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- (54) Benævnelse: **FILTERPATRON TIL ET SIKKERHEDSARBEJDSBORD OG SIKKERHEDSARBEJDSBORD MED MINDST EN FILTERPATRON**
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The invention relates to a filter cartridge for a safety cabinet according to the preamble of claim 1 and a safety cabinet according to the preamble of claim 13.

Safety cabinets are used in the pharmaceutical and biotechnological fields, among others, for handling substances that have a high risk potential. These substances include infectious, carcinogenic, mutagenic substances or substances that are hazardous to fertility, including hazardous substances.

Safety cabinets usually have a work opening at the front through which an operator seated in front of the cabinet can insert his hands and forearms into a work area of the safety cabinet where the work substances are located. In front of the work opening there is a glass pane which gives the operator a good view of the work substances in the interior or working space. To protect operators and other persons in the vicinity of the safety cabinet from work substances escaping through the work opening, ambient air is drawn through the work opening into the interior space of the safety cabinet. The resulting air flow prevents potentially contaminated air from escaping from the interior space into the environment, thus ensuring personal protection. For product protection, i.e. to protect the work substances in the interior space from contamination by microorganisms or other impurities in the supplied ambient air, the supplied ambient air is circulated together with part of the air inside the safety cabinet by means of a fan and cleaned with filters before contact with the work substances.

A safety cabinet is already known from EP 1 312 871 B1, in which the filters are designed as cartridge filters and are equipped with several filter cartridges of the type mentioned above arranged next to each other. These filter cartridges consist of a hollow cylindrical filter body, which surrounds an interior space of the filter cartridge in a radial direction, an open cover sealed with an upper end of the filter body, which surrounds an inflow opening which opens into the interior space, and a closed cover sealed with a lower end of the filter body. The ambient air sucked in through the work opening and the air circulated in the safety cabinet flow first through the inflow opening into the interior space of the filter cartridge and from there pass through the filter body or the filter material, whereby the air is cleaned. The cartridge filters are so-called micro or HEPA filters.

Although it has been found that these cartridge filters have a very good filtering effect, it would be advantageous if, without impairing the filtering effect and without modifying the

filter body or the filter material, the volume flow through the filter cartridge could be increased and/or the pressure difference between the inflow side and the outflow side could be reduced. As a result, either more air could be circulated through the filter cartridge at the same fan capacity in order to increase the flow rate of the air flowing in through the work opening and thus improve both personal and product protection, or the fan capacity could be reduced without changing the flow conditions thus achieving energy savings.

GB 2 261 830 A already discloses a filter cartridge according to the preamble of claim 1. There, the projection has no fluidic function, but only allows the attachment of a drawbar. The inflow surface of the projection comprises on its upper side an annular surface perpendicular to the longitudinal centre axis of the filter cartridge and a recessed conical surface surrounded by it, which together form at least half of the inflow surface. At high flow velocities, this leads to considerable turbulence and thus to a reduction in the kinetic energy of the air flow, whereby, with the same pressure gradient across the filter material, the amount of air flowing through the filter material is reduced. In addition, the flow velocity at the upper end of the projection increases abruptly due to the reduction of the flow cross section, so that fewer particles carried along by the air flow are deposited on the inner side of the filter body, which leads to an inconsistent filtering effect.

Based on this, the problem underlying the invention is to improve a filter cartridge of the aforementioned type for use in a safety cabinet in such a way that the flow rate of the air flowing through the filter body or the filter material can be increased without impairing the filter effect and without changing the filter material of the filter cartridges used in safety cabinets.

According to the invention, this problem is solved by the features of claim 1. Preferred embodiments are defined in the dependent claims.

The inflow surface on the inner side of the tapered projection protruding inwards above the closed cover is coaxial and rotationally symmetrical to the longitudinal centre axis of the filter cartridge and the filter body in order to deflect the air evenly in all directions.

In tests or measurements on a filter cartridge for a safety cabinet, it was found that the flow rate of the air flowing through the filter body can be influenced without changing the filter

material both by changing the geometric shape of the inflow opening and by changing the geometric shape of a surface on the inner side of the closed cover of the filter cartridge which is exposed to the air. Furthermore, it was found during the tests or measurements that by changing the geometric shape of the inflow opening, the pressure difference between the inflow side and the outflow side of the filter cartridge can also be influenced without changing the filter material.

A reduction of the pressure difference between the inflow side and the outflow side of the filter cartridge is achieved primarily when the inflow opening has, according to the invention, a nozzle-like flow cross-section decreasing in the direction of the inner space, while an increase in the flow rate, i.e. the amount of air flowing through the filter body per unit of time, is achieved by the decrease, according to the invention, in the flow cross-section of the inflow opening in the direction of the inner space, and by the tapered projection on the closed cover projecting, according to the invention, into the inner space towards the inflow opening.

During the tests it was further established that a filter cartridge with an inflow opening according to the invention causes considerably less turbulence in the interior space of the filter cartridge and that the turbulence almost completely disappears when the closed cover is provided by the projecting tapered projection with an inflow surface inclined at an angle to the direction of flow of the incoming air instead of an inflow surface perpendicular to the direction of inflow, which ensures that the air is deflected with less turbulence towards the interior side of the hollow cylindrical filter body.

The open cover is preferably designed in such a way that the flow cross-section of the inflow opening already decreases outside the filter body, or rather in the flow direction of the air before reaching the filter body, so that the entire length of the filter body can be used for air filtration without the air having to be deflected again against the inflow direction inside the filter body or behind the inflow opening.

According to an advantageous embodiment of the invention, the ratio between the smallest flow cross-section at an inner end of the inflow opening and the largest flow cross-section at an outer end of the inflow opening is smaller than 0.75 and preferably smaller than 0.5, so that the air inside the inflow opening is accelerated as in a nozzle. This acceleration is considered to be one of the reasons for the increase in volume flow through the filter cartridge. The

reduction of the flow cross-section is advantageously achieved over a relatively short distance, the length of which is expediently less than a tenth of the length of the filter cartridge, so that the nozzle-like inflow opening requires little space within the housing of the safety cabinet.

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Another expedient configuration of the invention provides that the inflow opening is delimited at its inner end by a hollow cylindrical short web coaxial with the longitudinal centre axis of the filter cartridge, which projects a little into the interior of the filter body and delimits a flat groove open towards the filter body, in which the adjacent front end of the filter
10 body can be cast. To enable the adjacent end of the filter body to be cast, the groove is also outwardly bordered by a web coaxial with the longitudinal centre axis of the filter cartridge and surrounding the outer peripheral surface of the filter body at its adjacent end.

For mounting the filter cartridge in the safety cabinet, the open cover of the filter cartridge
15 advantageously comprises an edge flange which projects in the radial direction of the longitudinal centre axis over the outer circumference of the filter body. A ring-shaped projection, which surrounds the inflow opening outside the filter cartridge and limits it in the radial direction, expediently projects beyond the side of the edge flange facing away from the filter body. The edge flange and the annular projection, which is hollow to save material, are
20 advantageously made of thermoplastic material to give the inflow opening a desired contour in a simple manner. The open cover can be made in one piece or in several pieces, whereby in the former case the edge flange and the projection are preferably integral parts of the open cover.

25 Preferably, the inflow opening has a rotationally symmetrical boundary surface coaxial to a longitudinal centre axis of the filter cartridge and the filter body, the inclination angle of which increases in the direction of air flow through the inflow opening.

Advantageously, the outer diameter of the inflow surface at a foot of the projection facing
30 away from the inflow opening is somewhat smaller than the inner diameter of the filter body, so that some of the air can flow past the projection to the very end of the filter body and the entire length of the filter body can thus be used for air filtration.

It is also advantageous that the closed cover and the projection are made in one piece of thermoplastic material, whereby the projection on the outer side of the closed cover expediently delimits a recess with a shape corresponding to the shape of the projection, so that the closed cover can be made as thin-walled as possible over its entire diameter, thus saving material.

In addition, the tests and measurements have shown that better results can be achieved in terms of increasing the air flow rate or flow volume with relatively low projections, e.g. if the height of the projection is less than a quarter and preferably less than a fifth of the axial length of the filter body.

In order to prevent the filter material, which is folded in a zigzag pattern and formed into a hollow cylinder and made of paper, from being damaged during handling of the filter cartridge, the filter body can be suitably surrounded by an air-permeable grip protection between the open and closed cover, which prevents contact with the filter body during handling.

In the following, the invention is explained in more detail by means of an exemplary embodiment shown in the drawing.

Fig. 1 shows a schematic, partially cut side view of a safety cabinet according to the invention;

Fig. 2 shows a perspective view of a filter housing of the safety cabinet with six filter cartridges;

Fig. 3 shows an enlarged sectional view along line III - III of fig. 2;

Fig. 4 shows an enlarged perspective view of a filter cartridge according to the invention;

Fig. 5 shows an upper side view of the filter cartridge;

Fig. 6 shows an exploded perspective view of the parts of the filter cartridge;

Fig. 7 shows a longitudinal sectional view of the filter cartridge along line VII – VII of fig. 5;

Fig. 8 shows a respective longitudinal sectional view of another filter cartridge according to the invention;

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Fig. 9 shows a respective longitudinal sectional view of yet another filter cartridge according to the invention;

Fig. 10 shows a respective longitudinal sectional view of an embodiment of the filter cartridge not belonging to the invention.

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Fig. 11 shows an exploded perspective view of the parts of yet another filter cartridge according to the invention.

15 The safety cabinet IC shown in the drawing, intended for handling carcinogenic, mutagenic, fertility-threatening or pathogenic work substances, consists substantially of a height-adjustable lower part or base frame 12 and an upper part 14 with a housing 16, which surrounds a work space 18 used for handling the work substances.

20 As best illustrated in Figs. 1 and 2, the work space 18 is bordered on one front side of the safety cabinet 10 by a glass pane 20, which gives an operator sitting in front of the safety cabinet 10 (not shown) a good view into the work space 18. Below the glass pane 20 there is an elongated slot-like work opening 22, through which the operator can insert his forearms and hands into the work space 18 for handling the work substances.

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The upper part 14 of the housing 16 contains, among other things, a blower 24, two HEPA filters 26 and 28 arranged above the work space 18, and six HEPA filters 30 arranged below the work space 18.

30 To prevent the work substances in the work space 18 from escaping into the environment through the work opening 22, a channel-shaped suction opening 32 is arranged on the lower side of the work space 18 directly behind the work opening 22, which, like the glass pane 20 and the work opening 22, extends substantially across the entire width of the safety cabinet 10. The suction opening 32, as well as other suction openings (not shown) arranged on the

floor of the work space 18, is connected by a plenum 34 to the inlet or raw air side 36 of the HEPA-Filter 30, the outlet or clean air side 38 of which is connected to the suction side of the blower 24 by a suction channel 40 at the rear of the housing 16. The blower 24 creates a slight negative pressure in the plenum 34 through the filters 30, whereby air from the surroundings and from the work space 18 is sucked through the work opening 22 into the channel-shaped suction opening 32, as shown by the arrows A in Fig. 1.

The aspirated air then flows through the filters 30 and the suction duct 40 to the blower 24. From there, part of the air is blown through the HEPA-Filter 26 from above into the work space 18, where the air flows down along the glass pane 20, as shown by the arrows B in Fig. 1. Another part of the air is discharged from the upper part 14 of the safety cabinet 10 through an exhaust air connection 39 located above the blower 24 and the HEPA-Filter 28 on the upper side of the upper part 14, as shown by the arrows C in Fig. 1.

As best illustrated in Figs. 2 and 3, the HEPA filters 30 are cartridge filters arranged side by side in a filter housing 44 with a wedge-shaped cross-section, which extends over the entire width of the safety cabinet 10. The filter housing 44 is bordered towards the plenum 34 by an inclined partition wall 42 with six circular openings. A replaceable filter cartridge 46 is inserted into each of the openings from above, which projects diagonally downwards into an interior space of the filter housing 40 communicating with the suction duct 40.

As best illustrated in Fig. 6, each filter cartridge 46 consists of a hollow cylindrical filter body 48, an open cover 50 attached to the upper end of the filter body 48, a flat sealing element 52 disposed between the filter body 48 and the cover 50, and a closed cover 54 attached to the lower end of the filter body 48.

The filter body 48 consists of a zigzag-folded filter material that is formed into a hollow cylinder and surrounds a cylindrical interior space 56. The ends of the filter material parallel to the fold are tightly joined together along a longitudinal adhesion seam. The opposite ends of the filter body 48 are air-tightly sealed with the open cover 50 and the sealing element 52 on the one hand and the closed cover 54 on the other.

The open cover 50, made of thermoplastic material, is designed in one piece and is provided with an integrated edge flange 60 on its side facing the filter body 48. The flat edge flange 60

perpendicular to a longitudinal centre axis 66 of the filter cartridge 46 and the filter body 48 has a square outer contour. A hollow annular projection 64 projects over the upper side of the edge flange 60 facing away from the filter body 48 and surrounds an inflow opening 70 coaxial to the longitudinal centre axis 66. After installation of the filter cartridge 46, when the safety cabinet 10 is in operation, the raw air flows through the inflow opening 70 from the plenum 34 into the interior space 56 of the filter body 48.

The inflow opening 70 has a rotationally symmetrical boundary surface coaxial to the longitudinal centre axis 66. The boundary surface consists of three partial surfaces disposed one behind the other in the direction of flow. The first partial surface is inclined at an angle of about 30 degrees and the second partial surface at an angle of about 45 degrees to a plane parallel to the edge flange 60, so that the angle of inclination of the partial surfaces increases in the direction of air flow through the inflow opening 70.

As best illustrated in Figs. 2, 3 and 4, the edge flange 60 or the flat sealing element 52 disposed under the edge flange 60 lie against the flat partition wall 42 from above after the filter cartridge 46 has been installed. To fasten and seal the filter cartridge 46, the edge flange 60 is screwed from above to the partition wall 24 with four screws (not shown) passing through the sealing element 52. For this purpose, the sealing element 52 has a passage opening 80 in each of its four corners for one of the fastening screws of the edge flange 60.

As best illustrated in Figs. 4, 6 and 7, the inflow opening 70 bordered by the projection 64 has a flow cross-section that decreases towards the interior space 56, so that the raw air is accelerated as it enters the filter cartridge 46 while passing through the inflow opening 70. The height of the projection 64 and thus the length of the tapered nozzle-like inflow opening 70 is less than one tenth of the length of the filter cartridge 46 and is therefore relatively small. The flow cross section at the upper or outer end of the tapered inflow opening 70 is more than twice as large as the smallest flow cross section at the lower or inner end of the inflow opening 70, so that the incoming air is strongly accelerated over a short distance.

The lower or inner end of the inflow opening 70 is bordered by a short ring-shaped hollow cylindrical web 72, which forms the third part of the surface. The web 72 projects slightly into the interior space 56 of the filter body 48 and forms the inner boundary of a flat groove 74 on the side of the open cover 50 or filter element 52 facing the filter body 48, in which the upper

front end of the filter body 48 is cast. The upper boundary 76 of the groove 74 is formed by the sealing element 52, while the outer boundary of the groove 74 is formed by a short annular web 62 (Fig. 7) projecting beyond the lower side of the sealing element 52.

- 5 Alternatively, the cover 50 and the sealing element 52 can be manufactured in one piece as an integral component, in which case the groove 74 is bordered at the top by a closed lower of the hollow projection 64, while its inner and outer borders are formed by short annular ridges which project downward beyond the closed lower of the hollow projection 64.
- 10 On the lower side of the sealing element 52 there is a flat seal made of a foam material (not shown), which, like the edge flange 60, has a square outer contour and a circular inner passage opening, the inner diameter of which is slightly larger than the outer diameter of the filter body 48.
- 15 The closed cover 54 at the lower end of the filter body 48 is also made of a thermoplastic material. As best illustrated in Fig. 6, the one-piece cover 54 comprises a hollow cylindrical outer peripheral edge 82 projecting towards the filter body 48 and having an inner diameter corresponding to the outer diameter of the filter body 48, an annular flat bottom part 84 inwardly adjoining the peripheral edge 82 and forming a contact surface for the lower end
- 20 face of the filter body 48 which is cast with the cover 54, as well as a central conical projection 86 which tapers towards the inflow opening 70 and which protrudes a little into the interior space 56 of the filter body 48.

- The conical projection 86 has on its inner side an inflow surface 90 facing the inflow opening
- 25 70, which is inclined at an angle of about 45 degrees with respect to the ring-shaped flat bottom part 84 and also with respect to the longitudinal centre axis 66 and is symmetrical to the longitudinal centre axis 66. The diameter at the base of the conical projection 86 is slightly smaller than the internal diameter of the filter body 48, so that some of the incoming air can pass along the projection 86 to the lower end of the filter body 48. The tip of the
- 30 conical projection 86 can be slightly rounded, as shown in Fig. 7. The height of the projection 86 is approximately one sixth to one seventh of the length of the filter body 48.

The wall thickness of the closed cover 54 is the same over its entire diameter, so that the closed cover 54 has a conical depression (not visible) on the outer or lower side of the filter cartridge 46 corresponding to the projection 86.

- 5 In contrast to the filter cartridge 46 in Figs. 4 to 7, the projection 92 projecting into the interior space 56 of the filter cartridge 46 in Fig. 8 has the shape of a hemisphere with its pole facing the inflow opening 70 and its equator adjoining the annular flat bottom part 84. The height of the projection 92 and the diameter at its base correspond to those of the projection 86 in Figures 6 and 7.

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- In the filter cartridge in Fig. 9, the projection 94 is conical like the projection 46 in Fig. 7, but projects considerably further into the interior space 56, its height being about seven tenths of the length of the filter body 48. The inclination of the inflow surface 90 on the inner side of the projection 94 is therefore steeper than that of the filter cartridge 46 in Fig. 7, wherein the angle of inclination is about 80 degrees in relation to the ring-shaped flat bottom part 84. The tip of the projection 94 is slightly convexly rounded.

15

- In the case of the filter cartridge 46 in Fig. 10, the closed cover 54 does not have an inwardly protruding projection, but is level and perpendicular to the longitudinal central axis 66 of the filter cartridge 46. In the case of the filter cartridges 46 in Figs. 8 to 10, the open cover 50 has the same nozzle-like inflow opening 70 as in the filter cartridge 46 in Figs. 4 to 7.

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- In comparison with a filter cartridge with a flat open cover and a flat closed cover perpendicular to the longitudinal central axis, according to EP 1 312 871 B1, flow and pressure measurements on the filter cartridges 46 shown in the drawing showed that the flow rate of the air flowing through the filter body 48 could be reduced respectively by about 15% in the case of the filter cartridges 46 in Figs. 7 and 8 and respectively by about 5 to 6% in the case of the filter cartridges 46.

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- 30 In flow and pressure measurements on the two filter cartridges 46 shown in Figs. 9 and 10, the pressure difference between the inflow side 36 and the outflow side 38 was reduced by about 5% compared to a filter cartridge according to EP 1 312 871 B1 without changes to the filter material.

While in the case of a filter cartridge according to EP 1 312 871 BI traversed by air, extreme turbulence was observed in the interior space of the filter body with the aid of small balls of polystyrene previously inserted into the filter cartridge in the form of a strong whirling of the polystyrene balls and even occasionally an escape of individual polystyrene balls from the filter cartridge, the whirling was already significantly reduced in the filter cartridge 46 from Fig. 10. The polystyrene balls were only swirled in the lower third of the filter cartridge 46. An escape of polystyrene balls from the filter cartridge 46 could not be observed there. In the filter cartridges 46 in Figures 7 to 9, no swirling of the polystyrene balls was observed.

10 In order to prevent damage to the zigzag-folded and hollow cylinder-shaped filter material of the filter body 48 when handling the filter cartridge 46, the filter cartridge 46 shown in Fig. 11 is additionally provided with an air-permeable grip protection 96 designed as a perforated cylinder, which surrounds the filter body 48 at a small distance from its outer circumference. The opposite ends of the grip protection 96 are cast together with the respective adjacent front
15 end of the filter body 48 in the groove 74 of the cover 50 or in the cover 54 and are thus firmly connected to the two covers 50, 54. The grip protection 96 consists of a thin-walled thermoplastic material, but can also be made of a thin metal sheet.

PATENTKRAV

1. Filterpatron (46) til et sikkerhedsarbejdsbord (10), med et hult cylindrisk filterlegeme (48) af et filtermateriale, som omgiver et indvendigt rum (56) i radial retning, et åbent dæksel (50) fastgjort på en ende af filterlegemet (48), som omgiver en indløbsåbning (70), der munder ud
5 i det indvendige rum (56), og et lukket dæksel (54) anbragt i den modsatte ende af filterlegemet (48), hvor der på det lukkede dæksel (54) rager et fremspring (86; 92; 94) ind i det indvendige rum (56), som smaller ind mod indløbsåbningen (70) og har en strømningsflade (90) vendt mod indløbsåbningen (70), hvilken strømningsflade er koaksial og rotationssymmetrisk i forhold til en langsgående midterakse (66) på filterpatronen
10 (46), **kendetegnet ved, at** fremspringet (86; 92; 94) har form af en kegle med en spids eller en let afrundet spids eller har form af en halvkugle.
2. Filterpatron ifølge krav 1, **kendetegnet ved, at** indløbsåbningen (70) har et dyselignende strømningstværsnit, som aftager i retning mod det indvendige rum (56).
15
3. Filterpatron ifølge krav 2, **kendetegnet ved, at** indløbsåbningens (70) strømningstværsnit, som aftager, er anbragt uden for filterlegemet (48).
4. Filterpatron ifølge krav 1, 2 eller 3, **kendetegnet ved, at** indløbsåbningen (70) har en
20 begrænsningsflade, som er koaksial og rotationssymmetrisk i forhold til filterpatronens (46) langsgående midterakse (66), og hvis hældningsvinkel tiltager i luftens strømningsretning gennem indløbsåbningen (70).
5. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** det åbne dæksel (50) er
25 udformet i ét stykke eller i flere dele af et termoplastisk kunstmateriale.
6. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** det åbne dæksel (50) har en kantflange (60), der rager ud over filterlegemets (48) ydre omkreds, og et ringformet fremspring (64), der omgiver indløbsåbningen (70) og rager aksialt ud over den side af
30 kantflangen (60), som vender væk fra filterlegemet (48).
7. Filterpatron ifølge krav 6, **kendetegnet ved, at** det ringformede fremspring (64) er hult.

8. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** indløbsåbningen (70) i sin indvendige ende begrænses af en hul cylindrisk kant (72), som rager en smule ind i filterlegemets (48) indre og begrænser en flad not (74), som er åben mod filterlegemet (48), og i hvilken den tilstødende frontende af filterlegemet (48) er støbt.

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9. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** forholdet mellem det mindste strømningstværsnit i en indvendig ende af indløbsåbningen (70) og det største strømningstværsnit i en udvendig ende af indløbsåbningen (70) er mindre end 0,75 og foretrukket mindre end 0,5.

10

10. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** den udvendige diameter af strømningsfladen (90) ved en fod af fremspringet (86; 92; 94), som vender væk fra indløbsåbningen (70), er lidt mindre end filterlegemets (48) indvendige diameter.

15 11. Filterpatron ifølge et af de foregående krav, **kendetegnet ved, at** fremspringets (86; 92) højde er mindre end en fjerdedel af filterlegemets (48) aksiale længde.

12. Filterpatron ifølge et af de foregående krav, **kendetegnet ved** en luftgennemtrængelig indgrebsbeskyttelse (96), som omgiver filterlegemet (48).

20

13. Sikkerhedsarbejdsbord med mindst en filterpatron (46) ifølge et af de foregående krav.

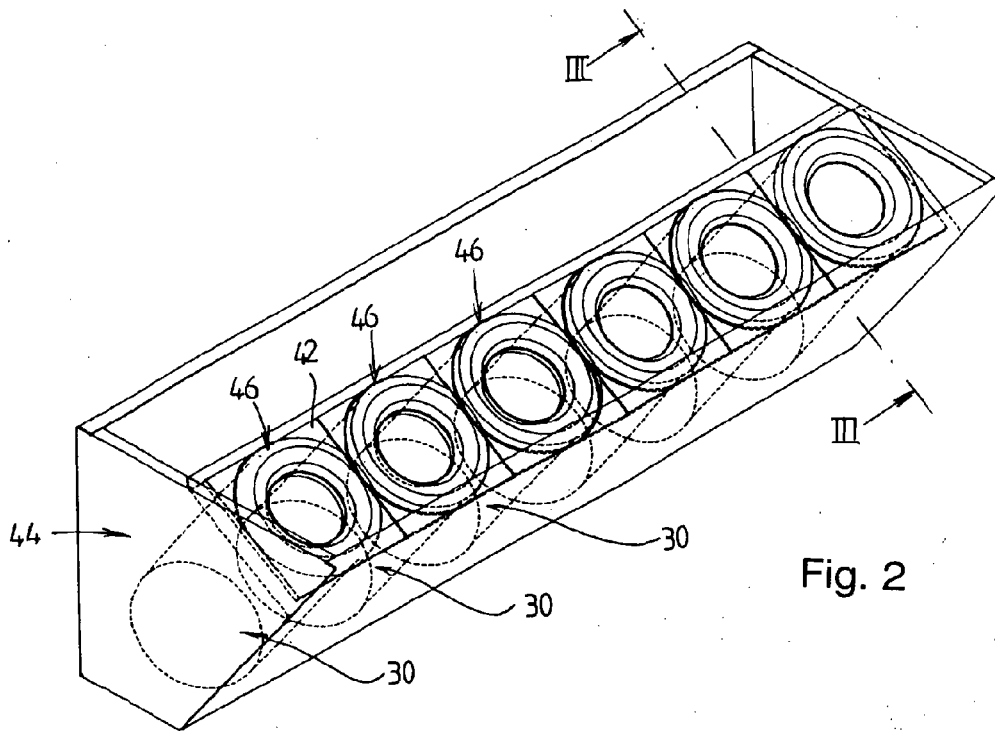


Fig. 2

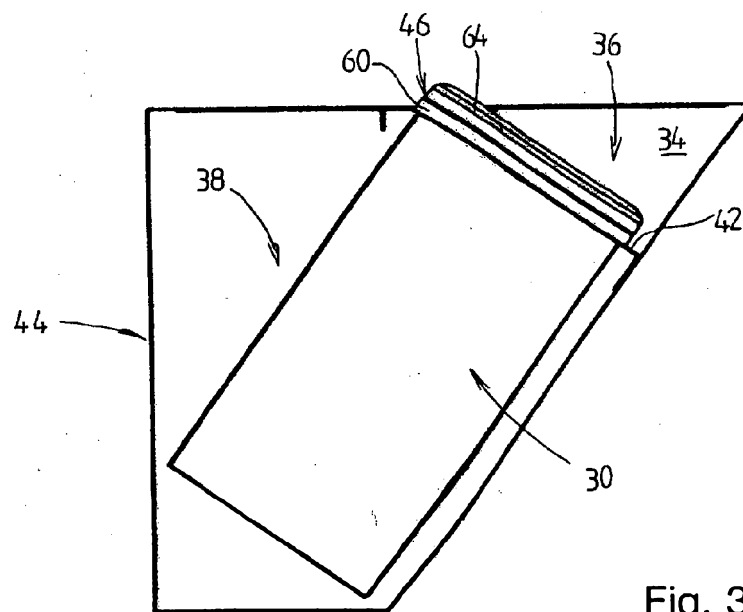


Fig. 3

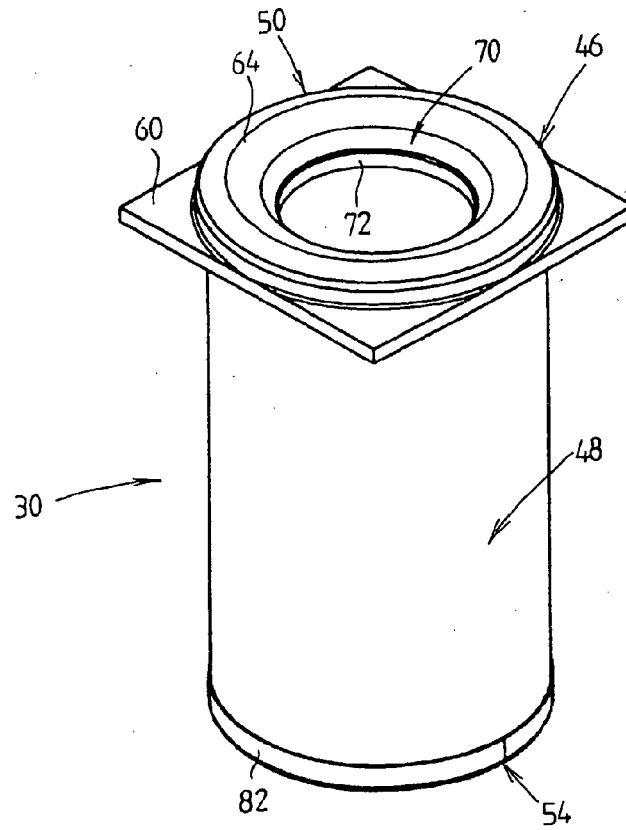


Fig. 4

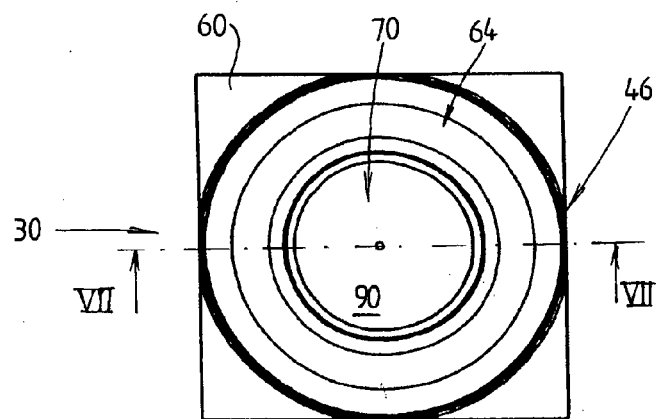


Fig. 5

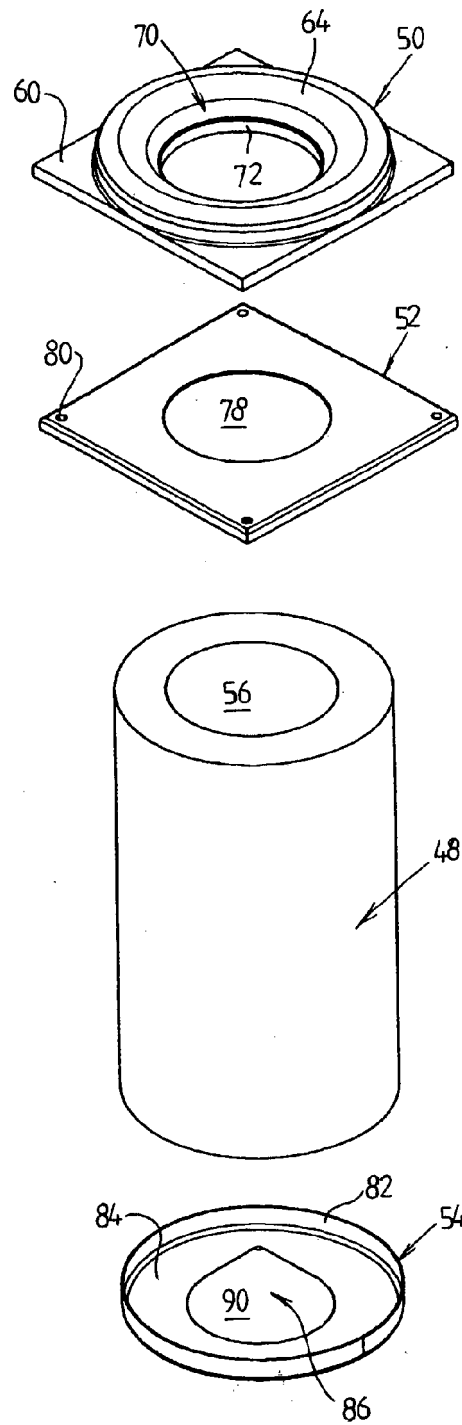
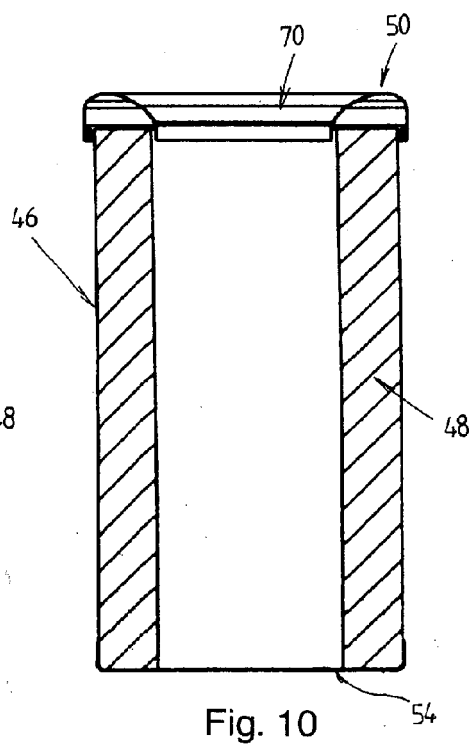
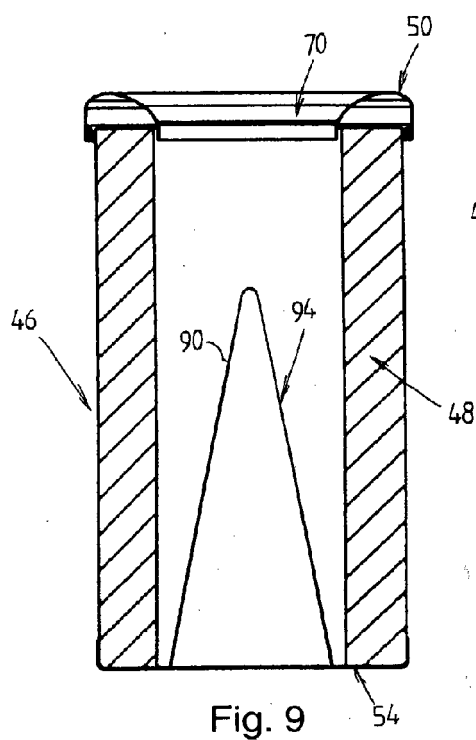
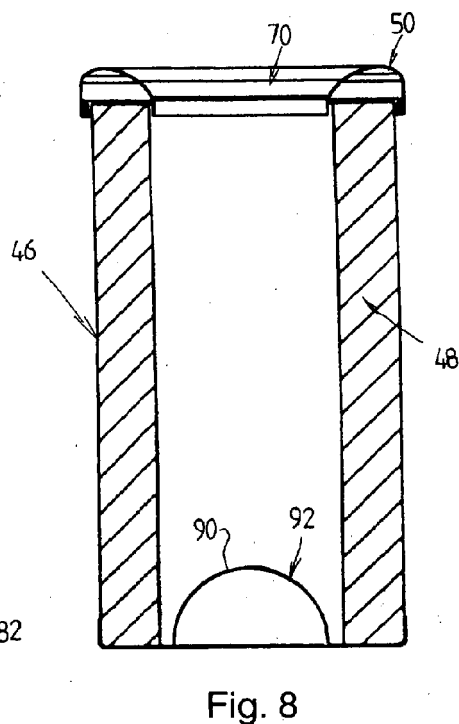
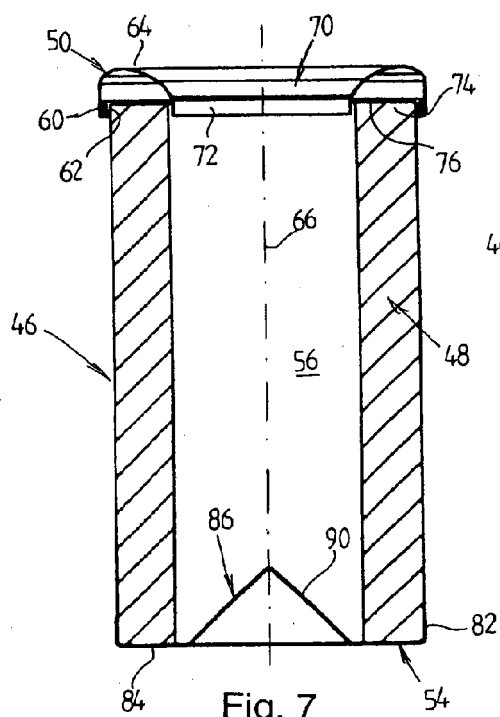


Fig. 6



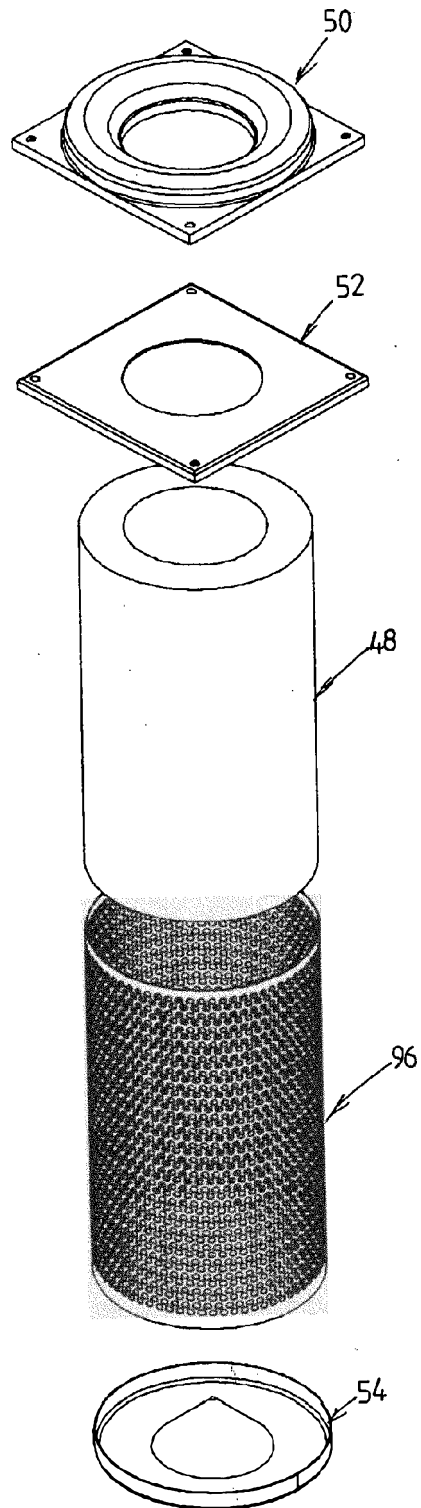


Fig. 11