without additional sealing means. Indeed, above 0,5 mm the medium thickness, radially compressed, for instance, between an axial extension 8 of the filter cover 3 and an inside peripheral wall 81 of the filter housing 2 authorizes a sufficient compressible deformation of the filter medium 51 to ensure liquid tightness between clean side 42 and dirty side 41 in the filtering chamber 4.

Some details of the liquid filter arrangement of figure 1 are now described here below with references to figure 5 and 6.

Preferably, the liquid filter arrangement of figure 1 comprises at least one peripheral wall 71, 72 that is attached to or part of the filter housing 2 or attached to or part of the filter cover 4. Said peripheral wall 71, 72 is designed with a star shape profile 75, 76 that is complementary to the inside or outside peripheral star shape profile 58, 59 of the filter element 5. The star shape of the peripheral wall 71, 72 has radial ends 73, 74 which penetrate radially between the pleats 57 of the filter element 5. In the absence of sealing end plates arranged on the axial ends 55, 56 of the filter element 5 and that are usually provided in filter elements 105 of prior art (see figure 7, sealing end plates 106, 107), the particular design of the liquid filter arrangement 1 according to the invention allows the pleats 57 of the filter element 5 to be maintained in the star shape configuration 54. In other words, peripheral wall 71, 72 having a star shape complementary to the star shape of the filter element avoids the pleats 57 of the filter element 5 to stick together.

Such as represented on figures 1, 5 and 6, two peripheral walls 71, 72 can be provided. A housing peripheral wall 71 can be attached to or part of the filter housing 2 and a cover peripheral wall 72 can be attached to or part of the filter cover 3. The cover peripheral wall

72 can be formed by an axial extension 8 that is attached to or part of the cover 3 and that is designed with an outside star shape profile 76 that is complementary to the inside star shape profile 58 of the filter element 5. The housing peripheral wall 71 can be formed in the filter housing 2 and designed with an inside star shape profile 75 that is
5 complementary to the outside star shape profile 59 of the filter element 5.

The housing peripheral wall 71 is represented on figures 1 and 5 with a generally truncated cone shape around the central axis X. However, it may also be designed with a generally cylindrical shape (not represented) to fit with a filter element 5 having, for
10 instance, a generally tubular shape.

The axial extension 8 forming the cover peripheral wall 72 is preferably designed as a truncated cone extension that is part or that is attached to the filter cover 3 and that extends inside the hollow filter element 5. The axial extension 8 may also be designed
15 with a tubular shape (not represented) to fit with a filter element 5 having, for instance, a generally tubular shape.

Preferably, the tubular or truncated cone extension is the central supporting member 8 such as previously described that provides a radial support for filtering medium 51 of the filter element 5 when liquid flows radially from outside to inside the filter element 5.
20 Conversely, this supporting function can be realized by the housing peripheral wall 71 formed in the housing when the liquid filter arrangement 1 is, for instance, designed such that the flow of liquid is inverted, that is to say when liquid flows radially from inside to outside the filter element 5.

25 Preferably, if only one peripheral wall 71, 72 is designed with a star shape profile, the peripheral wall that, depending on the flow direction, radially supports the filtering medium 51 is designed with a star shape profile. Therefore, if liquid radially flows from outside to inside the filter element 1, it is the central supporting member 8 that is designed with a star shape 76.

30

Peripheral walls 71, 72 comprise several openings 77, 78 homogenously distribute along height and periphery of the peripheral walls 71, 72 to allow liquid to flow through the filter medium 51 with a homogenous distribution.

35 Such as represented on figure 1 and to ensure an efficient sealing and a better circulation of liquid outside the filter element in the dirty side 42, the housing peripheral wall 71 can be arranged radially in recess with respect to the inside peripheral wall 81 used for sealing

function. In other words, the inside peripheral wall 81 is radially in contact with the filter element 5 whereas the housing peripheral wall 71 is not in contact with the filter element, i.e. not in contact with the filter medium 51, such that a gap J is created between the housing peripheral wall 71 and the the filter medium 51.

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Preferably, the filter cover 3 may be screwed onto the filter housing 2 and the tubular or truncated cone extension 8 is preferably attached to the filter cover 2 via a pivot connection 31 such that the tubular or truncated cone extension 8 is able to rotate with respect to the filter cover 3 around the central axis X. The pivot connection 31 may be,
10 such as represented on the embodiment of figure 1, realised by the cooperation of radial flexible fingers 32 of the tubular or truncated cone extension 8 with an annular groove 33 of the cover 3. In this embodiment radial flexible fingers 32 engaged the annular groove 33 to attached the tubular or truncated cone extension 8 with the cover 3. Such a connexion authorizes, especially when the cover 3 is screwed onto the filter housing 2, a
15 rotation of the the tubular or truncated cone extension 8 with respect to the filter cover because radial flexible fingers 32 may move along the the annular groove 33.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize
20 that many changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A filter element (5) adapted to fit in a filter housing (2), having a filtrating part that is made of a sheet of filtering medium (51) that is folded into a star shape configuration around a central axis (X) of the filter element, wherein the filter element is hollow
5 along its central axis (X) and has two axial ends (55, 56) **characterized in that** the filter element (5) has no central perforated tube and has no sealing end plate on its axial ends (55, 56).
2. The filter element according to claim 1, wherein each axial end has a star shape
10 when looked from outside the filter element in the direction of the central axis.
3. The filter element according to claim 1 or 2, wherein the filter element has a generally tubular shape or a generally truncated cone shape.
- 15 4. The filter element according to any one of the preceding claims, wherein the filter element is only made of deformable material.
5. The filter element according to the preceding claim wherein the filter element (5) is elastically deformable by compression in at least one direction (Y, Z) that is
20 transverse to the central axis (X) such that its size can be reduced in the transverse direction (Y,Z).
6. The filter element according to any one of the preceding claims, wherein the filter element (5) is only made of a filter constituent material that constitutes the filter
25 medium (51) and of one or of several materials chosen among the followings : glue material and/or elastomer material and/or unwoven material.
7. The filter element according to claim 6, wherein the glue material is of the flexible
30 type.
8. The filter element according to any one of the claims 1 to 5, wherein the filter element (5) is only made of a filter constituent material that constitutes the filter medium (51).
9. The filter element according to any one of the preceding claims, wherein the filter
35 constituent material is a cellulose or a synthetic material or a combination of cellulose and synthetic materials.

10. The filter element according to any one of the preceding claims, wherein several pleats (57) formed by the folded filtering medium (51) can be bended and re-grouped together in order to reduce the size of the filter element (5) in a direction (Y, Z) that is transverse to the central axis (X).
11. The filter element according to any one of the preceding claims, wherein the sheet of filtering medium (51) folded into a star shape configuration (54) defines, inside the filter element (5), an inside peripheral star shape profile (58) and defines, outside the filter element, an outside peripheral star shape profile (59), wherein at least one sealing zone (60) is formed on at least one axial end (55, 56) or in the vicinity of at least one axial end (55, 56) of the filter element, and wherein said sealing zone (60) is arranged outside the filter element (5) and follows the outside peripheral star shape profile (59).
12. The filter element according to any one of the preceding claims, wherein the sheet of filtering medium (51) folded into a star shape configuration (54) defines, inside the filter element (5), an inside peripheral star shape profile (58) and defines, outside the filter element, an outside peripheral star shape profile (59), wherein at least one sealing zone is formed on at least one axial end (55, 56) or in the vicinity of at least one axial end (55, 56) of the filter element, and wherein said sealing zone is arranged inside the filter element (5) and follows the inside peripheral star shape profile (58).
13. The filter element according to claim 11 or 12, wherein the sealing zone (60) is realized by a back fold (61) of the sheet of filtering medium (51), formed at the axial end (55, 56) of the filter element (5) and forming an extra thickness around the folded filtering medium (51).
14. The filter element according to claim 11 or 12, wherein the sealing zone (60) is realized by a glue bead, a rubber gasket (63) or a gasket (62) made of unwoven fabric having, when viewed in the direction of the central axis (X), a star shape and that is preferably glued around the folded filtering medium (51).
15. A liquid filter arrangement comprising a filter housing (2), a filter cover (3) that closes the filter housing and that delimits with the filter housing (2) a filtering chamber (4), and a filter element (5) according to one of the claims 1 to 14 that is located in the filtering chamber (4), wherein the sheet of filter medium (51), that is folded into a star shape configuration, defines, inside the filter element, an inside peripheral star shape

- profile (58) and defines, outside the filter element, an outside peripheral star shape profile (59) characterized the liquid filter arrangement further comprises a housing peripheral wall (71) that is attached to the filter housing (2) or that is part of the filter housing (2) and that has an inside star shape profile (75) that is complementary to said outside peripheral star shape profile (59) of the filter element.
- 5
16. A liquid filter arrangement comprising a filter housing (2), a filter cover (3) that closes the filter housing and that defines with the filter housing (2) a filtering chamber (4), and a filter element (5) according to one of the claims 1 to 14 that is located in the filtering chamber (4), wherein the sheet of filter medium (51), that is folded into a star shape configuration, defines, inside the filter element, an inside peripheral star shape profile (58) and defines, outside the filter element, an outside peripheral star shape profile (59) characterized the liquid filter arrangement further comprises a cover peripheral wall (72) that is attached to the filter cover or part of the filter cover (3) and that has an outside star shape profile (76) that is complementary to said inside peripheral star shape profile (58) of the filter element.
- 10
- 15
17. The liquid filter arrangement according to claim 15 or 16, wherein the star shape profile (75, 76) of the housing peripheral wall (71) and/or of the cover peripheral wall (72) form(s) radial ends (73,74) which penetrate radially between the pleats (57) of the filter element (5).
- 20
18. The filter arrangement according to one of claims 15 to 17, wherein the housing peripheral wall (71), the cover peripheral wall (72) or each of the housing peripheral wall and the cover peripheral wall (72) has a generally cylindrical or truncated cone shape around the central axis X.
- 25
19. The filter arrangement according to claim 15, wherein the housing peripheral wall (71) is made in one piece with the filter housing (2).
- 30
20. The filter arrangement according to any one of claim 16, wherein the cover peripheral wall (72) is formed by a tubular or a truncated cone extension (8) attached to the filter cover (3) and that extends inside the filter element (5).
- 35
21. The filter arrangement according to claim 20, wherein filter cover (3) is screwed onto the filter housing (2) and the tubular or truncated cone extension (8) is attached to the filter cover (3) via a pivot connection (31) such that the tubular or truncated cone

extension (8) is able to rotate with respect to the filter cover (3) and around the central axis (X).

Fig. 1

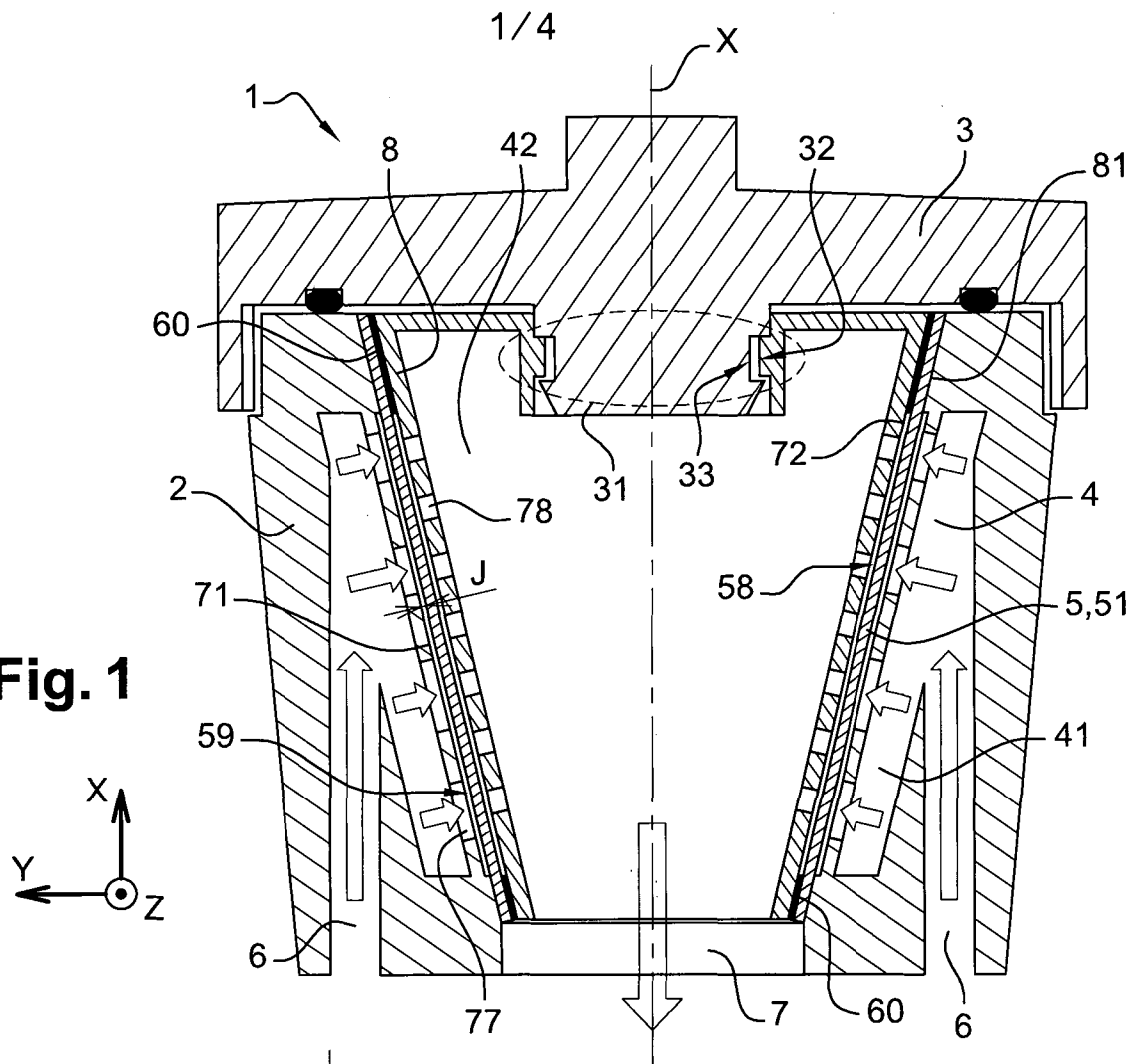
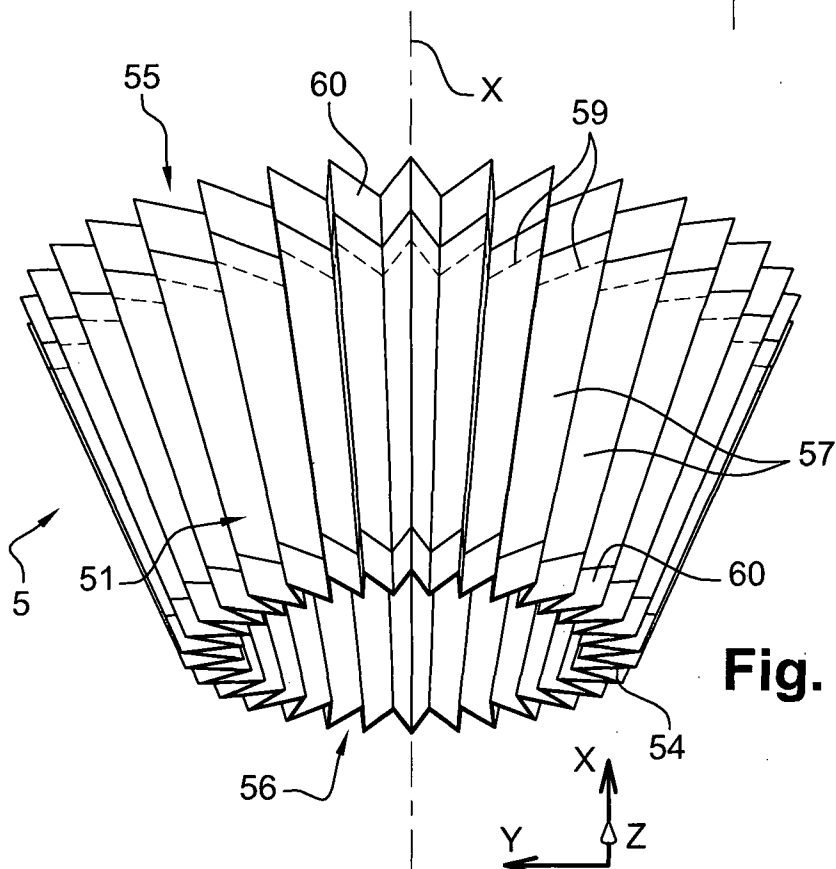


Fig. 2



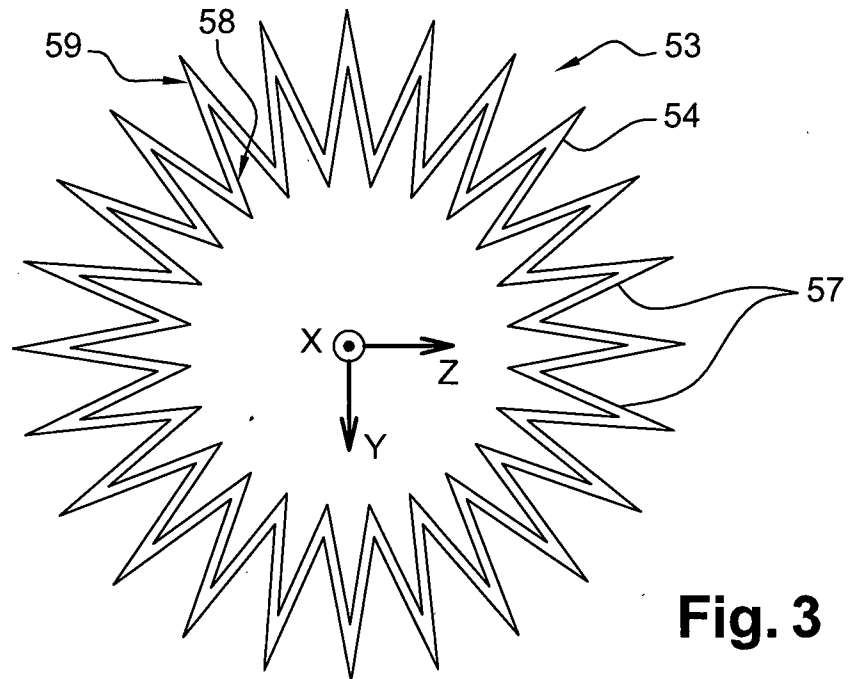


Fig. 3

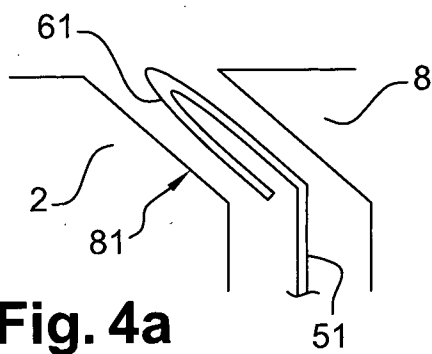


Fig. 4a

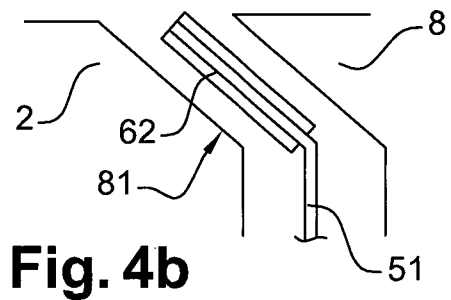


Fig. 4b

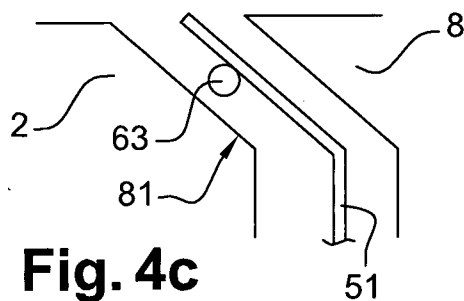


Fig. 4c

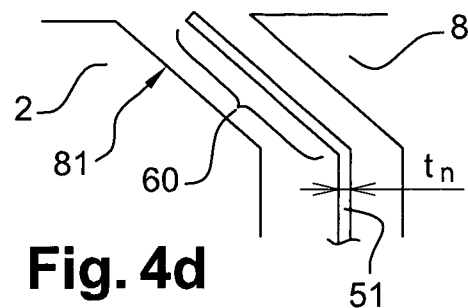
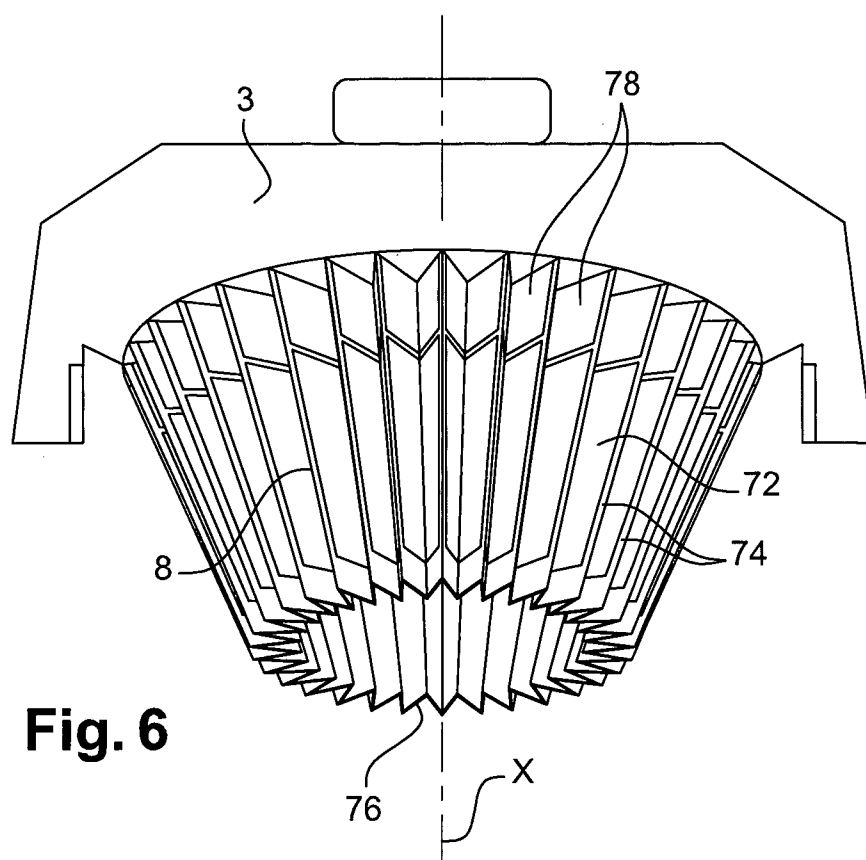
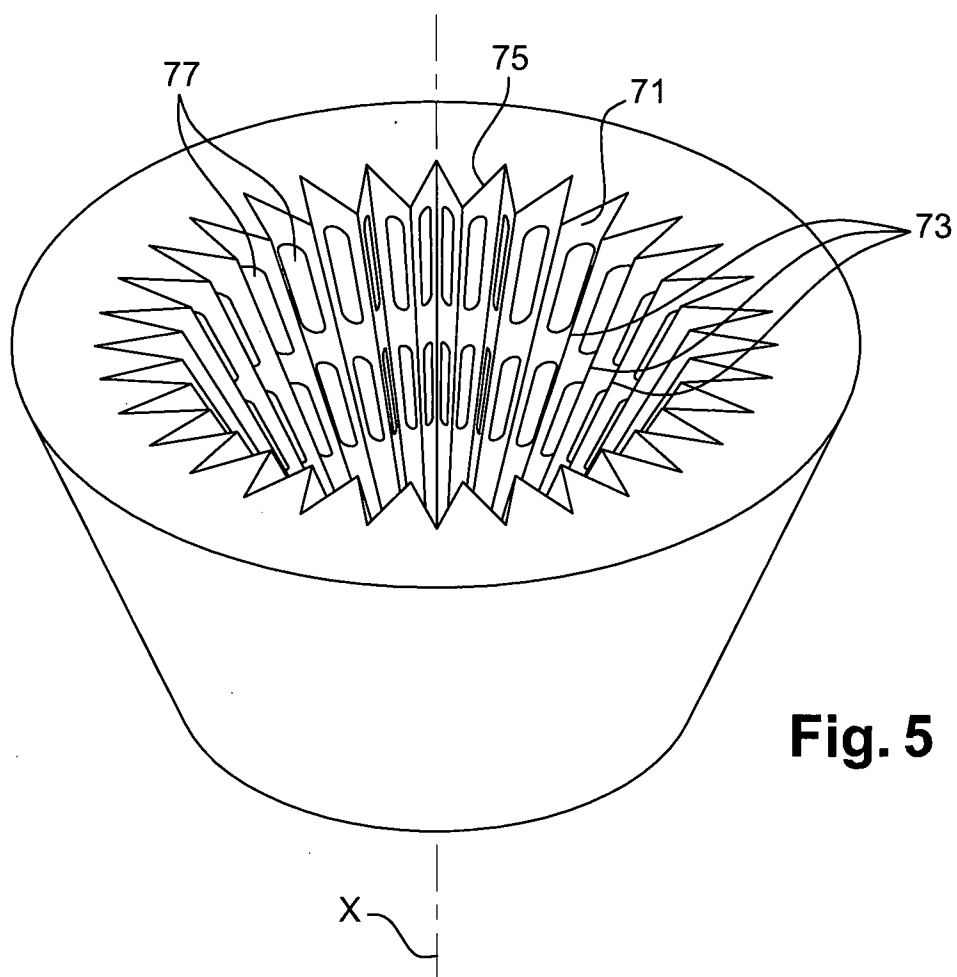


Fig. 4d

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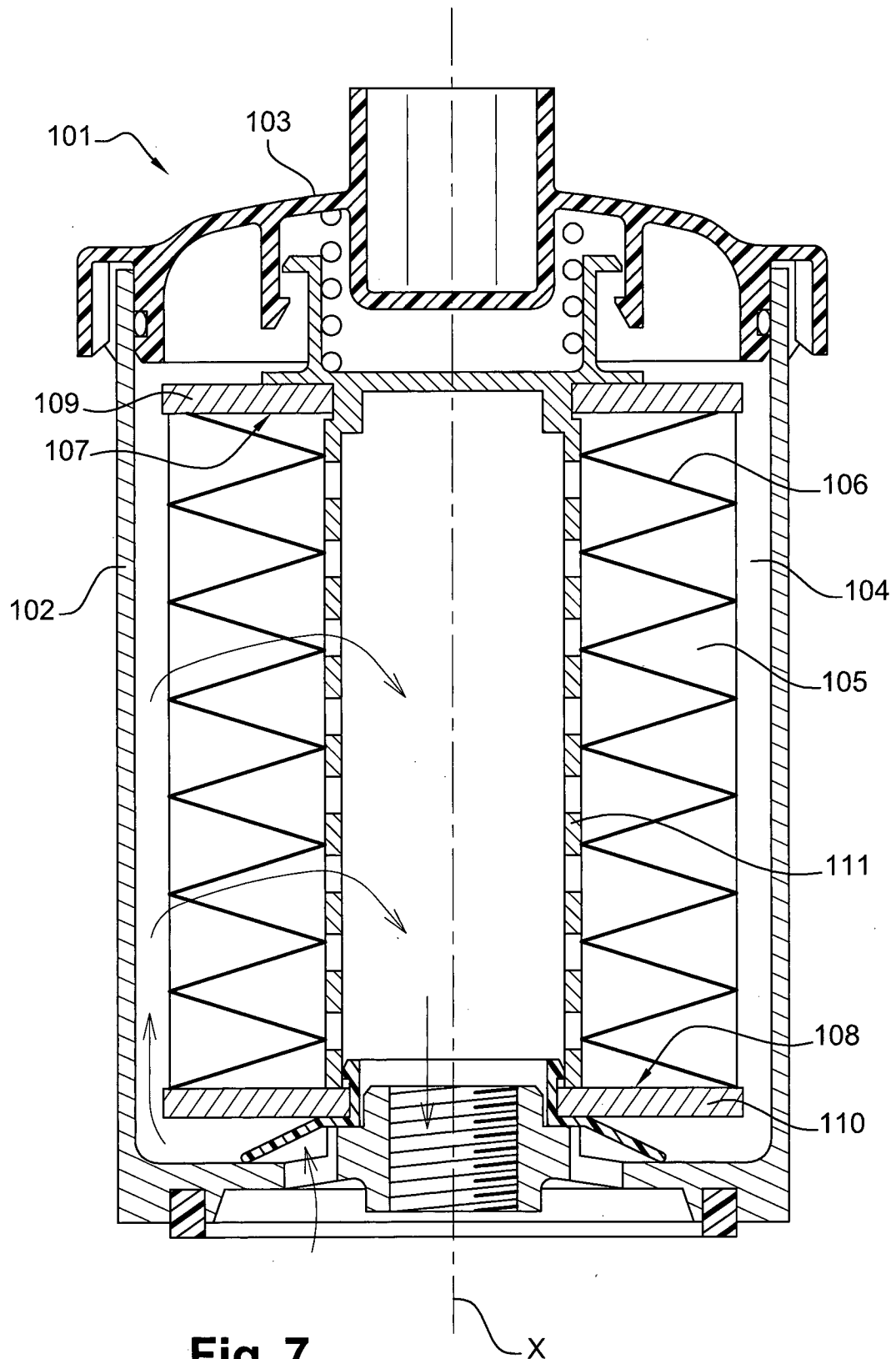


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/000459

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D35/153 B01D35/30 B01D29/21
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)
B01D

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)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2009 052123 A1 (MANN & HUMMEL GMBH [DE]) 12 May 2011 (2011-05-12) paragraph [0035]; figure 2 -----	1-12
X	DE 10 2012 015876 A1 (MANN & HUMMEL GMBH [DE]) 15 May 2014 (2014-05-15) figure 7 -----	1-12
X	DE 34 15 425 A1 (BOBST SA [CH]) 31 October 1984 (1984-10-31) the whole document -----	1-5,8, 10-14
X	US 4 186 099 A (HENSCHEL ARTHUR O JR [US] ET AL) 29 January 1980 (1980-01-29) the whole document -----	1-5,8, 10-14



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

8 November 2016

Date of mailing of the international search report

16/11/2016

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Hilt, Daniel

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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