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(54) MOTOR VEHICLE VACUUM PUMP

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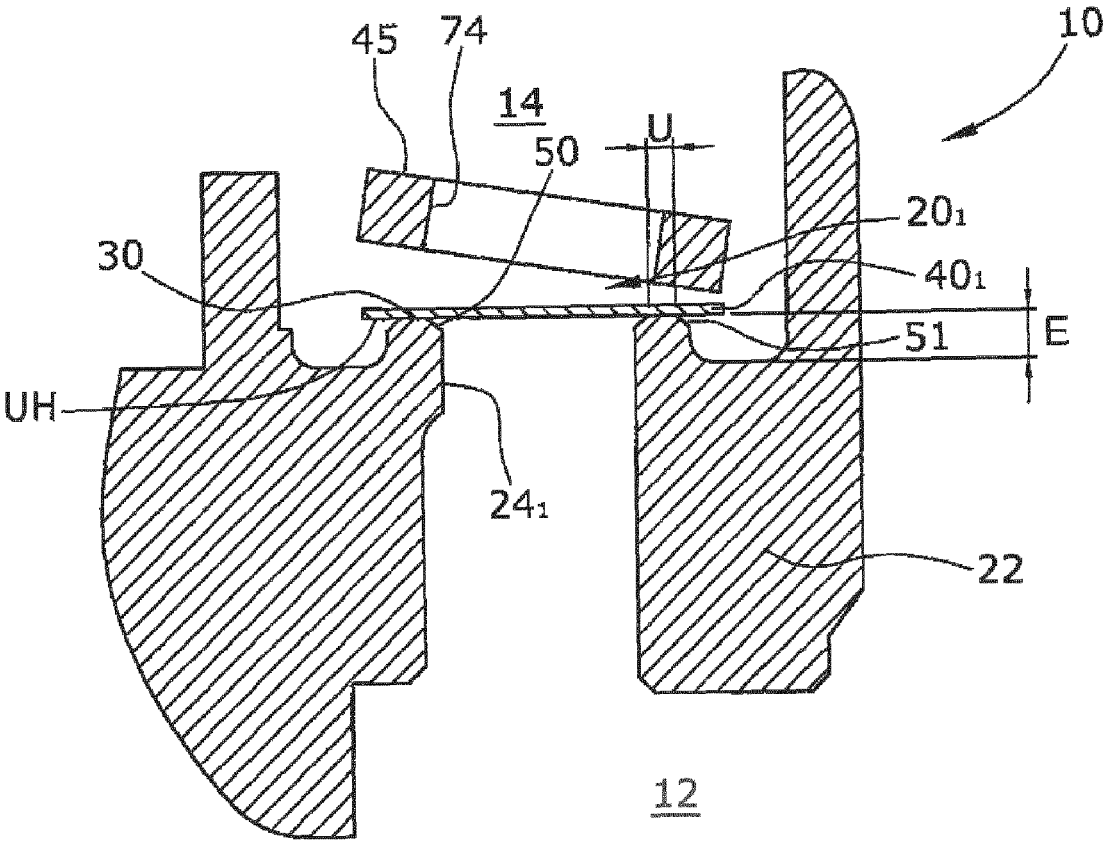
(57) **ABSTRACT**

A motor vehicle vacuum pump includes a pump chamber with a pump rotor, an outlet chamber, a separating wall which separates the pump chamber from the outlet chamber, and an outlet valve arranged in the separating wall. The outlet valve is designed so that a compressed gas escapes from the pump chamber into the outlet chamber therethrough. The outlet valve is formed by a valve opening in the separating wall, a valve seat having a raised shape arranged around the valve opening, and a leaf spring as a valve body. The leaf spring abuts on the valve seat in a closed position and is spaced from the valve seat in an open position. The leaf spring has a radial overlap with the valve seat in the closed position of less than 1.5 mm and a radial projection outward beyond the raised valve seat which is larger than 1.0 mm.



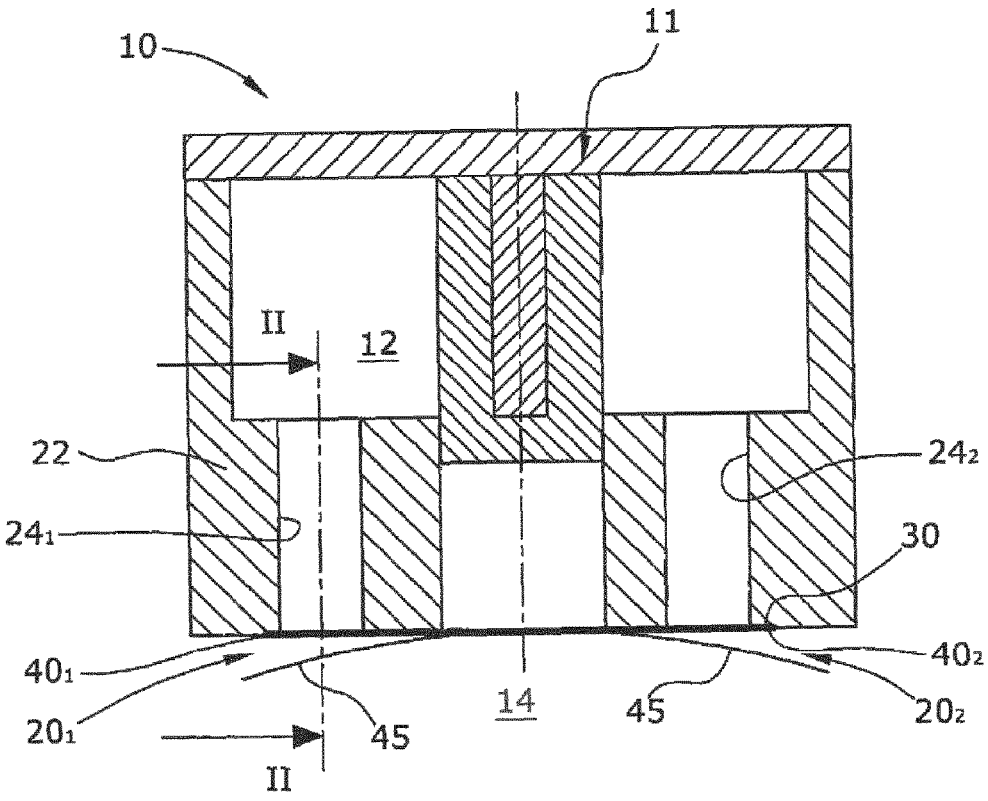


Fig. 1

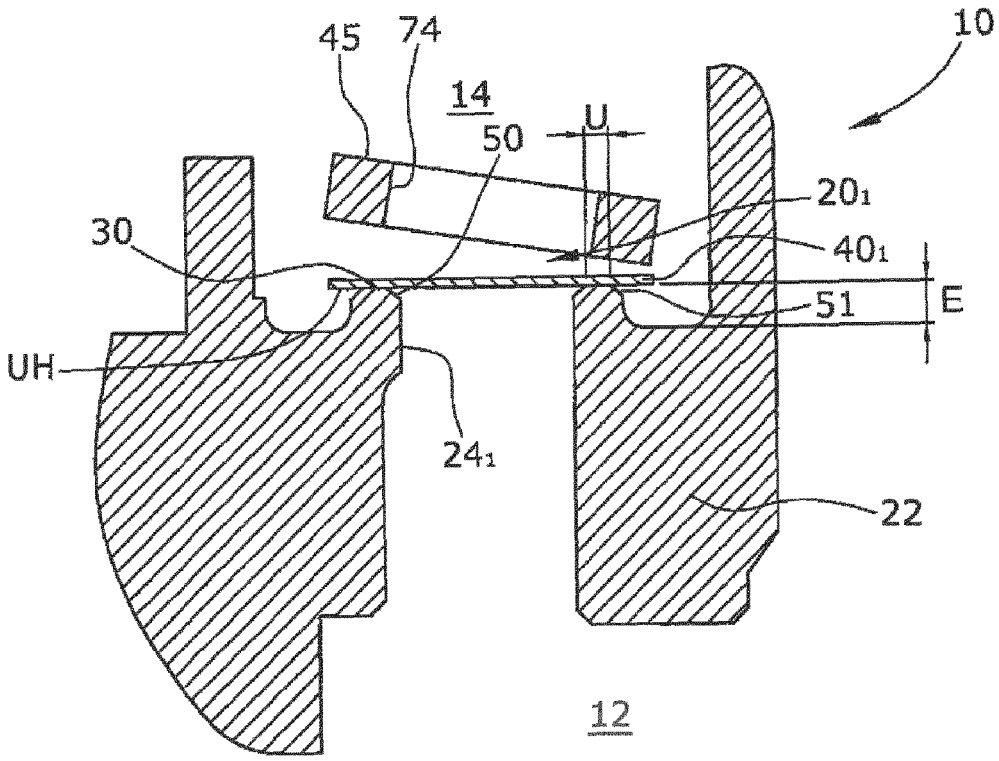


Fig. 2

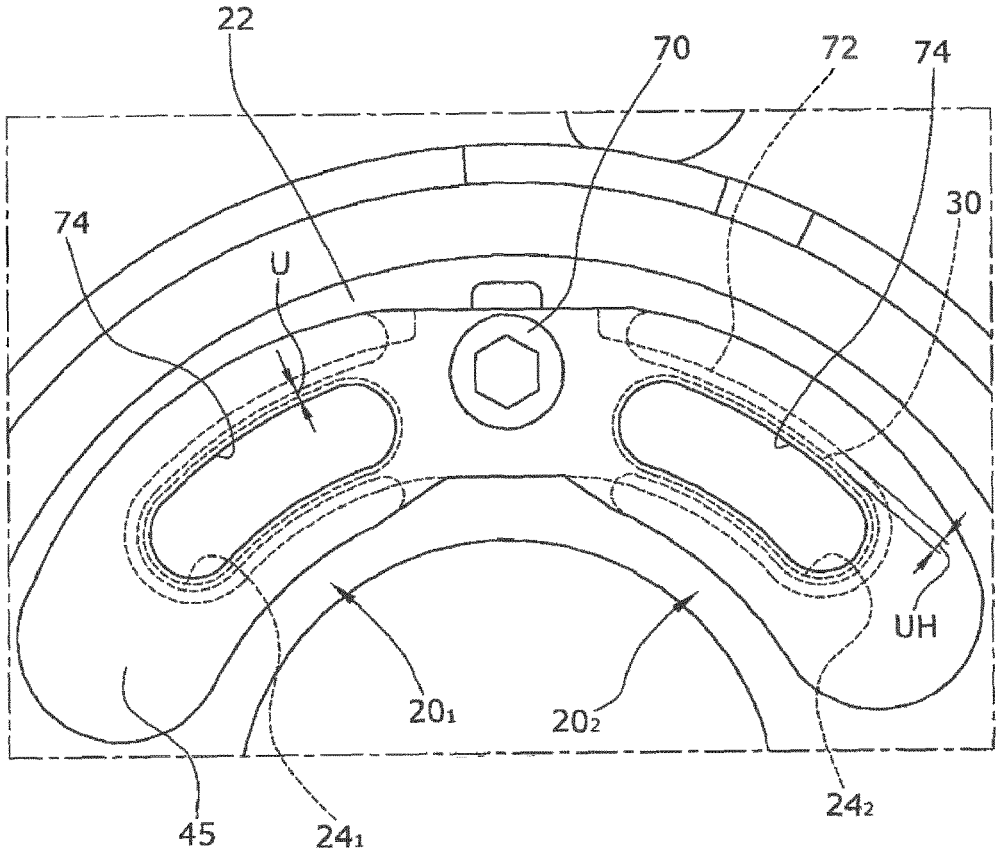


Fig. 3

MOTOR VEHICLE VACUUM PUMP

CROSS REFERENCE TO PRIOR APPLICATIONS

[0001] This application is a U.S. National Phase application under 35 U.S.C. § 371 of International Application No. PCT/EP2015/071848, filed on Sep. 23, 2015. The International Application was published in German on Mar. 30, 2017 as WO 2017/050362 A1 under PCT Article 21(2).

FIELD

[0002] The present invention relates to a motor vehicle vacuum pump comprising a pump chamber in which a pump rotor rotates in a compressing manner, and an outlet chamber into which the compressed gas escapes from the pump chamber. The vacuum pump has a separating wall which separates the pump chamber from the outlet chamber, and at least one outlet valve in the separating wall, which is designed as a check valve and through which the compressed gas escapes from the pump chamber into the outlet chamber.

BACKGROUND

[0003] Independent of the operating state of an internal combustion engine, a motor vehicle vacuum pump generates a vacuum of, for example, absolutely 100 millibar in a motor vehicle, which vacuum is required, for example, to operate a pneumatic brake booster and/or other pneumatically operated auxiliary units.

[0004] A leaf spring is often used in such a vacuum pump as the valve body for the outlet valve due to the simple structure and the reliability thereof, the leaf spring abutting, in the closed position, on a valve seat formed around the outlet opening. The outlet valve is actuated hydraulically and pneumatically. A problem with such operations is the noise emission generated thereby, which is primarily caused by the expansion of the oil/air mixture. Other noise emissions are caused by the high speed, unrestrained impact of the valve body on the valve seat during closing.

[0005] A vacuum pump is described in EP 1 953 389 A2 wherein, for the purpose of noise reduction, a hole is provided in the leaf spring of the outlet valve to reduce the pressure difference in this region.

[0006] Another vacuum pump is described in DE 102 27 772 A1. A channel is formed near the valve opening for noise reduction in this vacuum pump, the channel connecting the pump chamber to the outlet chamber to thereby decelerate the opening and closing movement of the leaf spring and to reduce the pressure difference in this region.

[0007] A permanent connection exists between the pump chamber and the outlet chamber in these prior art vacuum pumps. The vacuum pump is therefore not sealed in the closed state of the outlet valve. This results in the problem that, due to these arrangements, the pump chamber is vented, whereby the power consumption of the pump significantly worsens.

SUMMARY

[0008] An aspect of the present invention is to provide a silent motor vehicle vacuum pump with a high degree of efficiency.

[0009] In an embodiment, the present invention provides a motor vehicle vacuum pump which includes a pump chamber in which a pump rotor is arranged to rotate so as to provide a compressed gas, an outlet chamber into which the compressed gas escapes from the pump chamber, a separating wall arranged to separate the pump chamber from the outlet chamber, and at least one outlet valve arranged in the separating wall. The at least one outlet valve is designed as a check valve so that the compressed gas escapes from the pump chamber into the outlet chamber therethrough. The at least one outlet valve is formed by a valve opening arranged in the separating wall, a valve seat arranged around the valve opening, and a leaf spring provided as a valve body. The leaf spring is configured to move between a closed position of the at least one outlet valve in which the leaf spring abuts on the valve seat, and an open position of the at least one outlet valve in which the leaf spring is spaced from the valve seat. The valve seat is formed with a raised shape. The leaf spring, in the closed position, is arranged to have a radial overlap with the valve seat of less than 1.5 mm. A radial projection of the leaf spring which extends radially outward beyond the raised valve seat is larger than 1.0 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention is described in greater detail below on the basis of embodiments and of the drawings in which:

[0011] FIG. **1** shows a motor vehicle vacuum pump of the present invention;

[0012] FIG. **2** shows a section through the outlet valve of the motor vehicle vacuum pump of FIG. **1**; and

[0013] FIG. **3** shows a top plan view on the outlet valve of the motor vehicle vacuum pump of FIG. **1** according to an embodiment.

DETAILED DESCRIPTION

[0014] The motor vehicle vacuum pump of the present invention is provided with a valve seat around the valve opening which is of a raised design. The valve seat here is that part of the housing which forms an abutment surface for the leaf spring forming the valve body. In the closed state, the leaf spring sealingly abuts on the valve seat in a pre-tensioned state so that the pump is not vented. The degree of efficiency of the pump is thereby improved. The term "raised" as used in the present invention relates to a design in which the region of the housing that forms the valve seat is raised structurally by at least 0.2 mm relative to the immediately adjoining region. A raised valve seat is advantageous in that the valve seat is thus clearly delimited from the adjoining housing. In an oil-lubricated vacuum pump, oil is ejected during operation from the valve opening, with the oil also settling on the valve seat and on the leaf spring. This oil generates a substantial adhesion force between the valve seat and the leaf spring during the opening process. A high adhesion force is disadvantages because the leaf spring only opens at higher outlet pressures. Higher outlet pressures cause a stronger expansion of the oil/gas mixture at the valve outlet resulting in increased noise emissions. The raised valve seat thus has the advantage that an adhesion force is generated only between the valve seat and the leaf spring and is not also generated in the regions adjoining the valve seat. The emission of noise by the vacuum pump is thereby reduced.

[0015] A radial overlap between the valve seat and the leaf spring of the present invention is less than 1.5 mm, for

example, 1.0 mm and, for example, even less than 0.7 mm. The overlap exists in a greater part, i.e., more than 50% of the circumference of the valve seat. The leaf spring can show a greater overlap in a fastening region of the leaf spring in which practically no opening movement occurs and/or in which the oil film between the valve seat and the leaf spring does not tear off. An overlap in the sense of the present invention is the region of the valve seat that comes into contact with the closed leaf spring. The leaf spring overlaps with the valve seat in this contact region. A radial direction in the sense of the present invention is a direction that extends, in the plane of the valve seat, vertically to a circumferential direction of the valve seat. By reducing the overlap, the adhesion force between the leaf spring and the valve seat is reduced so that the outflow is harmonized upon opening. By reducing the overlap, the leaf spring already opens at lower outlet pressures. An expansion of the expelled oil/gas mixture, which depends on the outlet pressure, is thereby reduced. The noise emission is therefore also reduced so that the vacuum pump becomes even less noisy in operation.

[0016] A radial projection of the leaf spring is greater than 1.0 mm. The amount of the radial projection is not, however, equal throughout and may locally be less than 1.0 mm. The amount of 1.0 mm for the radial projection in the sense of the present invention indicates that a mean amount of the radial projection is greater than 1.0 mm. The radial projection in the sense of the present invention relates to the region of the leaf spring that projects radially outward beyond the valve seat. Due to this design, an air cushion can also form between the leaf spring and the housing. This air cushion provides for additional deceleration of the leaf spring during the closing movement, so that the noise emission can be reduced even further.

[0017] Strict error tolerances generally had to be observed to date during the manufacture of the leaf spring and the valve seat and the assembly of the vacuum pump so that, after assembly, the leaf spring rests exactly on the valve seat. By forming a projection, the region in which the leaf spring still covers the valve seat is in an unfavorable case enlarged. It is thus possible to produce and assemble the leaf spring and the valve seat with error tolerances which are less strict. The leaf spring and the valve seat can thereby be manufactured more economically and assembly is facilitated.

[0018] The leaf spring used in the vacuum pump can, for example, have a thickness of 0.15 to 0.2 mm. The material used for the leaf spring is Uddeholm UHB Stainless 716 steel.

[0019] In an embodiment of the present invention, the valve seat can, for example, be surrounded by at least one adjoining chamfer. The term "chamfer" as used in the present invention relates to radii, chamfered edges or a beveled surface formed at an edge of a work piece. The chamfer here connects two different sides of the work piece.

[0020] The chamfer has the effect that, during the closing operation of the leaf spring, a circular air cushion of higher pressure forms between the chamfer and the leaf spring which decelerates the leaf spring and minimizes the generation of noise between the valve seat and the leaf spring. The noise generated by the impact of the leaf spring on the valve seat is thereby significantly reduced.

[0021] In an embodiment of the present invention, the chamfer can, for example, be formed at the inner circumference of the raised valve seat. The chamfer adjoins the valve seat on the inner side, i.e., proximally. Such a chamfer has the advantage that no structural changes must be made therefor. The chamfer can thus also be formed retroactively at the raised valve seat. In a further embodiment of the present invention, a chamfer can, for example, be formed at the outer circumference of the raised valve seat instead of the chamfer at the inner circumference, or in addition thereto.

[0022] In an embodiment of the present invention, the valve opening and the leaf spring can, for example, have a kidney-like shape, and the leaf spring can, for example, be fixed at a longitudinal end. This is advantageous because the outlet valve can be accommodated in a housing in a space-saving manner.

[0023] In an embodiment of the present invention, two outlet valves can, for example, be formed in the separating wall. The first outlet valve forms a fluid outlet during forward operation and the second outlet valve forms a fluid outlet during inverted operation of the rotor. This has the advantage that the motor vehicle vacuum pump can be operated in rotation directions of the rotor. The two leaf springs of the outlet valves are here formed by a single common spring body. The number of parts of the vacuum pump is thus reduced so that assembly is facilitated and confusion between the leaf springs is excluded.

[0024] In an embodiment of the present invention, the valve seat can, for example, be raised by at least 0.5 mm, for example, at least 1.0 mm, and, for example, at least 1.5 mm. As used in the present invention, "raised" relates to the distance between the valve seat and a housing surface from which the valve seat stands out structurally. It is thereby possible to provide a sufficient chamfer at the circumference of the valve seat.

[0025] Further details and advantages of the present invention are explained below based on a description of the embodiments shown in the drawings.

[0026] FIG. **1** shows a motor vehicle vacuum pump **10** of the present invention. The vacuum pump **10** forms a pump chamber **12** in which a gas is compressed by a rotating pump rotor **11**. A separating wall **22** separates the pump chamber **12** from an outlet chamber **14**. A kidney-shaped valve opening for forward rotation $\mathbf{24}_1$ and a kidney-shaped valve opening for reverse rotation $\mathbf{24}_2$ are formed in the separating wall **22**. For a fluidic connection of the pump chamber **12** and the outlet chamber **14**, the vacuum pump **10** comprises an outlet valve for forward rotation $\mathbf{20}_1$ in the form of a check valve and an outlet valve for reverse rotation $\mathbf{20}_2$ in the form of a check valve. The outlet valves $\mathbf{20}_1$, $\mathbf{20}_2$ have kidney-shaped leaf springs $\mathbf{40}_1$, $\mathbf{40}_2$ as the valve bodies, the leaf springs $\mathbf{40}_1$, $\mathbf{40}_2$ closing the valve openings $\mathbf{24}_1$, $\mathbf{24}_2$ in the closed state.

[0027] FIG. **2** shows a section through the outlet valve for forward rotation $\mathbf{20}_1$. The outlet valve for forward rotation $\mathbf{20}_1$ is formed by the kidney-shaped leaf spring $\mathbf{40}_1$, a raised valve seat **30** formed as a raised part by the pump housing, and the kidney-shaped valve opening $\mathbf{24}_2$ connecting the pump chamber **12** and the outlet chamber **14**. The raised valve seat **30** is formed with an elevation E which is higher than a region of the pump housing directly adjoining the raised valve seat **30**. The valve opening $\mathbf{24}_1$ is closed by the leaf spring $\mathbf{40}_1$, as is shown in FIG. **2**. In the closed position, the leaf spring $\mathbf{40}_1$ sealingly abuts on the raised valve seat **30** with an overlap U. In an open position, the leaf spring $\mathbf{40}_1$ is bent so that it is spaced from the raised valve seat **30**. The

movement of the leaf spring 40_1 is restricted by a valve limiter **45** provided at a distance from the raised valve seat **30**, as seen in the movement direction of the leaf spring 40_1. A respective chamfer **50**, **51** is provided at an inner circumferential surface and an outer circumferential surface of the valve opening 24_1 to reduce noise emissions. In the embodiment of FIG. **2**, the raised valve seat **30** is thus surrounded by two chamfers **50**, **51**. The leaf spring 40_1 is designed so that it extends laterally beyond the raised valve seat **30**. The leaf spring thus has a radial projection UH. As seen in the fluid outflow direction, the lateral ends of the leaf spring 40_1 are thus situated above a region of the pump housing that adjoins the raised valve seat **30**.

[0028] FIG. **3** shows a second embodiment of the present invention wherein two outlet valves 20_1, 20_2 are provided. One outlet valve 20_1 forms a fluid outlet during a forward operation and the other outlet valve 20_2 forms a fluid outlet during reverse operation of the pump rotor **11**. The valve opening 24_1, 24_2 of the outlet valves 20_1, 20_2 are provided on the right and the left of a fastening device **70** as seen in the fluid outflow direction. This fastening device **70** fixes a spring body **72** that forms the kidney-shaped leaf springs 40_1, 40_2, and the integral valve limiter **45** arranged, as seen in the fluid outflow direction, above the leaf springs 40_1, 40_2, on the separating wall **22** between the two kidney-shaped valve openings 24_1, 24_2. In the fluid outflow direction, the valve limiter **45** has kidney-shaped valve limiter openings **74** on the right and the left of the fastening device **70** which, as seen in the fluid outflow direction, are provided above the leaf springs 40_1, 40_2, and beyond which the leaf springs 40_1, 40_2 protrude laterally. These valve limiter openings **74** allow the leaf springs 40_1, 40_2 to be more easily released from the valve limiter **45** during a closing operation.

[0029] The present invention is not limited to embodiments described herein; reference should be had to the appended claims.

LIST OF REFERENCE NUMERALS

[0030] **10** motor vehicle vacuum pump
[0031] **11** pump rotor
[0032] **12** pump chamber
[0033] **14** outlet chamber
[0034] 20_1 outlet valve (for forward operation/rotation)
[0035] 20_2 outlet valve (for reverse operation/rotation)
[0036] **22** separating wall
[0037] 24_1 valve opening (for forward operation/rotation)
[0038] 24_2 valve opening (for reverse operation/rotation)
[0039] **30** raised valve seat
[0040] 40_1 leaf spring (for forward operation)
[0041] 40_2 leaf spring (for reverse operation)
[0042] **45** valve limiter
[0043] **50**, **51** chamfer
[0044] **70** fastening device
[0045] **72** spring body
[0046] **74** valve limiter opening
[0047] E elevation
[0048] U overlap
[0049] UH radial projection

What is claimed is:

1-7. (canceled)

8: A motor vehicle vacuum pump comprising:
a pump chamber in which a pump rotor is arranged to rotate so as to provide a compressed gas;
an outlet chamber into which the compressed gas escapes from the pump chamber;
a separating wall arranged to separate the pump chamber from the outlet chamber; and
at least one outlet valve arranged in the separating wall, the at least one outlet valve being designed as a check valve so that the compressed gas escapes from the pump chamber into the outlet chamber therethrough,
wherein,
the at least one outlet valve is formed by;
a valve opening arranged in the separating wall,
a valve seat arranged around the valve opening, and
a leaf spring provided as a valve body,
wherein,
the leaf spring is configured to move between a closed position of the at least one outlet valve in which the leaf spring abuts on the valve seat, and an open position of the at least one outlet valve in which the leaf spring is spaced from the valve seat,
the valve seat is formed with a raised shape,
the leaf spring, in the closed position, is arranged to have a radial overlap with the valve seat of less than 1.5 mm, and
a radial projection of the leaf spring which extends radially outward beyond the raised valve seat is larger than 1.0 mm.

9: The motor vehicle vacuum pump as recited in claim **8**, wherein the raised valve seat is surrounded by at least one adjoining chamfer.

10: The motor vehicle vacuum pump as recited in claim **9**, wherein the at least one adjoining chamfer is formed at an inner circumference of the raised valve seat.

11: The motor vehicle vacuum pump as recited in claim **9**, wherein the at least one adjoining chamfer is formed at an outer circumference of the raised valve seat.

12: The motor vehicle vacuum pump as recited in claim **8**, wherein,
the valve opening and the leaf spring are each arranged to have a kidney-shape, and
the leaf spring is fixed at a longitudinal end of the valve opening.

13: The motor vehicle vacuum pump as recited in claim **8**, wherein,
two outlet valves are arranged in the separating wall,
a leaf spring is provided for each of the two outlet valves, and
the two leaf springs are formed by a single common spring body.

14: The motor vehicle vacuum pump as recited in claim **8**, wherein the raised valve seat comprises an elevation of at least 0.5 mm.

15: The motor vehicle vacuum pump as recited in claim **8**, wherein the raised valve seat comprises an elevation of at least 1.0 mm.

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