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(54) FILTERING DEVICE FOR THE AIR TAKEN IN BY AN INTERNAL COMBUSTION ENGINE WITH RESIDUAL WATER DRAINAGE

(57) Filtering device (1) for the air taken in by an internal combustion engine; the filtering device (1) having: an air-box (2) that defines inside it a cavity and has at least an inlet opening (3) toward the external environment and at least an outlet opening toward an engine intake system (4); at least a filter (5), which is housed inside the air-box (2); a drainage through-hole (10), which is formed through a lower wall (8) of the air-box (2) and allows the drainage of any residual water inside the air-box (2); and a valve (11) which is coupled to the drainage hole (10) and is movable between a closed position, where it closes the drainage hole (10), and an open position, where it lets the drainage hole (10) free.

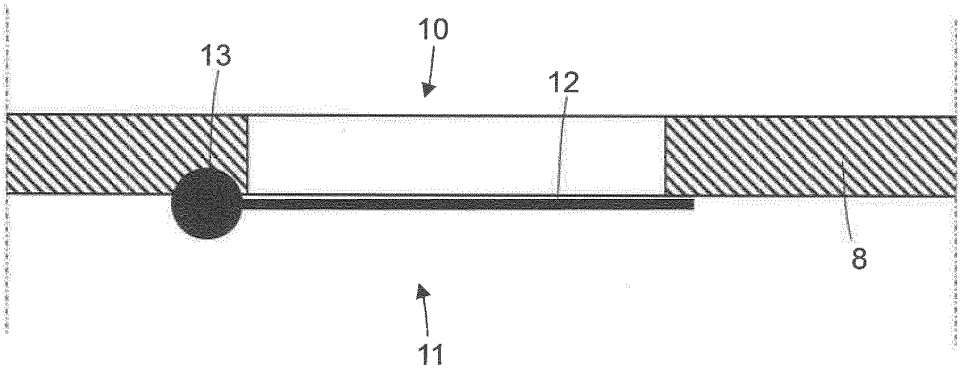

Fig.2

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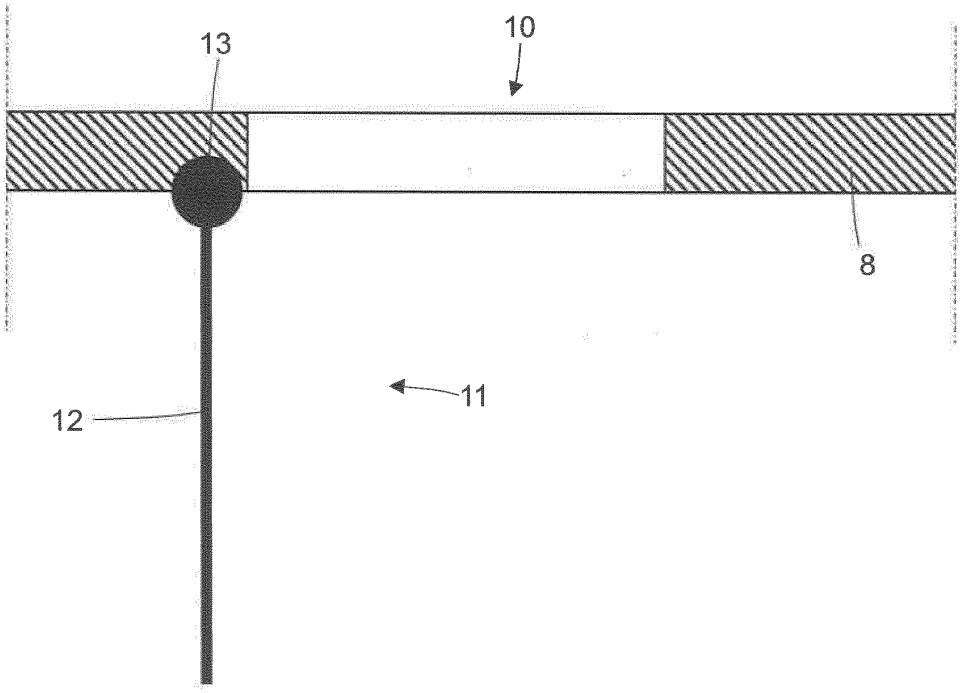


Fig.3

Description

TECHNICAL FIELD

[0001] The present invention relates to a filtering device for the air taken in by an internal combustion engine.

PRIOR ART

[0002] A filtering device for the air taken in by an internal combustion engine comprises an air-box, usually made of plastic material, which houses an internal filter; the filter divides the air-box in an inlet chamber, which is arranged upstream of the filter and communicates with the external environment through an inlet opening, and an outlet chamber, which is arranged downstream of the filter and communicates with the engine intake system through an outlet opening. A lower wall of the air-box at the inlet chamber has a drainage through-hole for the drainage of any residual water inside the air-box (both due to the condensation of the moisture of the air taken in and to the direct entry of raindrops).

[0003] To increase the maximum range of air which can be taken in by the internal combustion engine when the vehicle is in motion, the air inlet collecting the air that is fed to the inlet opening is arranged at the front of the vehicle; in this way, when the vehicle is in motion, the air pressure against the air inlet generates an overpressure inside the air-box; the higher the vehicle speed, the greater the overpressure. This overpressure inside the air-box increases the filling of the cylinders of the internal combustion engine and therefore increases the power generated by the internal combustion engine. The drainage hole puts in direct communication the inlet chamber of the air-box with the external environment, thus determining a decrease of the pressurization inside the air-box when the motion of the vehicle pressurizes the air-box. The drainage hole may be provided with an elastic duct, which is normally closed or semiclosed and at the same time allows the (slow) descent by gravity of water to reduce the negative effect of the drainage hole on the pressurization inside the air-box. In other words, the elastic duct constitutes a passive valve which is normally closed and is controlled by the water pressure that builds up in the elastic duct (namely when the amount of water collected in the elastic duct is relatively large, it exerts a sufficient thrust by gravity to open the elastic duct and allow the water outlet); the patent applications DE19737545A1, FR2857058A1, FR2862576A1 and DE10200673A1 describe some examples of air-boxes provided with a drainage hole equipped with an elastic duct (namely, equipped with a passive valve which is normally closed and is controlled by the water pressure that builds up). However, such elastic duct has various drawbacks, as it cannot seal the drainage hole (which then always causes a pressurization decrease inside the air-box), can be easily clogged, thus hindering the residual water drainage (or making completely ineffective the drainage hole), and in time tends to lose elasticity, thus causing a progressive deterioration of its functionality.

DESCRIPTION OF INVENTION

[0004] The object of the present invention is to provide a filtering device for the air taken in by an internal combustion engine, such filtering device being free from the aforesaid drawbacks and being at the same time easy and economical to manufacture.

[0005] According to the present invention, it is provided a filtering device for the air taken in by an internal combustion engine, as claimed by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention will now be described with reference to the accompanying drawings showing a non-limiting embodiment, in which:

- Figure 1 is a schematic, cross-section view of a filtering device for the air taken in by an internal combustion engine made in accordance with the present invention;
- Figures 2 and 3 are two schematic, cross-section views, on an enlarged scale, of a drainage hole provided with a valve of the filtering device of Figure 1; and
- Figure 4 is a schematic, plan view of the valve of Figures 2 and 3.

PREFERRED EMBODIMENTS OF THE INVENTION

[0007] In Figure 1, number 1 indicates in its entirety a filtering device for an intake system of an internal combustion engine (shown schematically in Figure 4) of a vehicle (shown schematically in Figure 4); namely, the filtering device 1 filters the air taken in by the internal combustion engine.

[0008] The filtering device 1 comprises an air-box 2, which has inside it a cavity having (at least) an inlet opening 3 toward the external environment and (at least) an outlet opening 4 toward the intake system of the internal combustion engine. Furthermore, the filtering device 1 comprises (at least) a filter 5 that is housed inside the air-box 2, is arranged between the inlet opening 3 and the outlet opening 4 and divides the cavity in an inlet chamber 6, which is arranged upstream of the filter 5 and communicates with the external environment through the inlet opening 3, and an outlet chamber 7, which is arranged downstream of the filter 5 and communicates with the intake system of the internal combustion engine through the outlet opening 4.

[0009] In the shown embodiment, the filter 5 has a parallelepiped shape, but according to other and completely equivalent embodiments, the filter 5 may have a different shape (for example a tubular cylindrical or truncated-conical shape). By way of example, the filtering material of

the filter 5 may be made of fabric or non-woven fabric of cotton or other fibres enclosed between two layers of thin metallic net, conferring shape and strength to the filtering material.

[0010] In the embodiment shown in the accompanying figures, the air-box 2 is cup-shaped and has a lower wall 8 and an open upper end opposite to the lower wall 8. Furthermore, the air-box 2 is provided with a removable lid 9 (typically screwed to side walls of the air-box 2) that closes the open upper end, thus forming an upper wall of the air-box 2.

[0011] According to a preferred embodiment, the inlet opening 3 receives the air from a dynamic air inlet formed through a front or side wall of the vehicle; in this way, when the vehicle is in motion, the air pressure against the front or side wall of the vehicle generates an overpressure inside the cavity of the air-box 2; the higher the vehicle speed, the greater the overpressure. This overpressure inside the cavity of the air-box 2 increases the filling of the cylinders of the engine, and therefore increases the power generated by the engine.

[0012] The lower wall 8 of the air-box 2 which inferiorly delimits the cavity has (at least) a drainage through-hole 10 for the drainage of any residual water inside the cavity of the air-box 2 (both due to the condensation of the moisture of the air taken in and to the direct entry of raindrops). Preferably (but not necessarily), the lower wall 8 of the air-box 2 has a slope converging toward the drainage hole 10; in other words, the drainage hole is arranged at the lowest point of the whole lower wall 8 of the air-box 2 so that any residual water inside the air-box 2 flows by gravity toward the drainage hole 10.

[0013] As shown in Figures 2 and 3, it is provided a valve 11 which is coupled to the drainage hole 10 and is movable between a closed position (shown in Figure 2), where it closes (seals) the drainage hole 10 not to jeopardize the pneumatic sealing of the air-box 2, and an open position (shown in Figure 3), where it lets the drainage hole 10 free to allow the drainage of any residual water inside the air-box 2. The valve 11 comprises a shutter 12, which moves to close (seal) the drainage hole 10 (Figure 2) or to let the drainage hole 10 free (Figure 3). As shown in Figure 4, the valve 11 comprises a shaft 13, which is rotatably mounted to rotate about the axis of rotation 14 and supports the shutter 12, and an actuator 15, which is mechanically connected to the shaft 13 to rotate the shaft 13 around the axis of rotation 14. A spring 16 is mechanically coupled to the shaft 13 and pushes the shaft 13 toward the closed position (shown in Figure 2); in this way, the valve 11 is normally closed (i.e. when the actuator 15 is not activated, the valve is closed by the thrust of the spring 16) and opens only when the actuator 15 is activated to rotate the shaft 13 against the elastic force generated by the spring 16.

[0014] As shown in Figure 4, it is provided an electronic control unit 17, which drives (turns on) the actuator 15 to control the opening of the valve 11.

[0015] According to a possible (but not limiting) embodiment, the control unit 17 opens the valve 11 at regular intervals and at each opening it keeps the valve 11 open only for a short time lapse (much shorter than the time lapse between a valve opening 11 and the subsequent opening); for example, the control unit 17 opens the valve 11 every 10-20 minutes for a few seconds (enough to guarantee the drainage of any residual water inside the air-box 2). In this way, a regular drainage of any residual water inside the air-box 2 is guaranteed with no substantial disadvantage in the performance of the internal combustion engine.

[0016] According to a possible (but not limiting) embodiment, the control unit 17 opens the valve 11 only when the internal combustion engine generates a limited power (namely remarkably lower than the maximum power), not to jeopardize the performance of the internal combustion engine exactly when the maximum performance is required to the internal combustion engine. For example, the control unit 17 opens the valve 11 only when the rotation speed of the internal combustion engine is lower than a first threshold and/or when the load of the internal combustion engine is lower than a second threshold.

[0017] The control unit 17 opens the valve 11 only when a rain sensor 18 of the vehicle detects the presence of rain (the rain sensor 18 is usually an optical sensor and is coupled to the vehicle windshield). In particular, when the rain sensor 18 detects the presence of rain, the control unit 17 may keep the valve 11 always open or may increase the opening frequency and/or duration of the valve 11. For example, in the absence of rain, the control unit 17 opens the valve 11 for a few seconds every 20-30 minutes, while in the presence of rain the control unit 17 opens the valve 11 for several seconds every 3-8 minutes. If the vehicle is not equipped with a rain sensor 18, the control device 19 of the windshield wiper may be used instead of the rain sensor 18 (i.e. when the windshield wiper is switched on, then it is inferred the presence of rain).

[0018] According to a possible (but not limiting) embodiment, the control unit 17 determines the opening of the valve 11 also depending on the position of a vehicle "*knob*", namely a selector set by the driver according to the desired driving mode; in particular, the control unit 17 increases the opening frequency and/or duration of the valve 11 when the vehicle "*knob*" requires a *"wet driving mode".*

[0019] According to a possible (but not limiting) embodiment, the control unit 17 opens the valve 11 for a few moments at each shutdown and/or ignition of the internal combustion engine; in other words, as a precaution, each time the internal combustion engine is switched off and/or switched on, the control unit 17 shortly opens the valve 11 to allow the drainage of any residual water which has not been previously evacuated.

[0020] According to other perfectly equivalent embodiments, the shutter 12 may have a circular or a semicircular shape; alternatively, it may be provided with two adjacent shutters, having e.g. a semicircular shape. Ac-

cording to other perfectly equivalent embodiments, the shutter 12 may have a linear movement instead of a rotary movement.

[0021] The aforesaid filtering device 1 has numerous advantages. First, the aforesaid filtering device 1 allows an effective and efficient drainage of any residual water inside the air-box 2, at the same time not jeopardizing the performance of the internal combustion engine. The drainage of any residual water inside the air-box 2 is particularly effective, since the drainage hole 11 can be quite large (and therefore can rapidly drain any residual water and is free from clogging) as it is normally closed by the valve 11.

[0022] Furthermore, the aforesaid filtering device 1 is easy and economical to produce, since the valve 11 and the actuator 15 are of a standard type and are commercially available at very low prices, and since the handling of the valve 11 is trivial (i.e. it has only two end positions: fully closed valve 11 and fully open valve 11).

Claims

1. A filtering device (1) for the air taken in by an internal combustion engine; the filtering device (1) comprising:

an air-box (2), which defines inside it a cavity (3) and has at least an inlet opening (3) toward the outside and at least an outlet opening (4) toward an engine intake system;
at least a filter (5), which is housed inside the air-box (2) and is arranged between the inlet opening (3) and the outlet opening (4);
a drainage through-hole (10), which is obtained through a lower wall of the air-box (2) and is designed to allow the drainage of any residual water inside the air-box (2); and
a valve (11), usually closed, which is coupled to the drainage hole (10);
the filtering device (1) being **characterized in that**:

the valve (11) comprises: a mechanical shutter (12) which is movable between a closed position, where it closes the drainage hole (10), and an open position, where it lets the drainage hole (10) free to allow the drainage of any residual water inside the air-box (2); an elastic element (16) that pushes the shutter (12) toward the closed position; and an actuator (15) which is operable to move the shutter (12) from the closed position to the open position against the elastic force generated by the spring (16); and
it is provided a control unit (17) that controls the actuator (15), is connectable to a rain sensor (18) or to a control device (19) of a windshield wiper, and sets the valve opening (11) depending on the fact that the rain sensor (18) detects the presence of rain or on the fact that the control device (19) of the windshield wiper is activated.

2. A filtering device (1) according to claim 1, wherein the control unit (17) opens the valve (11) at regular intervals, and with every opening it keeps the valve (11) open only for a limited time lapse, which is shorter than the time lapse between an opening of the valve (11) and the subsequent opening.

3. A filtering device (1) according to claim 1 or 2, wherein the control unit (17) opens the valve (11) only when the internal combustion engine generates a limited power.

4. A filtering device (1) according to claim 1, 2 or 3, wherein the control unit (17) sets the opening frequency and/or duration of the valve (11) depending on the fact that the rain sensor (18) detects the presence of rain or that the control device (19) of the windshield wiper is activated.

5. A filtering device (1) according to any one of claims 1-4, wherein the control unit (17) opens the valve (11) only when the rain sensor (18) detects the presence of rain or when the control device (19) of the windshield wiper is activated.

6. A filtering device (1) according to any one of claims 1-5, wherein:

the control unit (17) is connected to a selector, which is moved depending on the desired driving mode; and
the control unit (17) sets the opening of the valve (11) based on the position of the selector.

7. A filtering device (1) according to claim 6, wherein the control unit (17) increases the opening frequency and/or duration of the valve (11) when the selector requires a "*wet driving mode*".

8. A filtering device (1) according to any one of claims 1-7, wherein the control unit (17) opens the valve (11) for a few moments at each shutdown and/or ignition of the internal combustion engine.

9. A control method of a filtering device (1) for the air taken in by an internal combustion engine; the filtering device (1) comprising:

an air-box (2), which defines inside it a cavity and has at least an inlet opening (3) toward the external environment and at least an outlet

opening (4) toward an engine intake system;
at least a filter (5), which is housed inside the air-box (2) and is arranged between the inlet opening (3) and the outlet opening (4);
a drainage through-hole (10) which is formed through a lower wall (8) of the air-box (2) and allows the drainage of any residual water inside the air-box (2); and
a valve (11), usually closed, which is coupled to the drainage hole (10) and comprises: a mechanical shutter (12) that is movable between a closed position, where it closes the drainage hole (10), and an open position where it lets the drainage hole (10) free to allow the drainage of any residual water inside the air-box (2); an elastic element (16) that pushes the shutter (12) toward the closed position; and an actuator (15) which is operable to move the shutter (12) from the closed position to the open position against the elastic force generated by the spring (16);
the control method being **characterized in that** it comprises the steps:

detecting the presence of rain through a rain sensor (18) or detecting the activation of a control device (19) of the windshield wiper; and
setting the valve opening (11) depending on the fact that the rain sensor (18) detects the presence of rain or on the fact that the control device (19) of the windshield wiper is activated.

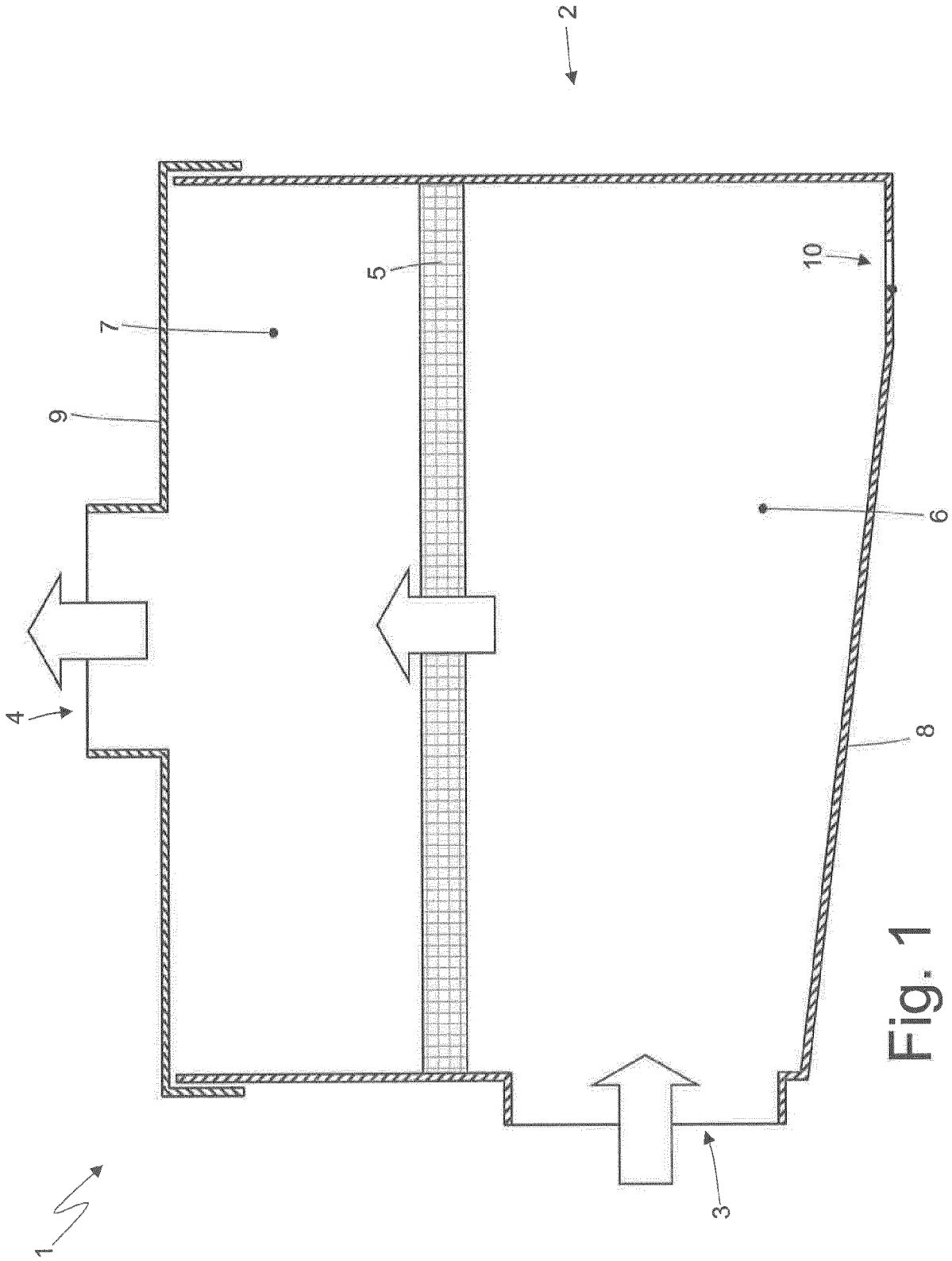


Fig. 1

Fig.2

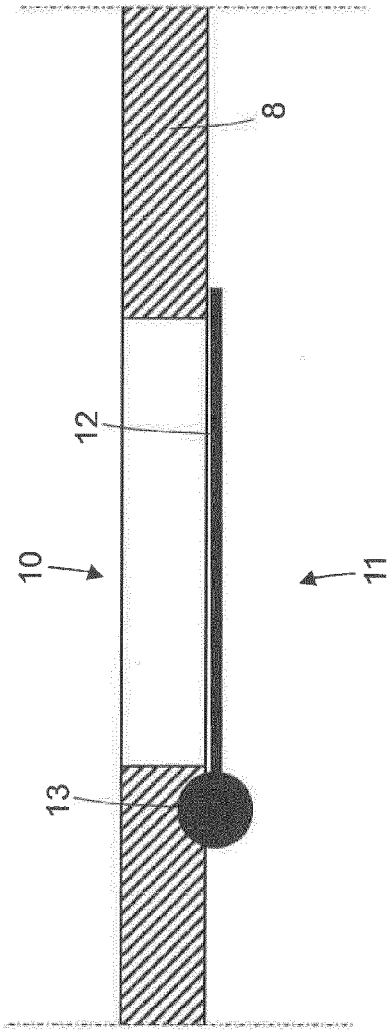
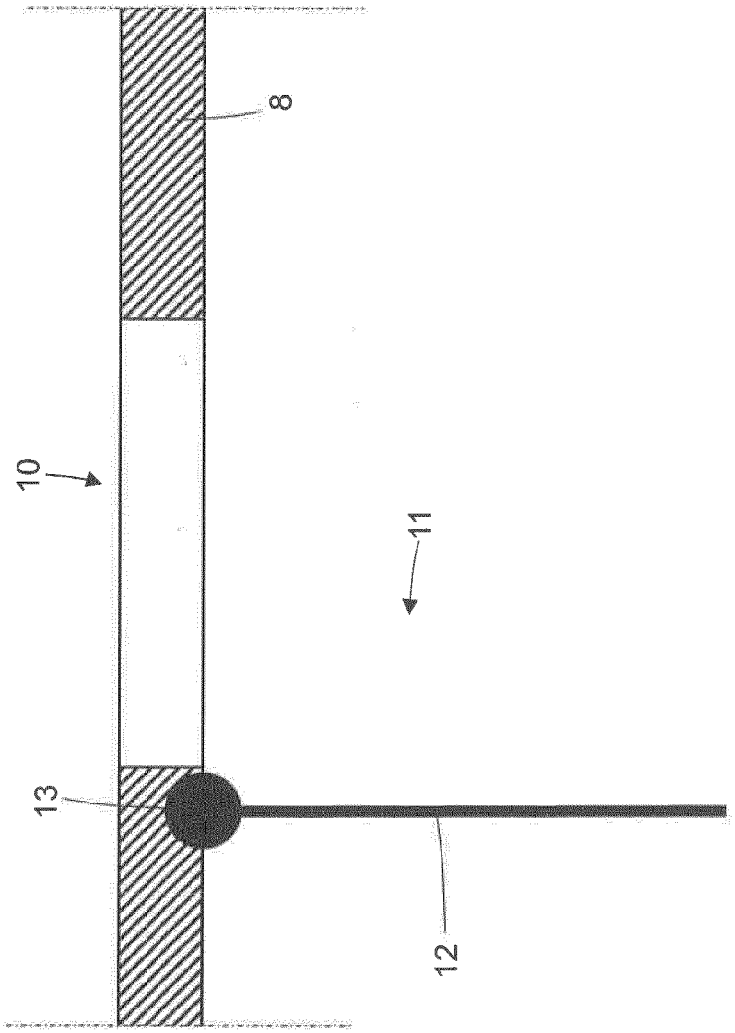


Fig.3



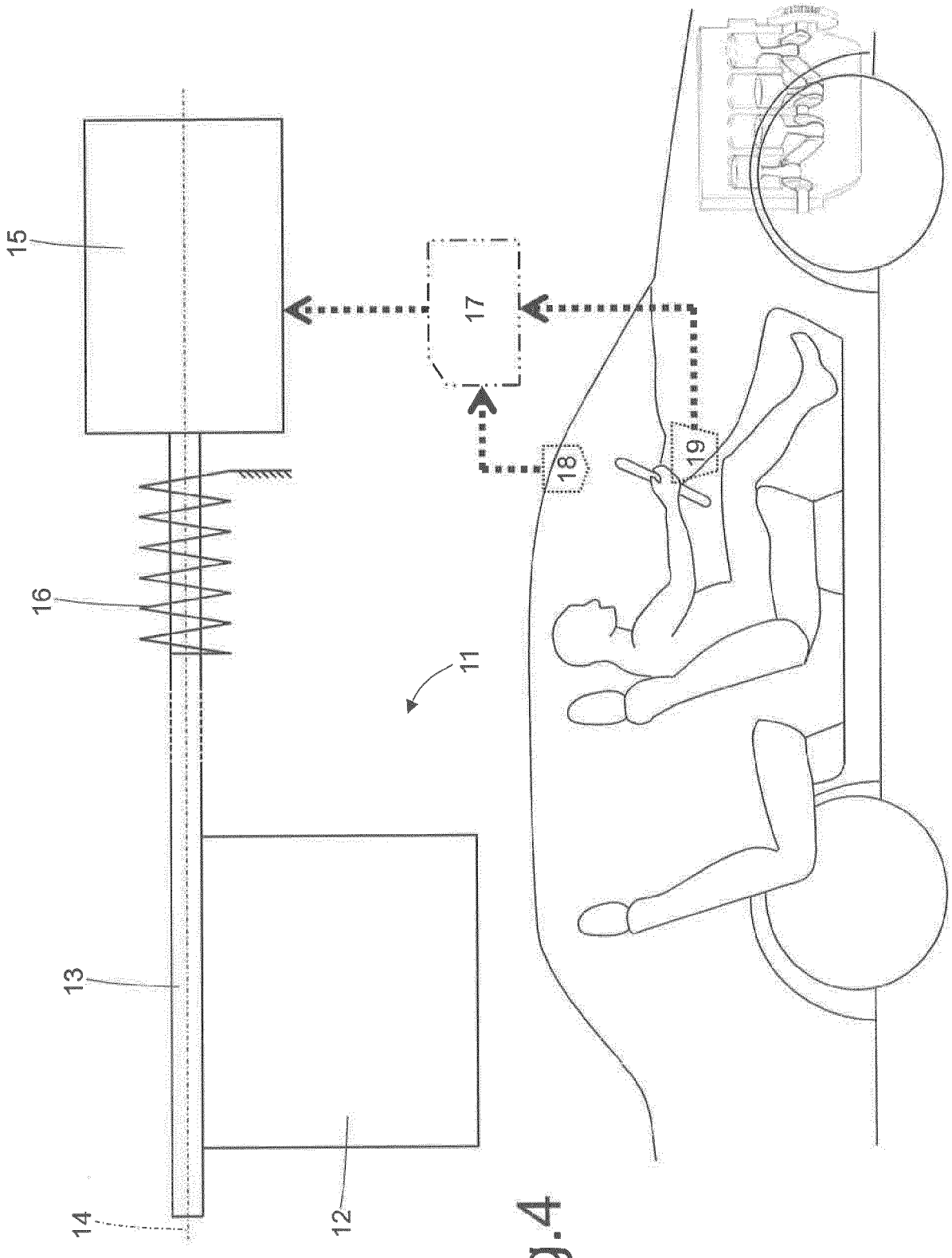


Fig.4

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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 September 2016	Marsano, Flavio

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EUROPEAN SEARCH REPORT

Application Number
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