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(71) Applicant: **Danieli Corus BV**
1951 ME Velsen Noord (NL)

(72) Inventors:
- **Domin, Oleksandr**
  1951 ME Velsen Noord (NL)
- **de Koning, Maurice Philipe**
  1951 ME Velsen Noord (NL)
- **Nobel, Willem Teunis**
  1951 ME Velsen Noord (NL)
- **Klut, Pieter Dirk**
  1951 ME Velsen Noord (NL)
- **Vaynshteyn, Roman**
  1951 ME Velsen Noord (NL)

(74) Representative: **De Vries & Metman**
Overschiestraat 180
1062 XK Amsterdam (NL)

(54) **BLEEDER VALVE FOR PRESSURIZED FURNACE**

(57) A bleeder valve (300) for controlling a gas outflow from the interior of a pressurized container (302) to an ambient atmosphere through an exhaust conduit (303) comprises: a valve seat (309) associated with said exhaust conduit (303), a movable lid (311) having a central closure portion (313) and a peripheral sealing surface (315) cooperating with said valve seat (309), and an actuating mechanism (316) connected to said lid (311) for moving said lid between a closed position on said valve seat and an open position distant from said valve seat. The lid comprises a deflection portion (317) at the periphery of said sealing surface. The deflection portion comprises a deflection surface (318) inclined relative to a tangent (Tsl) to said sealing surface (315) by an included angle (α) less than 180 degrees for imparting to a gas outflow passing between said valve seat (309) and said lid (311) a velocity component which is perpendicular or opposite to the initial opening movement of said lid. The central closure portion (313) is recessed with respect to said sealing surface (315).

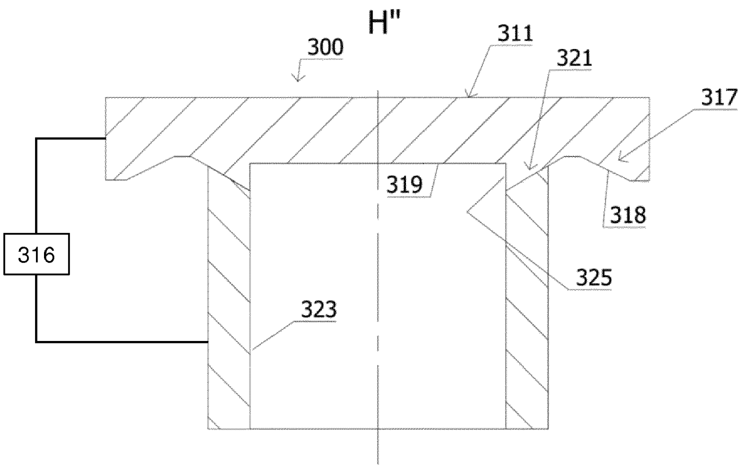

Fig. 8

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to bleeder valves for controlling a gas outflow from the interior of a pressurized container, in particular a pressurised furnace, to an ambient atmosphere through an exhaust conduit.

BACKGROUND

[0002] When operating pressurized containers, bleeder valves, also referred as pressure relief valves or explosion prevention valves, may be used to control an interior pressure to an acceptable level by venting gases from the interior of the container to the ambient atmosphere.

[0003] Bleeder valves may be operated by active control, wherein the interior pressure is monitored and the valve is opened in controlled manner using an actuating mechanism when the interior pressure exceeds a predetermined level. In a safety-arrangement the actuating system may comprise a safety mechanism providing a biasing force to maintain the valve closed but allowing opening of the valve when the interior pressure exceeds a predetermined level against the biasing force. In such case the valve should reliably open under the influence of the lifting force derived from the interior pressure against the biasing force.

[0004] The shape of the valve affects its operation. In particular, WO 2007/090747 proposes for a bleeder valve of the above referenced type a closure member comprising a recurved deflection portion at the periphery of the peripheral sealing surface, the recurved deflection portion comprising a deflection surface inclined against the convex surface by an angle in the range of 30° to 70° for imparting to a gas outflow passing between the valve seat and the closure member a velocity component which is opposite to the initial opening movement of the closure member.

[0005] However, further improvements in bleeder valves are desired, in particular in relation to safety and/or reliability and longevity.

SUMMARY

[0006] In view of the above, herewith bleeder valves are provided according to the following.

[0007] An aspect comprises a bleeder valve for controlling a gas outflow from the interior of a pressurized container, in particular a pressurised furnace, to an ambient atmosphere through an exhaust conduit, comprising: a valve seat associated with said exhaust conduit; a movable lid having a central closure portion and a peripheral sealing surface cooperating with said valve seat, and an actuating mechanism which is connected to said lid for moving said lid between a closed position on said valve seat and an open position distant from said valve seat. Said lid comprises a deflection portion at the periphery of said sealing surface. Said deflection portion comprises a deflection surface inclined relative to a tangent to said sealing surface by an included angle less than 180 degrees for imparting to a gas outflow passing between said valve seat and said lid a velocity component which is perpendicular to or opposite to the initial opening movement of said lid. The central closure portion, at least in proximity to said sealing surface, is recessed with respect to said sealing surface.

[0008] With such valve, chattering of the valve and associated damage may be prevented and accurate dimensioning of a biasing force may be facilitated. A reason for this is that the recessed central closure portion provides for balancing opening and closing forces on the lid, in particular in initial stages of opening of the valve.

[0009] The valve is in particular suited as a bleeder valve for containers operating at pressures of several tenths of a bar to a few bars (1 bar = 100 kPa) relative to the ambient atmosphere surrounding the container and/or as a bleeder valve for controlling a gas outflow of such pressures and/or such fluxes that the outflowing gas is a supersonic regime for the particular gas. E.g. the container may be a pressurized blast furnace or a steel making vessel with a customary operating overpressure relative to the environment at the top of the container, e.g. of 0.1 - 4 bar (g) top pressure (the pressure above the blast furnace charge or, respectively, the steel making charge).

[0010] The included angle may depend on dimensions of one or more of the conduit, the valve seat, the sealing surface and the deflection portion.

[0011] At or near the seat, the conduit may extend along a central axis, and in the closed position relative to the axis seen from an interior side of the valve to an exhaust side of the valve, the seat surface may be convex, i.e. flaring outward. This facilitates a gas outflow. The sealing surface may also correspondingly be generally convex. Such combination of correspondingly convex surfaces may provide a self-centring effect facilitating closing of the valve.

[0012] In an embodiment, at or near the seat, the conduit extends along a central axis, and in the closed position relative to the axis seen from an interior side of the container and the valve to an exhaust side of the valve, the sealing surface is convex and the deflection surface is radially plane or concave. Such valve may facilitate imparting on the outflowing gas a velocity component which is perpendicular to or opposite to the initial opening movement of said lid.

This provides an improved lifting force on the lid.

[0013] In an embodiment, the central closure portion of the lid is concave, as seen in the closed position relative to the axis seen from an interior side of the container and the valve to an exhaust side of the valve. Such valve may render design and calculation easier. It also may enable weight reduction of the valve member. In particular, the central closure portion of the lid may be concave from a portion of the sealing surface on one side to a portion of the sealing surface on an opposite side of the lid, such as being concave in diametrical cross section.

[0014] In an embodiment at or near the seat, the conduit extends along a central axis, and in the closed position an extension in axial direction of the recessed portion of the lid is more than an extension in axial direction of the sealing surface. Thus, the recessed portion is deeper than the sealing surface. Such valve may facilitate establishment of a homogeneous pressure distribution across a gap between the seat and the sealing surface, as seen in the axial direction. Thus, a smooth outflow may be achieved and pressure differences on the lid may be prevented.

[0015] In an embodiment at or near the seat (309), the conduit (303) extends along a central axis (H"), and the seat and the conduit at or near the seat are defined at least in part by an interior wall surface, and at least part of the recessed portion of the lid is defined by a recess surface, and in the closed position said interior wall surface and the recess surface register with each other. Thus, the conduit at or near the seat defines a lumen and the lumen continues substantially continuously into the lid. Such valve enables a gas flow into the gap from opposite directions, as seen in axial direction of the valve. This facilitates establishment of a homogeneous pressure distribution over the surfaces of the interior wall surface and the recess surface. When a gap is formed between the seat and the sealing surface due to opening of the bleeder valve, the homogeneous pressure difference may substantially be retained across the opening width of the gap as seen along the surfaces, such that the pressures on the interior wall surface and the recess surface on opposite sides of the gap may be substantially equal, which benefits a gas outflow pressure distribution and a gas flow distribution through the gap.

[0016] In an embodiment, the deflection portion extends along the entire periphery of the lid. Thus, the effect of the deflection portion may be achieved around the lid. Depending on, e.g. details of the movement of the lid from the closed position to the open position, details of positions and/or shapes of portions of the valve and/or of objects near the valve, the deflection portion may have different shapes in different sections around the lid, e.g. to affect a local lifting force on the lid which could reduce mechanical moments on associated portions.

[0017] In an embodiment, the seat and the lid have a cylindrical symmetry. Thus, a symmetric behaviour of the valve may be facilitated, e.g. improving predictability and robustness of the valve.

[0018] In an embodiment in at least part of the valve, the conduit extends along a central axis, one of the seat surface and the sealing surface is a frusto-conical surface and the other one of the seat surface and the sealing surface is part of a spherical or toroidal surface. A toroidal surface is formed if the sealing surface has a first radius of curvature about the central axis and a second radius of curvature in a direction perpendicular to the first radius of curvature being (significantly) smaller than the first radius of curvature.

[0019] This facilitates formation of a line contact, providing a relatively high closing pressure, rather than a flat surface contact which may reduce effective contact pressure. Also, tolerances with respect to parallelism may be reduced. Also, a self-centring arrangement may be provided. Any and each of such effects provides for a relatively robust valve.

[0020] In an embodiment, the valve seat comprises a seat surface cooperating with the peripheral sealing surface of the lid and the seat is provided with a soft seal element. The soft seal element may be a resilient seal element, e.g. an O-ring. The soft seal element may be embedded into said seat or into the lid within the seat surface or the sealing surface, respectively. Thus, part of the seal may deform and thus it may cushion a return of the lid onto the valve seat. Further, the soft seal member may conform to (the sealing surface of) the lid and improve tightness of the seal. Embedding of the soft seal into the seat surface or the sealing surface facilitates localisation of the seal, improving its reliability. An O-ring ensures sealing around the valve.

[0021] In an embodiment between the sealing surface and the deflection surface a transition area is located, comprising a surface oriented in another angle than the sealing surface and the deflection surface. The angle may be in between the sealing surface and the deflection surface, more in particular providing a smooth transition from the sealing surface to the deflection surface. The transition zone, which may take the form of a smoothly curved surface, e.g. having a continuously varying tangent, may facilitate manufacturing of the lid. Also, the transition zone may facilitate outflow of gas by preventing obstructions such as sudden bends. Preventing obstructions may also prevent deposition of particles from the gas flow, which could lead to (wear) damage and/or to leakage.

[0022] In an embodiment, at or near the seat, the conduit extends along a central axis, and wherein in the closed position of the valve the deflection surface extends at an angle between 90 and 110 with respect to the axis, being outwardly directed away from an exhaust side of the valve, for imparting to a gas outflow passing between said valve seat and said lid a velocity component which is perpendicular to or opposite to the initial opening movement of said lid.

[0023] In an embodiment said included angle (α) is in a range of 140 degrees to 180 degrees, in particular in a range of 150 degrees to 170 degrees, more in particular in a range of 155 degrees to 165 degrees. The valve seat (309) may have a width (Wv) in the direction of gas flow in a range of 45 mm to 65 mm, in particular in a range of 49 mm to 61 mm, more in particular in a range of 52 mm to 58 mm. The sealing surface (315) may have a width in the direction of gas flow in a range of 37 mm to 56 mm, in particular in a range of 40 mm to 53 mm, more in particular in a range of 43 mm to 50 mm. The deflection surface (318) may have a width in the direction of gas flow in a range of 55 mm to 75 mm, in particular in a range of 59 mm to 71 mm, more in particular in a range of 62 mm to 68 mm. Such values, in particular in combination, are considered to provide, results with, respectively, progressively better results from the widest to the narrowest range specified.

[0024] In an aspect, a container is provided comprising a bleeder valve as provided herein. The container may be a pressurized furnace, such as a blast furnace. Such pressurized container, and in particular such furnace, may be particularly robust and reliable. Operation safety of such container, in particular of such a (blast) furnace may be increased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The above-described aspects will hereafter be further explained with more details and benefits, with reference to the drawings, in which:

Fig. 1 shows a traditional bleeder valve;
Fig. 2 indicates a relation between an uplift force and the amount of opening in a valve according to **Fig. 1;**
Fig. 3 indicates a relation between an uplift force and a closing force and the amount of opening in a valve according to **Fig. 1;**
Fig. 4 shows a bleeder valve according to WO 2007/090747;
Fig. 5 indicates a relation between an uplift force and a closing force and the amount of opening in a valve according to **Fig. 4;**
Figs. 6-7 indicate components of the uplift force in a valve according to **Figs. 4** and **5;**
Fig. 8 shows a bleeder valve according to the present principles;
Fig. 9 is a detail of a valve according to **Fig. 8;**
Fig. 10 shows another embodiment of a bleeder valve according to the present principles;
Fig. 11 indicates a relation between an uplift force and a closing force and the amount of opening in a valve according to **Fig. 8;**
Figs. 12-13 indicate components of the uplift force in a valve according to **Figs. 8** and **11;**
Fig. 14 shows a comparison between **Figs. 5** and **11.**

DETAILED DESCRIPTION OF EMBODIMENTS

[0026] It is noted that the drawings show aspects and embodiments by way of example only. The drawings are schematic, not necessarily to scale and details that are not required for understanding the present explanation may have been omitted. The terms "upward", "downward", "below", "above", and the like relate to objects as oriented in the drawings, unless otherwise specified. Further, elements that are at least substantially identical or that perform an at least substantially identical function are denoted by the same numeral, where helpful individualised with alphabetic suffixes, primes and/or in particular by increasing reference numbers by one or more hundreds.

[0027] Referring to **Fig. 1,** consider a traditional bleeding valve **100** for controlling a gas outflow from the interior of a pressurized container **102,** in particular a pressurised furnace, to an ambient atmosphere through an exhaust conduit **103,** the exhaust channel 103 extending along a central axis **H** from an interior side **105** of the valve **100,** towards the container **102,** to an exhaust side **107,** away from the container 102. The valve **100** comprises: a valve seat **109** associated with said exhaust conduit **103;** a movable lid **111** having a central closure portion **113** and a peripheral sealing surface **115** cooperating with said valve seat **109** having a seat surface **110;** and an actuating mechanism (not shown) which is connected to said lid **111** for moving said lid **111** between a closed position on said valve seat **109** (as shown in **Fig. 1**) and an open position distant from said valve seat **109** (not shown). Herein, the central closure portion **113** is the portion of the lid **111** radially inside of the valve seat **109** in a closed position of the valve **100** being exposed to the container pressure.

[0028] When closed (**Fig. 1**), the lid **111** and the exhaust conduit **103** may be cylindrically symmetrical about the central axis **H.** In the shown embodiment, the central closure portion **113** and the peripheral sealing surface **115** are integrated in a single conically shaped surface.

[0029] In the valve **100,** and in general in a bleeder valve, the valve lid **111** is subject to two forces acting in opposite directions: a closing force $\mathbf{F_d}$ and an uplift force $\mathbf{F_u}$. Note that we consider the strengths of the forces $\mathbf{F_d}$, $\mathbf{F_u}$ only; the forces are (assumed to be) directed parallel to each other. **Figs. 2** and **3** schematically show the general behaviour of these forces $\mathbf{F}_u$ and, respectively, $\mathbf{F_d}$, in a valve **100** according to **Fig. 1** in dependency of valve stroke $\mathbf{v_s}$.

[0030] The uplift force $\mathbf{F_u}$ has two components; a static force $\mathbf{F_s}$ resulting from the internal container pressure acting on the central closure portion **113** and a gas velocity induced force (also called "wind force") $\mathbf{F_w}$ caused by gas flowing between the valve lid and the valve seat:

$$\text{Eq. 1:} \qquad F_u = F_s + F_w$$

[0031] The traditional valve design shown in **Fig. 1** exhibits a negative relationship between the uplift force $\mathbf{F_u}$ and the amount of opening of the valve or "valve stroke" $\mathbf{v_s}$ of the lid **111** relative to the seat **109.** This behaviour is shown in **Fig. 2** and is determined by the following facts:

$\mathbf{F_s}$ reduces with valve stroke, i.e. $\mathbf{F_s}$ keeps reducing as the valve opening increases;
$\mathbf{F_w}$ is absent or negligible, i.e. $\mathbf{F_w}$ = 0.

[0032] The valve stroke-dependent behaviour of the uplift force $\mathbf{F_u(v_s)}$ may be essentially independent from the interior pressure in the container **102,** which mainly determines the absolute value of the force $\mathbf{F_u}$.

[0033] Since bleeder valves are generally oriented substantially vertical, the closing force $\mathbf{F_d}$ is generally downward and caused at least in part by the sum of the effective gravitational force on the lid **111** and associated valve portions (parts of the actuation mechanism, handles, etc., that may be attached to the lid **111**), and as an optional part forces of a spring and/or other resilient portion of the actuating mechanism that keeps the valve closed. In such case, $\mathbf{F_d}$ is generally dependent on the valve stroke $\mathbf{s_v}$:

$$\text{Eq. 2:} \qquad F_d \sim s_v$$

[0034] However, the dependency need not be proportional; in an actual valve the relation between $\mathbf{F_d}$ and $\mathbf{s_v}$ will depend on particularities of the system considered. For a system having a spring with spring constant **c, Eq. 2** may result in:

$$\text{Eq. 3:} \qquad F_d = c\ s_v + F_0$$

wherein $\mathbf{F_0}$ is a possible offset, e.g. due to weight factors, e.g. see point **A** in **Fig. 3.** In an embodiment, the closing force $\mathbf{F_d}$ may be derived solely on gravity, e.g. based on the weight of the lid and possibly one or more additional weights and/or counterweights.

[0035] In any case for a bleeder valve, if the uplift force $\mathbf{F_u}$ is smaller than the closing force $\mathbf{F_d}$, $\mathbf{F_u < F_d}$, the valve will tend to remain closed or to close when opened, and in an opposite situation, when $\mathbf{F_u > F_d}$, the valve will tend to open or open further when opened. An equilibrium position is reached where both forces are equal, $\mathbf{F_u = F_d}$.

[0036] In **Fig. 3** can be discerned that $\mathbf{F_s}$ keeps decreasing as the valve opening increases whereas $\mathbf{F_d}$ increases approximately linearly with increasing valve stroke $\mathbf{v_s}$. In the somewhat simplified model considered, for and during opening a closed valve **100,** several stages may be discerned:

a- the pressure on an inside of the valve **100** needs to create an uplift force $\mathbf{F_u}$ higher than a closing force $\mathbf{F_u > F_d}$ up to a (downward) offset force **F = A** for initialling opening the valve (**Fig. 3**);
b- when the valve **100** opens (i.e. $\mathbf{v_s}$ small but > 0) the uplift force F_u reduces, while the closing force $\mathbf{F_d}$ increases;
c- as long as $\mathbf{F_u > F_d}$, the valve **100** will continue opening (increasing valve stroke $\mathbf{v_s}$) up to the equilibrium valve stroke $\mathbf{v_s}$ = **D,** where the uplift and closing forces are equal at $\mathbf{F_u = F_d = C}$;
d- due to its inertia of the movement, the lid **111** will overshoot the equilibrium position **D** up to a larger valve stroke $\mathbf{v_s = E > D}$ where $\mathbf{F_u < F_d}$ and the net closing force (difference between $\mathbf{F_d}$ and $\mathbf{F_u}$) is sufficient to stop the movement and
e- impose a return movement of the lid **111** towards an equilibrium position at $\mathbf{v_s = D}$;
f- however, due to its inertia of the movement, the lid **111** will again overshoot the equilibrium position **D** down to a smaller valve stroke $\mathbf{v_s = F < D}$, where $\mathbf{F_u > F_d}$ and the net uplift force (difference between $\mathbf{F_u}$ and $\mathbf{F_d}$) is sufficient to stop the movement and
g- force an opposite return movement of the lid towards equilibrium position $\mathbf{v_s = D}$; this is a repetition of stage c above.

[0037] Thus, the lid, subject to the valve stroke $\mathbf{v_s}$-dependent forces $\mathbf{F_u}$ and $\mathbf{F_d}$ will perform an oscillatory movement (repeating stages c-g), which, dependent on damping in the system reducing the oscillation amplitude **E-F,** eventually ends in a stable situation at the equilibrium valve stroke **D.**

[0038] Note that the valve stroke dependent behaviour of the uplift force $\mathbf{F_u(v_s)}$ and the of closing force $\mathbf{F_d(v_s)}$ F_u are a characteristic of a given valve **100** and that the exact values of $\mathbf{F_u = F_d = C}$ and $\mathbf{v_s = D}$ may depend on the internal pressure in the container **102** determining a force offset to F_u (e.g. up to F_u = **B**). Note further that in the above model description it is assumed that, at least for the duration of consideration, the interior gas pressure in the container **102** is substantially constant and unaffected by opening of the bleeder valve **100** and any gas outflow from the container **102.**

[0039] Since the valve stroke equilibrium position v_s = **D** is determined by the relation of the uplift force F_u and the closing force F_d, in actual valves according to **Fig. 1,** the above-described oscillation effect can occur close to the closed position of the valve **100** where the lid **111** of the valve **100** may hit the valve seat **109** repeatedly, e.g. in every oscillation cycle. This is well known as "chattering" and may cause damage to (surfaces of) the valve seat **109** and/or (of) the lid **111.**

[0040] **Fig. 4** schematically shows a valve **200** according to WO 2007/090747. **Figs. 5-7** show some effects of the valve design according to **Fig. 4,** cf. **Figs. 2-3** relative to the valve design of **Fig. 1.**

[0041] In the valve **200,** relative to a transitional valve **100** according to **Fig. 1,** the lid comprises a recurved deflection portion **217** at the periphery of the sealing surface **215.** The deflection portion **217** imparts to an initial gas outflow passing between the valve seat **209** and the lid **211** (i.e. at small apertures) a substantial velocity component in the direction opposite to the initial opening movement of the lid **211** without compromising gas throughput especially at small apertures. Thus, the design of the valve **200** aims to provide an increased lifting force transmitted to the lid **211** by the gas flowing out of the exhaust conduit **203** and along the lid **211.**

[0042] Thus, the uplift force F_u (**Fig. 5**) is a sum of the static force F_s (**Fig. 6**) and the nonzero gas velocity induced force F_w (**Fig. 7**) caused by the recurved deflection portion **217.**

[0043] The static force F_s (**Fig. 6**) in the valve **200** according to **Fig. 4** is equal to that in a traditional valve **100** according to **Fig. 1,** for a given valve diameter.

[0044] When well-optimized, a valve **200** according to **Fig. 4** may provide that, different from a traditional valve **100** according to **Fig. 1,** F_w is nonzero and increases with the opening of the valve **200;** see **Fig. 7.** As such, a decrease of F_s (**Fig. 6**) is compensated for by increasing F_w (**Fig. 7**). The resulting uplift force $F_u = F_s + F_w$ (**Eq. 1**) may then have positive relationship to the valve opening, F_u increasing with valve stroke v_s, see **Fig. 5.**

[0045] Therefore, the valve **200** may be designed to provide a closing biasing force F_d such that $F_u > F_d$ for all (practical) valve strokes v_s as indicated in **Fig. 5.** Thus, an equilibrium position of the lid **200** which results from equality of the uplift force and the closing force $F_u = F_d$ is absent and chattering of the valve **200** may be prevented.

[0046] However, the present inventors have realised that also the valve **200** still has significant shortcomings. E.g. the decrease of the static force F_s (**Fig. 6**) in the initial phases of opening of the valve cannot be compensated by the gas velocity induced force F_w **(Fig. 7),** so that, just as in the traditional valve **100,** the uplift force F_u shows a steep decrease for small valve strokes v_s; see **Fig. 5.** As a consequence, the minimum value **G** of the uplift force F_u may readily become equal to or lower than the closing force F_d for small valve strokes v_s, causing chattering at small openings. Thus, to prevent such chattering, valves **200** must be designed to provide an uplift force F_u and a closing force F_d such that an initial opening moment of the valve **200** requires a significantly higher uplift force F_u = **B** >> **A** than would be optimum for a safe operation.

[0047] Therefore, a further improved valve is provided herewith. **Figs. 8-12** show an embodiment of the further improved valve **300** and a number of its characteristics. The presently provided bleeder valve **300** comprises: an exhaust conduit **303,** a valve seat **309** associated with exhaust conduit **303;** a movable lid **311** having a central closure portion **313** and a peripheral sealing surface **315** cooperating with said valve seat **309,** and an actuating mechanism **316** which is connected to said lid **311** for moving said lid **311** between a closed position on said valve seat **309** and an open position distant from said valve seat **309.** The lid **311** further comprises a deflection portion **317** providing a deflection surface **318.**

[0048] The lid **311** and the seat **309,** here also the conduit **303,** have a cylindrical symmetry about the axis **H",** with the deflection portion **317** extending along the entire periphery of the lid **311** and the recess **319** extending along the entire sealing portion **321.** However, such symmetry is not required. For opening of the valve **300,** the lid **311** is movable with respect to the valve seat **309** essentially along the axis **H",** at least for small openings. Suitable actuating mechanisms provide opening of the valve **300** from the closed position to the open position by a movement that is substantially perpendicular to the valve seat **309,** at least in initial stages of opening, e.g. a translation along the axis **H"** and/or a rotation along a path to which the axis **H"** is tangential. A preferred mechanism comprises the lid **311** being pivotal to a distant pivoting axis by a long arm arranged between the two, but other constructions may also be provided. The actuating mechanism should preferably allow opening of the valve **300** at least up to a separation between the valve seat **309** and the lid **311** sufficient to provide an opening with a cross sectional area for gas flow through it equal to the cross-sectional area of the conduit **303,** to reduce flow resistance of the valve **300.**

[0049] In a typical example, initial opening of the valve 300 comprises translation of the lid **311** without rotation, or only a small tilt of the lid **311** in the range of 1 - 5 degrees tilting angle relative to the closed position. In such range, and up to a gap height in axial direction along **H"** of about 10% of the conduit inner diameter, e.g. about 5 cm at a conduit diameter of 50 cm, the outflow of the gas will be substantially unaffected by the tilting. At larger tilting angles, typically > 5 degrees, the gas distribution may become distorted.

[0050] The actuating mechanism **316** should preferably provide as little inertia as possible to the valve. Hydraulic, pneumatic or electrical or other type of actuating mechanism can be used. A powered actuating mechanism **316** should preferably have a power back-up system.

[0051] The valve **300** comprises, compared to the valve **200,** predominantly that the central closure portion **313** is recessed with respect to said sealing surface **315,** at least in proximity to the sealing surface **315.** As will be appreciated from **Fig. 8,** the lid **311** thus comprises a peripheral sealing portion **321** providing the sealing surface **315** protruding from the adjacent central closure portion **313.** This is in contrast the valves **100** and **200,** wherein a convex portion of the lid **111, 211,** protrudes from the respective lid **111, 211,** into the respective conduit **103, 203.**

[0052] In the shown valve **300,** the recess **319** extends substantially from a portion of the sealing surface **315** on one side of the lid **311** to a portion of the sealing surface **315** on the opposite side of the lid **311,** relative to the central axis **H",** so that the recess **319** spans across the entire lid **311** inside the sealing portion **321** and a dome-like lid **311** is provided.

[0053] In the valve **300,** the conduit **303** defines a lumen **327** at least at or near the seat **309,** and the lumen **327** continues into (the recess **319** of) the lid **311.** Best seen in **Fig. 9,** the seat **309** and the conduit **303** at or near the seat **309** are defined at least in part by an interior wall surface **323,** and at least part of the recessed portion **319** of the lid **311** is defined by a recess surface **325.** In the closed position of the valve **300** said interior wall surface **323** and the recess surface **325** register with each other. Thus, here, the lumen **327** continues into (the recess **319** of) the lid **311** substantially continuously and unchanged in shape.

[0054] In the embodiment of **Figs. 8-10,** at least at or near the seat **309,** the conduit **303** extends along the central axis **H".** The valve seat surface **310** has a width **Ws** relative to the axis **H"** and a tangent **Tss** to the seat surface **301** extends at a seat surface angle ϕ**ss** to the axis **H".** The extension **Dr** of the recessed portion **319** of the lid **311** in axial direction along **H",** or: the depth **Dr** of the recessed portion **319,** is more than said width **Ws** of the seat surface **310** times the cosinus of said seat surface angle ϕ**ss**, although it may also be equal to that:

$$\text{Eq. 4:} \qquad \mathbf{Dr} \geq \mathbf{Ws} * \cos \phi\mathbf{ss}$$

[0055] The same holds, mutatis mutandis, for the extension **Dr** relative to the sealing surface **315.** In other words, in the closed position an extension **Dr** in axial direction of the recessed portion **319** of the lid **311** is more than at least one of (a) an extension **S** in axial direction of the sealing surface **315** of the lid **311** and (b) an extension **V** in axial direction of the seat surface **310,** i.e. in axial direction **H",** the recessed portion **319** is recessed deeper into the central portion **313** of the lid **311** than the height of the sealing surface **315** and/or the seat surface **310.**

[0056] Relative to the axis **H"** seen from an interior side **305** of the valve **300** to an exhaust side **307** of the valve **300,** the sealing surface **315** is convex and the deflection surface **318** is concave, so that a self-seeking effect is provided during closing of the valve 300. Note that the lid **311** may, after opening return to a slightly different geometry in a closed position than before; however, small (e.g. < 3 % of the seat width **Ws**) may be acceptable. In particular, in at least part of the valve **300,** preferably in all of the valve **300,** the seat surface **310** is a frusto-conical surface and the sealing surface **315** is portion of a spherical surface or of a toroidal surface, or the other way around. The frusto-conical surface preferably is tangential to the spherical or, respectively, toroidal surface portion at or near the location of contact between the seat surface **310** and sealing surface **315,** forming a line contact. The latter condition of tangentiality preferably also applies along all portions of a non-circular conduit such that along such non-circular seal also a line contact is reliably formed.

[0057] The shown valve seat **309** comprises an optional soft seal element **327,** which may be a more or less resilient seal element, e.g. an O-ring of a rubber and/or of any other suitable natural and/or synthetic material, or a relatively soft and deformable material relative to the valve surface and the sealing surface materials. Here, the soft seal element **327** is embedded into said seat surface **310.** Alternatively, and/or additionally, a soft seal element (not shown) may be provided in the lid, e.g. embedded into the sealing surface **315,** in the latter case the two soft seal elements are preferably radially offset from each other with respect to the axis **H".** The shown lid **311** is provided, here by embedding, with an optional sealing element **329** providing a sealing surface **315** of a suitable material, which may differ from one or more other portions of the lid **311.** One or more of the valve seat **309,** the soft seal element **327** and/or the sealing element **329** may be replaceable, e.g. for maintenance or repair.

[0058] In the lid **311** the tangent **Tsl** to the sealing surface **315** and the tangent **Tdl** to the deflection surface **318** relative to the axis **H"** are at an included angle α to each other. Between the sealing surface **315** and the deflection surface **318** an optional transition area **331** is located, comprising a surface **333** with a width **Wt** in radial direction relative to axis **H"** and being oriented in another angle than the sealing surface **315** and the deflection surface **318,** in particular being curved and transitioning uninterruptedly with a continuously varying tangent to, respectively, both the sealing surface **315** and the deflection surface **318.** The transition area **331** thus may provide a smooth aerodynamic transition from the sealing surface **315** to the deflection surface **318,** preventing gas turbulence there.

[0059] In embodiments, said included angle α is in a range of 140 degrees to 180 degrees, in particular in a range of 150 degrees to 170 degrees, more perpendicular in a range of 155 degrees to 165 degrees.

[0060] In the closed position of the valve **300** the deflection surface **318** extends at an angle between 90 and 110 degrees with respect to the axis **H"**, i.e. at an angle β between 0 and 10 relative to a radial direction about the axis **H"**.

[0061] Thus, the deflection surface **318** is outwardly directed away from an exhaust side of the valve **300,** for imparting to a gas outflow passing between the valve seat **309** and the lid **311** a velocity component which is perpendicular to or opposite to the initial opening movement of said lid **311.**

[0062] Further, the valve seat **309,** or at least the valve seat surface **310,** may have a width **Wv** along its surface radial to the axis **H",** the direction of gas flow when flowing out of the conduit **303,** in a range of 46 mm to 64 mm, in particular in a range of 49 mm to 61 mm, more in particular in a range of 52 mm to 58 mm.

[0063] The sealing surface **315** may have a width **Ws** along its surface radial to the axis **H",** the direction of gas flow when flowing out of the conduit **303,** in a range of 37 mm to 56 mm, in particular in a range of 40 mm to 53 mm, more in particular in a range of 43 mm to 50 mm.

[0064] The widths **Wv** and **Ws** may differ, but they may also, preferably, be substantially the same, e.g. the width **Wv** being bigger than **Ws** by some 20% down to being equal.

[0065] The deflection surface **318** has a width **Wd** in the direction of gas flow in a range of 56 mm to 74 mm, in particular in a range of 59 mm to 71 mm, more in particular in a range of 62 mm to 68 mm.

[0066] Thus, the deflection portion **317** and the optional transition area **331** are, in a closed state of the valve **300,** arranged outside of the valve seat **309** and in particular outside the ring type joint of the conduit **311,** so that a protruding wing providing the deflection portion **317** extends to a total width **Ww** of $\mathbf{Ww} \geq \mathbf{Wd} + \mathbf{Wt}$.

[0067] Thus, best seen in **Fig. 10,** when considering a valve **300** with cylindrical symmetry about the central axis **H",** the conduit **303** has an inner diameter $\mathbf{D_i}$, the walls **304** of the conduit **303** have a radial thickness **E,** providing an outer diameter of $\mathbf{D_c = D_1 + 2E}$, the lid has an outer diameter **Do** and an inner diameter $\mathbf{D_{dome}}$ of the recessed portion or "dome". Thus, the lid **311** has an inner surface area **A1** and an outer surface area **A2,** which here applying that **A1** is equal to the cross-sectional area of the conduit $\mathbf{A_{cond} = 1/4\ \pi\ D_i^2}$, and the outer surface area **A2** being equal to $\mathbf{1/4\ n\ (D_o^2 - D_c^2)}$.

[0068] As a result of the recess **319,** the static force **Fs** due to the interior pressure of the container **302** onto the central portion **313** of the lid **311** is largely unaffected by opening of the valve **300:** see **Fig. 12.** Thus, local pressure drops due to opening of the valve **300** may be prevented and a stable pressure onto the lid **311** within the valve **300** is provided. **Figs. 15-16** indicate pressure levels and, respectively, a gas stream in a valve **200; Figs. 17-18** show pressure levels and, respectively, a gas stream in a valve **300,** according to a finite-element- model of the respective valves as shown. From a comparison between **Figs. 15-16** and, respectively, **Figs. 17-18,** but without wishing to be bound to any particular theory, one may consider that the present valve **300** (**Figs. 17-18**) provides more of a lateral opening and a lateral gas flow component inside of the conduit **303** of the present valve **300,** than an axial opening imparting an axial gas flow component inside of the conduit **303** as is the case in the known valve **200.** Thus, in the present valve **300** the upward force on the lid **311** within the conduit **303** acts on a larger effective diameter than in the known valve **200.** Further, in the present valve **300** a local pressure maximum is formed at or near the transition area **331,** further radially outward than in the known valve **200.** Note that the upward force may be equal for all container pressures for which the gas flow escaping through the valve **300** is supersonic; a pressure correction of the downward pressure $\mathbf{F}_d$ may be obviated. Further, the deflection portion **317** may be designed to provide a deflection surface **318** at a smaller angle α than in the known valve **200** providing a flatter increase of the gas velocity induced force $\mathbf{F_w}$ versus the valve stroke $\mathbf{v_s}$ (see Fig. 13).

[0069] Since in the initial phases of opening of the valve **300,** the uplift force $\mathbf{F}_u = \mathbf{F_s} + \mathbf{F_w}$ (**Eq. 1**) is mainly determined by the static pressure $\mathbf{F_s}$ and in the present valve **300** the static pressure $\mathbf{F_s}$ is largely or actually constant, a significant pressure drop and decrease in the uplift force $\mathbf{F_u}$ in the initial phases of opening may be prevented.

[0070] Fig. 14 shows a comparison between the uplift force $\mathbf{F_u}$**200** of a valve **200** according to WO 2007/090747 (**Fig. 5**) and the uplift force $\mathbf{F_u}$**300** of a valve **300** according to the present teachings (**Fig. 11**), both valves having equal sizes and masses. Clearly, the decrease in uplift force in $\mathbf{F_u}$**300** is less than that in $\mathbf{F_u}$**200**. Thus, a difference between $\mathbf{F_u}$**300** and $\mathbf{F_d}$ may be less than that for $\mathbf{F_u}$**200** without risking provision of an equilibrium valve stroke $\mathbf{v_s}$ where both opposing forces ($\mathbf{F_u}$**300** and $\mathbf{F}_d$) are equal (but directed opposite each other) so that chattering may occur. Also, since the uplift force $\mathbf{F_u}$**300** increases less with increasing valve stroke $\mathbf{v_s}$ compared to the valve **200** a more constant force difference ($\mathbf{F_u}$ - $\mathbf{F_d}$) and/or smaller spring constant may be provided for the closing force $\mathbf{F_d}$ providing a more linear behaviour of the valve **300.**

[0071] Further, removal of the conical central portion **213** of the central portion of the known lid **200,** as is done in (the lid **311** of) the presently provided valve **300** reduces weight of the lid **311** compared to a known lid **211** having a convex conical shape. Note that for forming a deflection portion **217, 317** laterally protruding outwards with respect to the lid **211, 311** and the conduit **203, 303,** additional material may have to be added to the lid, relative to (the lid **111** of) the traditional valve **100,** so that (the lid **211** of) the known valve **200** may be heavier than (the lid **111** of) a traditional valve **100** for a given valve size. The lid **311** of the presently provided valve, providing a recess thus being concave rather than convex, may be designed lighter than the lid **111, 211** of either of both known valves (**100** and **200**) for a given valve size. This reduces material consumption, and it may enable a lighter structure of the valve as a whole. Further, inertia of the lid of the presently provided valve may thus be reduced relative to the known valves so that a chattering amplitude (see valve stroke range **F-E** in **Fig. 3**) and associated damage risks to the lid and/or the valve seat may be reduced.

[0072] The disclosure is not restricted to the above described embodiments which can be varied in a number of ways within the scope of the claims.

[0073] Elements and aspects discussed for or in relation with a particular embodiment may be suitably combined with elements and aspects of other embodiments, unless explicitly stated otherwise.

Claims

1. A bleeder valve (300) for controlling a gas outflow from the interior of a pressurized container (302), in particular a pressurised furnace, to an ambient atmosphere through an exhaust conduit (303), comprising:

   a valve seat (309) associated with said exhaust conduit (303);
   a movable lid (311) having a central closure portion (313) and a peripheral sealing surface (315) cooperating with said valve seat (309),
   and an actuating mechanism (316) which is connected to said lid (311) for moving said lid (311) between a closed position on said valve seat (309) and an open position distant from said valve seat (309);
   wherein said lid (311) comprises a deflection portion (317) at the periphery of said sealing surface (315),
   wherein said deflection portion (317) comprises a deflection surface (318) inclined relative to a tangent (Tsl) to said sealing surface (315) by an included angle (α) less than 180 degrees for imparting to a gas outflow passing between said valve seat (309) and said lid (311) a velocity component which is perpendicular to or opposite to the initial opening movement of said lid (311),
   wherein the central closure portion (313), at least in proximity to said sealing surface (315), is recessed with respect to said sealing surface (315).

2. The bleeder valve (300) according to claim 1, wherein at or near the seat (309), the conduit (303) extends along a central axis (H"), and wherein in the closed position relative to the axis (H") seen from an interior side (305) of the container (302) and the valve (300) to an exhaust side (307) of the valve (300), the sealing surface (315) is convex and the deflection surface (318) is radially plane or concave.

3. The bleeder valve (300) according to claim 1, wherein the central closure portion (313) of the lid (311) is concave, in particular being concave from a portion of the sealing surface on one side to a portion of the sealing surface on an opposite side of the lid (311).

4. The bleeder valve (300) according to any preceding claim, wherein at or near the seat (309), the conduit (303) extends along a central axis (H"), and wherein in the closed position an extension in axial direction of the recessed portion (313) of the lid (311) is more than an extension in axial direction of the sealing surface (315).

5. The bleeder valve (300) according to any preceding claim, wherein at or near the seat (309), the conduit (303) extends along a central axis (H"),
   wherein the seat (309) and the conduit (303) at or near the seat (309) are defined at least in part by an interior wall surface (323), and at least part of the recessed central closure portion (313) of the lid (311) is defined by a recess surface (325), and
   wherein in the closed position said interior wall surface (323) and the recess surface (325) register with each other.

6. The bleeder valve (300) according to any preceding claim, wherein the deflection portion (317) extends along the entire periphery of the lid (311).

7. The bleeder valve (300) according to any preceding claim, wherein the seat (309) and the lid (311) have a cylindrical symmetry.

8. The bleeder valve (300) according to any preceding claim, wherein in at least part of the valve, one of the seat surface (310) and the sealing surface (315) is a frusto-conical surface and the other one of the seat surface (310) and the sealing surface (315) is part of a spherical or toroidal surface.

9. The bleeder valve (300) according to any preceding claim, wherein the valve seat (309) comprises a seat surface (310) cooperating with the peripheral sealing surface (315) of the lid (311) and wherein the seat (309) is provided

with a soft seal element (327), in particular a resilient seal element, e.g. an O-ring, wherein preferably the soft seal element (327) is embedded into said seat (310) or into the lid (311) within the seat surface (310) or the sealing surface (315), respectively.

10. The bleeder valve (300) according to any preceding claim, wherein between the sealing surface (315) and the deflection surface (318) a transition area (331) is located, comprising a surface (333) oriented in another angle than the sealing surface (315) and the deflection surface (318), in particular an angle in between the sealing surface (315) and the deflection surface (318), more in particular providing a smooth transition from the sealing surface to the deflection surface.

11. The bleeder valve (300) according to any preceding claim, wherein at or near the seat (309), the conduit (303) extends along a central axis (H"), and wherein in the closed position of the valve (300) the deflection surface (318) extends at an angle (β) between 90 and 110 with respect to the axis (H"), being outwardly directed away from an exhaust side (307) of the valve (300), for imparting to a gas outflow passing between said valve seat (309) and said lid (311) a velocity component which is perpendicular to or opposite to the initial opening movement of said lid (311).

12. The bleeder valve (300) according to any preceding claim, wherein said included angle (α) is in a range of 140 degrees to 180 degrees, in particular in a range of 150 degrees to 170 degrees, more in particular in a range of 155 degrees to 165 degrees,
and wherein the valve seat (309) has a width (Wv) in the direction of gas flow in a range of 45 mm to 65 mm, in particular in a range of 49 mm to 61 mm, more in particular in a range of 52 mm to 58 mm,
and wherein the sealing surface (315) has a width in the direction of gas flow in a range of 37 mm to 56 mm, in particular in a range of 40 mm to 53 mm, more in particular in a range of 43 mm to 50 mm,
and wherein the deflection surface (318) has a width in the direction of gas flow in a range of 55 mm to 75 mm, in particular in a range of 59 mm to 71 mm, more in particular in a range of 62 mm to 68 mm.

13. A container (302) comprising a bleeder valve (300) according to any preceding claim.

14. The container (302) according to claim 13 wherein the container (302) is a pressurized furnace, such as a blast furnace.

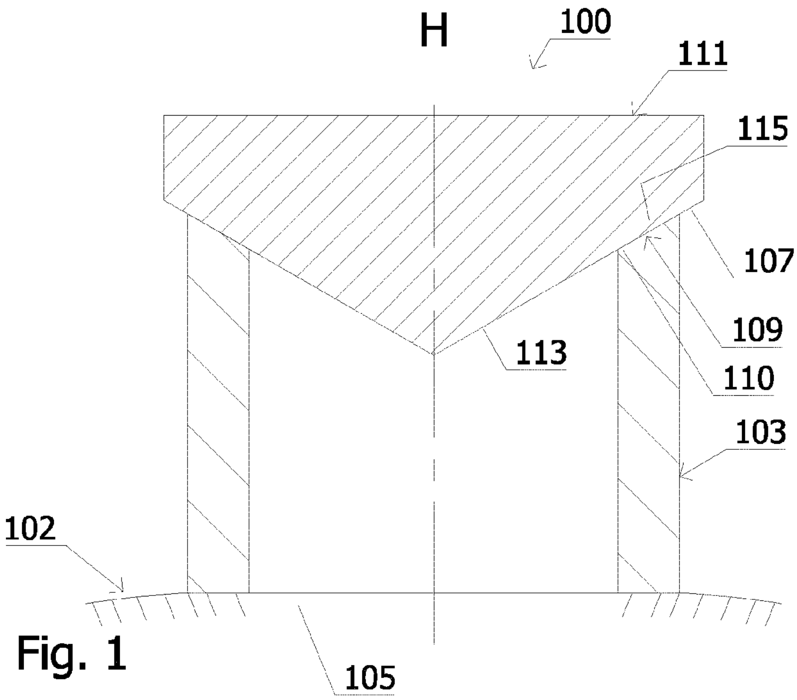

Fig. 1

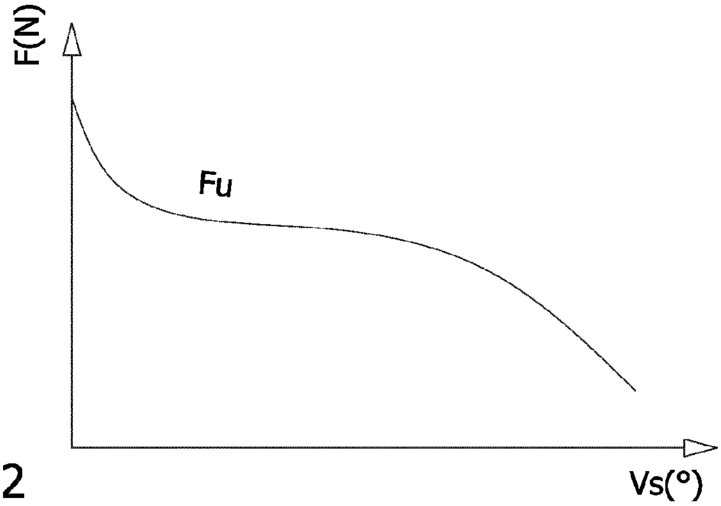

Fig. 2

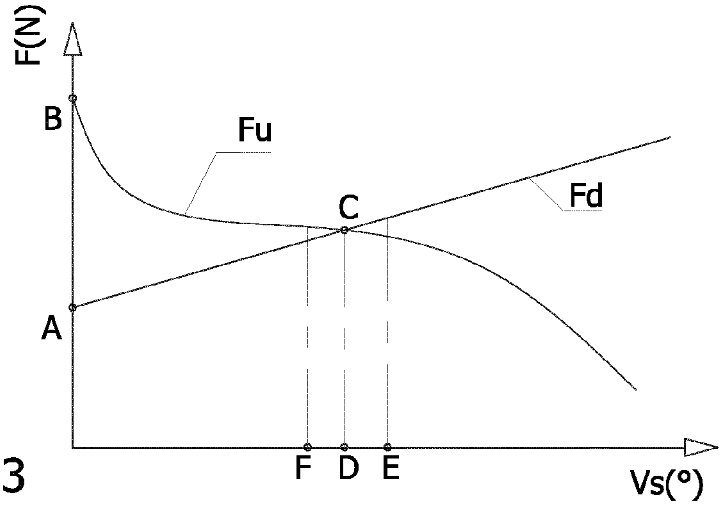

Fig. 3

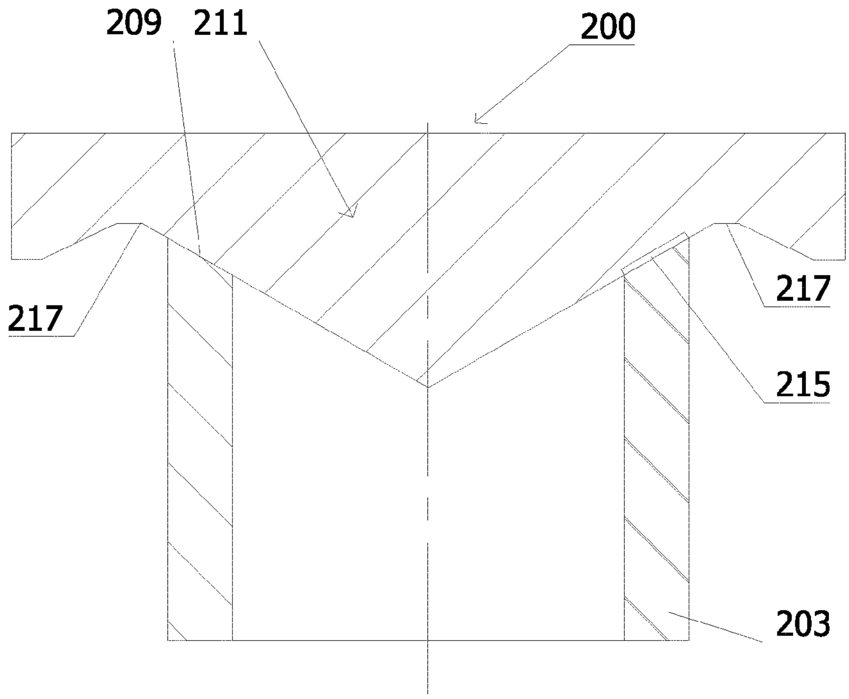

Fig. 4

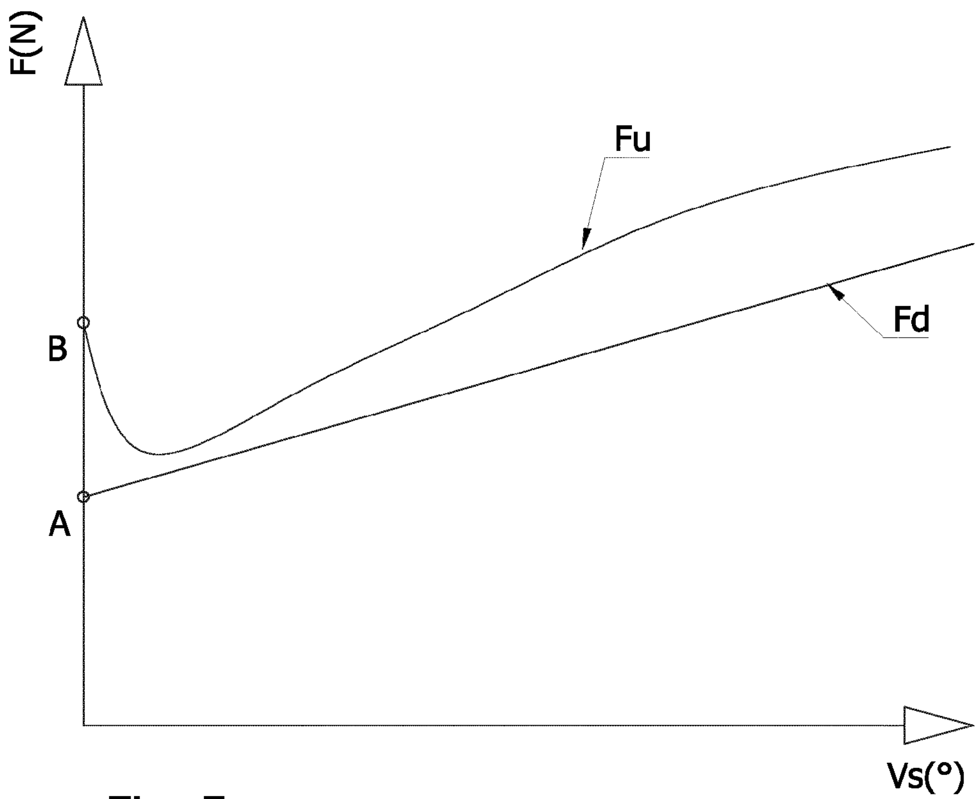

Fig. 5

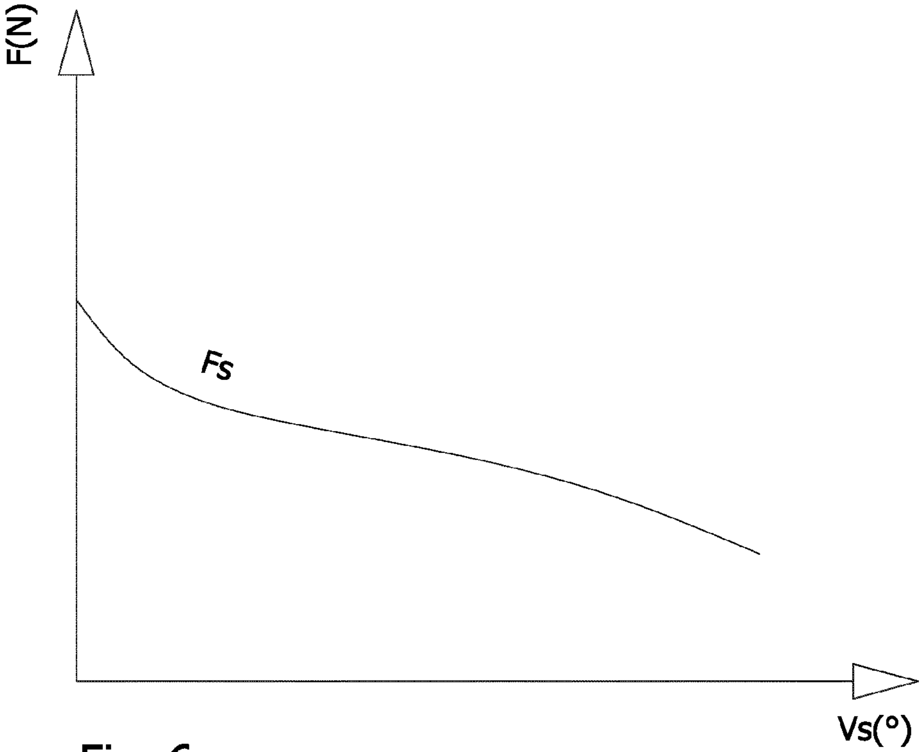

Fig. 6

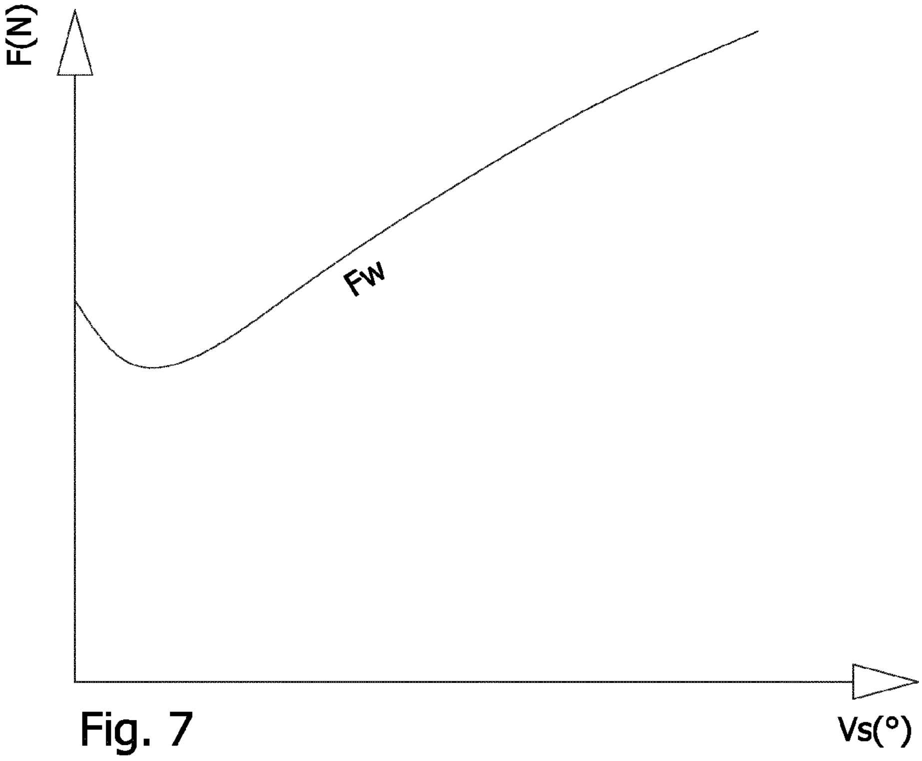

Fig. 7

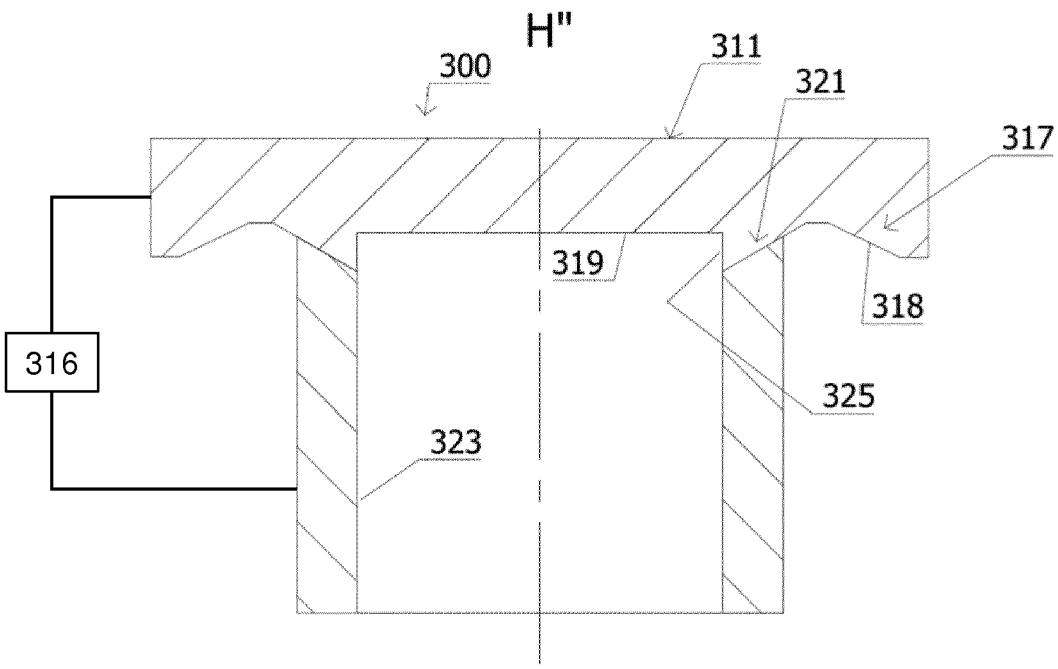

Fig. 8

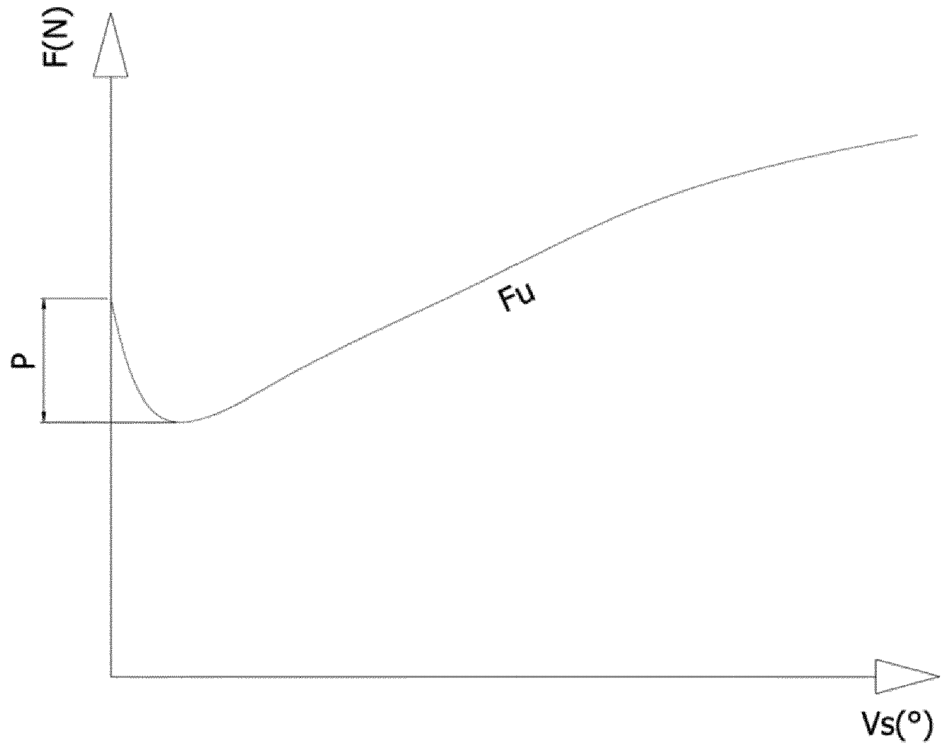

Fig. 11

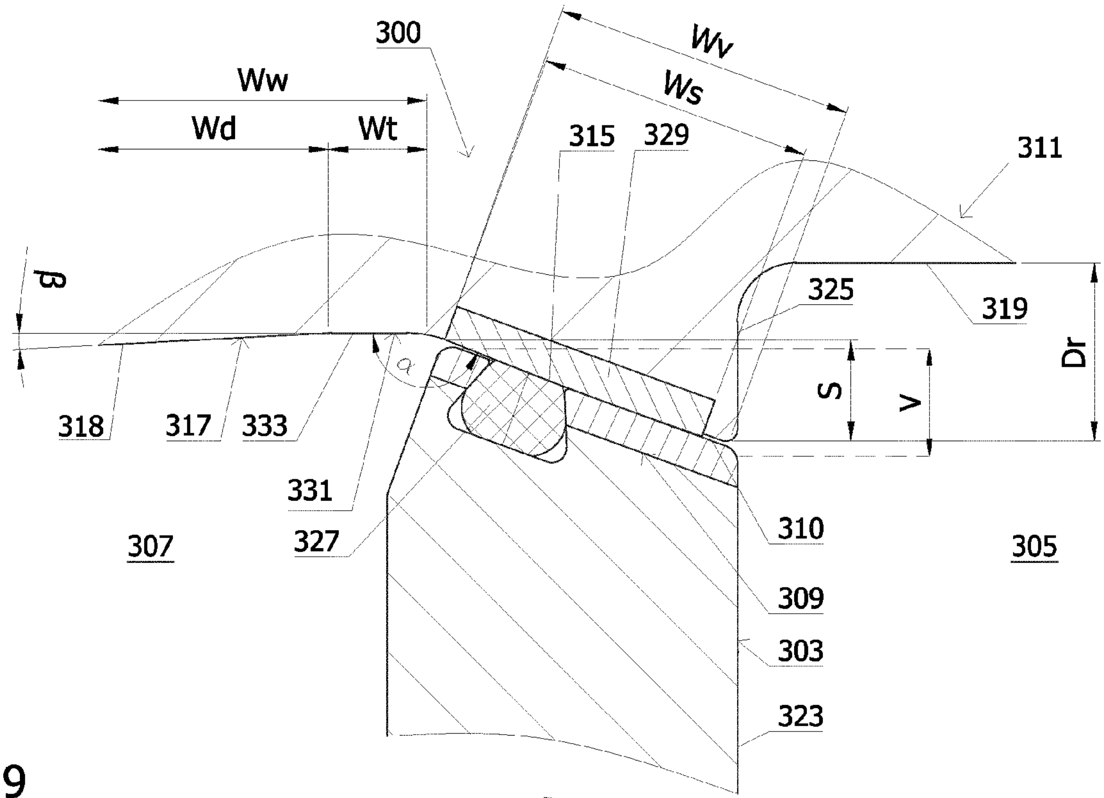
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Fig. 9

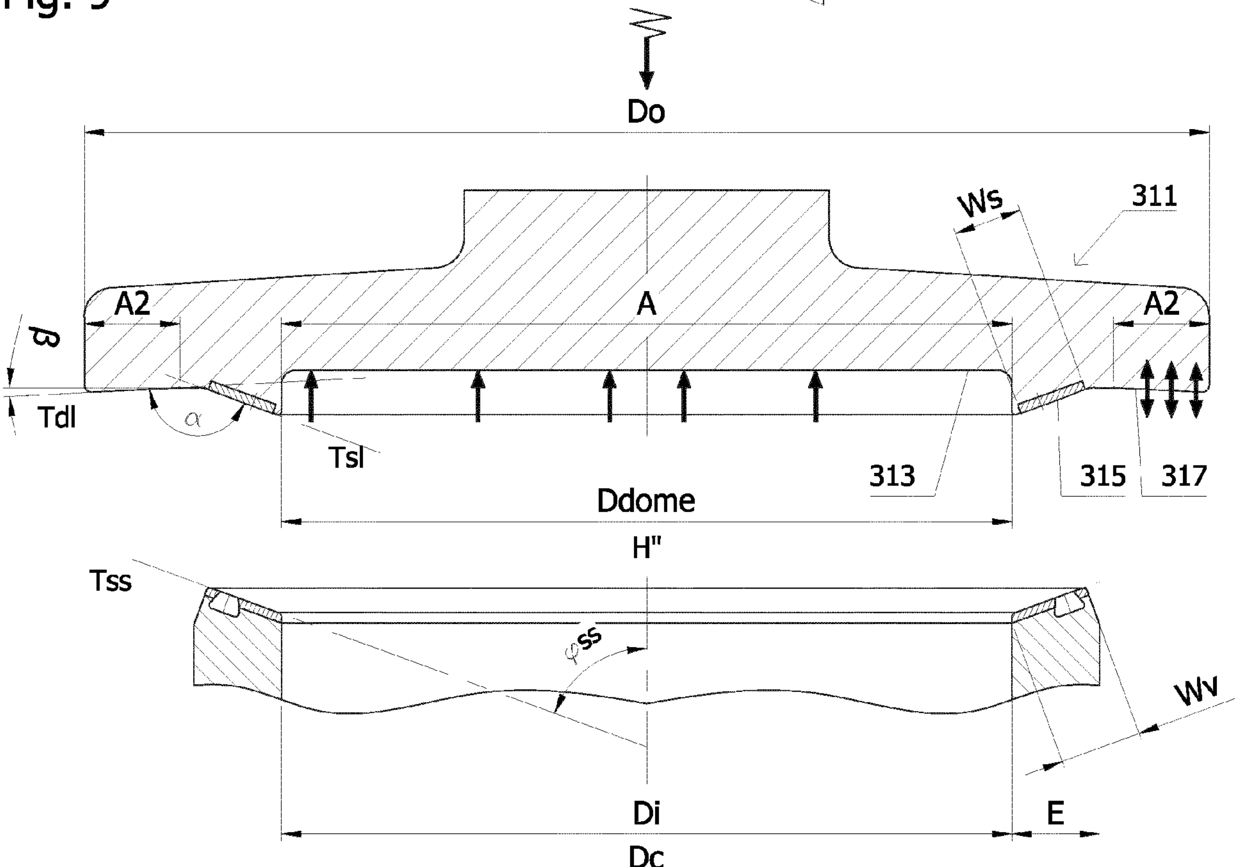
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Fig. 10

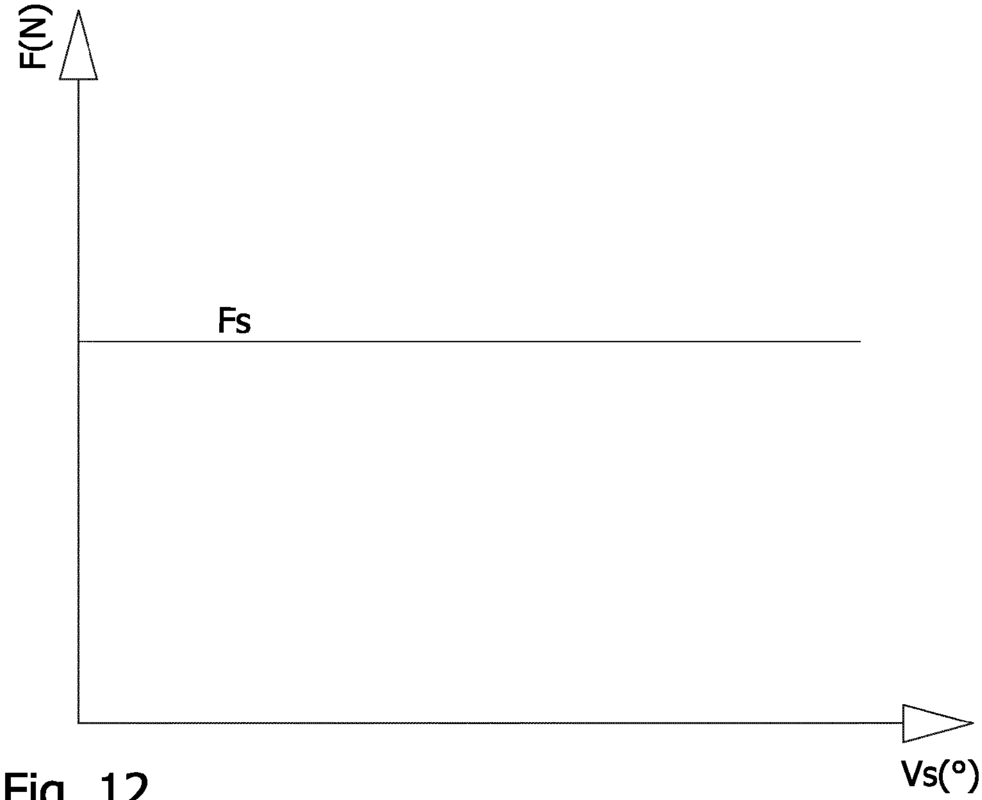

Fig. 12

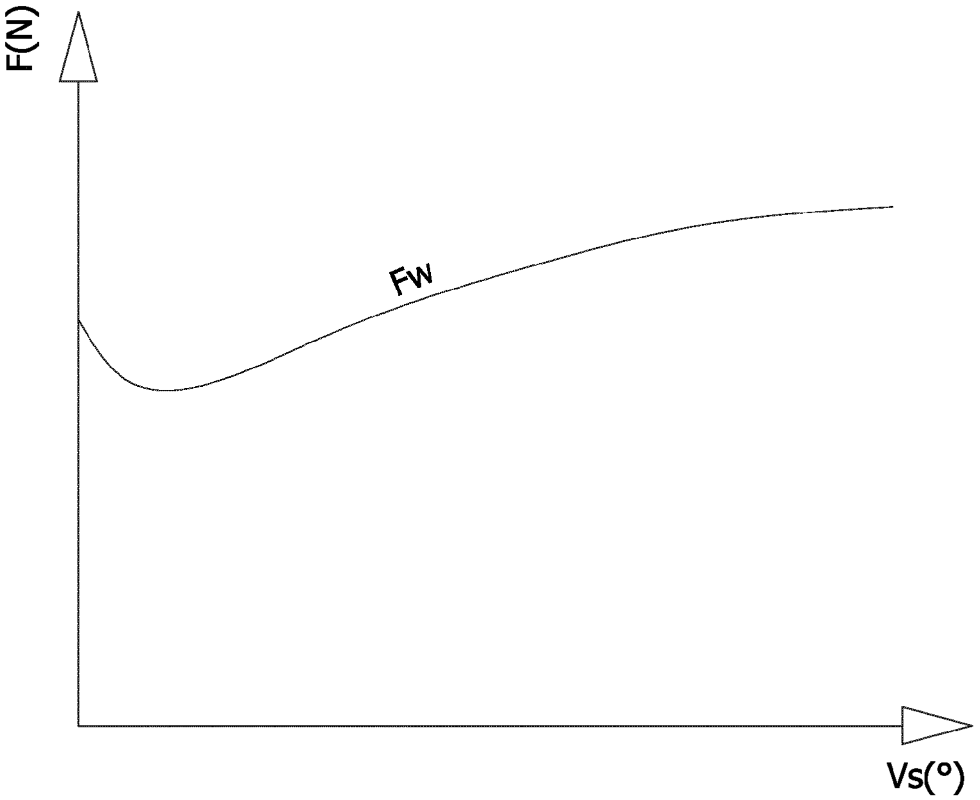

Fig. 13

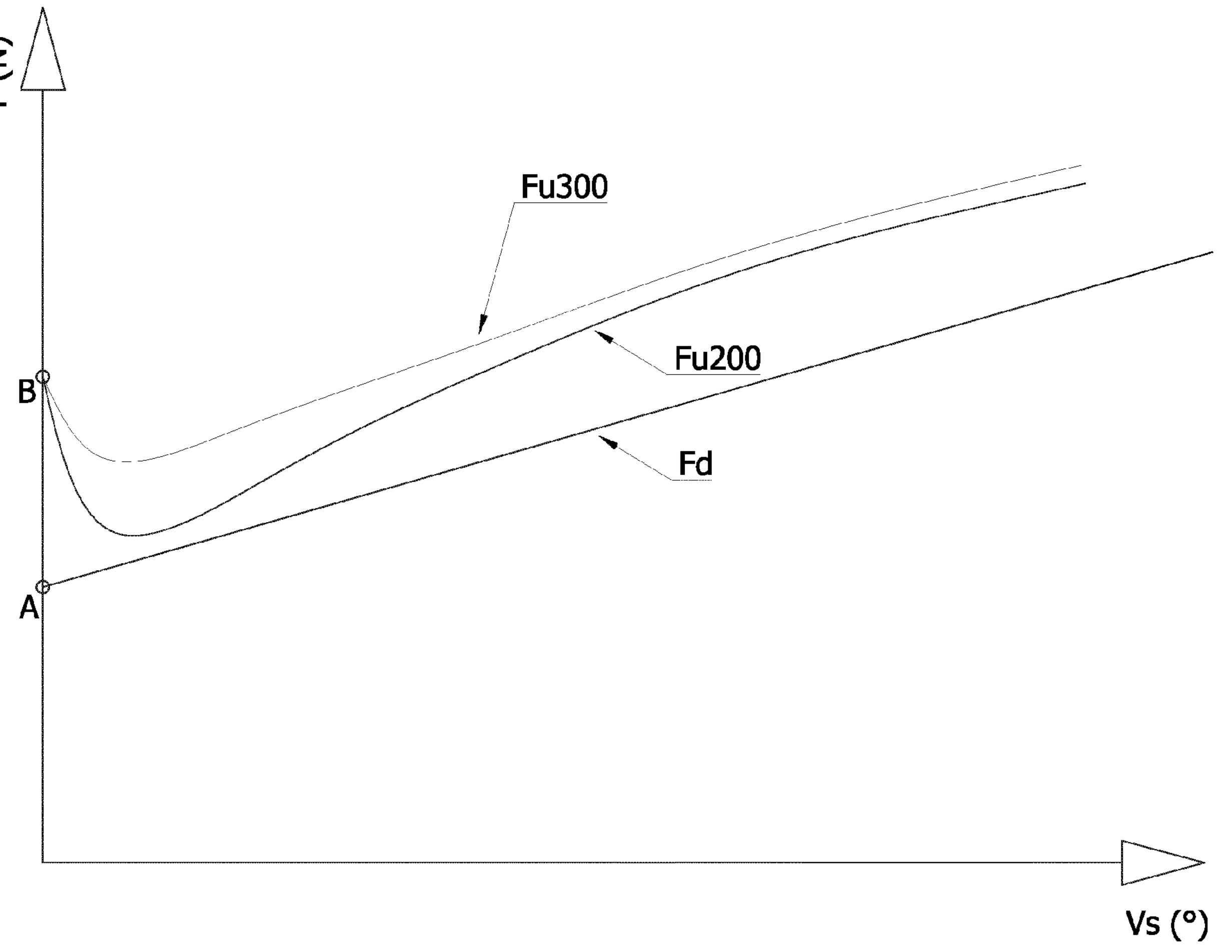

Fig. 14

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 0652

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	WO 2007/090747 A1 (WURTH PAUL SA [LU]; LONARDI EMILE [LU]; HAUSEMER LIONEL [LU]; FRANZISK) 16 August 2007 (2007-08-16) * figures 3-6 * * paragraph [0001] * * paragraph [0004] * * paragraph [0005] * * paragraph [0007] * * paragraph [0028] * -----	1-14	INV. C21B7/00
A	CN 205 874 462 U (HUATIAN NANJING ENG & TECH CORP MCC) 11 January 2017 (2017-01-11) * figure 1 * -----	1	
A	CN 2 753 738 Y (MA YING [CN]) 25 January 2006 (2006-01-25) * figure 1 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

C21B
F16K
F27D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	31 August 2017	Desvignes, Rémi

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 16 0652

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31-08-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007090747 A1	16-08-2007	AT 427364 T	15-04-2009
		AU 2007213830 A1	16-08-2007
		BR PI0707442 A2	03-05-2011
		CA 2637210 A1	16-08-2007
		CN 101379199 A	04-03-2009
		EA 200801768 A1	27-02-2009
		EP 1818418 A1	15-08-2007
		EP 1982000 A1	22-10-2008
		ES 2323522 T3	17-07-2009
		JP 4890567 B2	07-03-2012
		JP 2009526181 A	16-07-2009
		KR 20080091855 A	14-10-2008
		TW I402351 B	21-07-2013
		UA 92632 C2	25-11-2010
		US 2010201051 A1	12-08-2010
		WO 2007090747 A1	16-08-2007
		ZA 200806325 B	28-10-2009
CN 205874462 U	11-01-2017	NONE	
CN 2753738 Y	25-01-2006	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2007090747 A **[0004] [0025] [0040] [0070]**