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(54) **GAS BUBBLING ELEMENT AND CORRESPONDING GAS BUBBLING SYSTEM**

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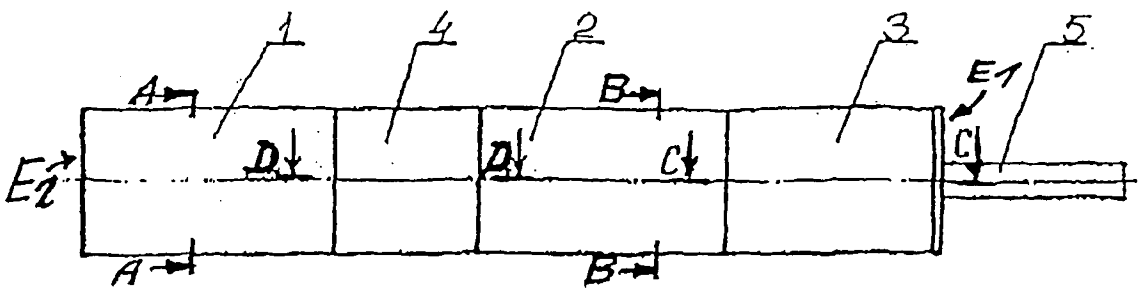
(57) **ABSTRACT**

The invention relates to a refractory ceramic gas bubbling element for a metallurgical crucible and to a corresponding gas bubbling system comprising such a gas bubbling element.



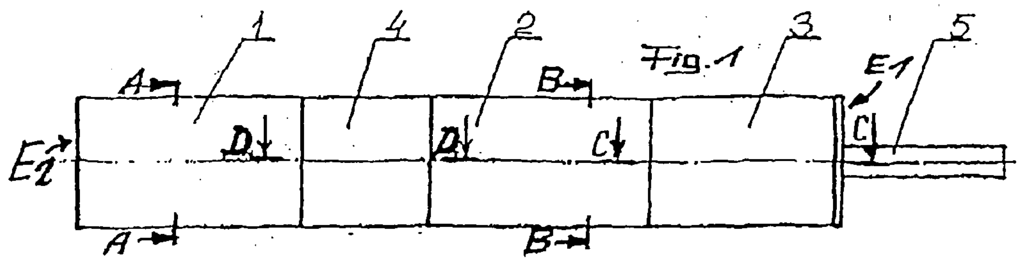


Fig.1

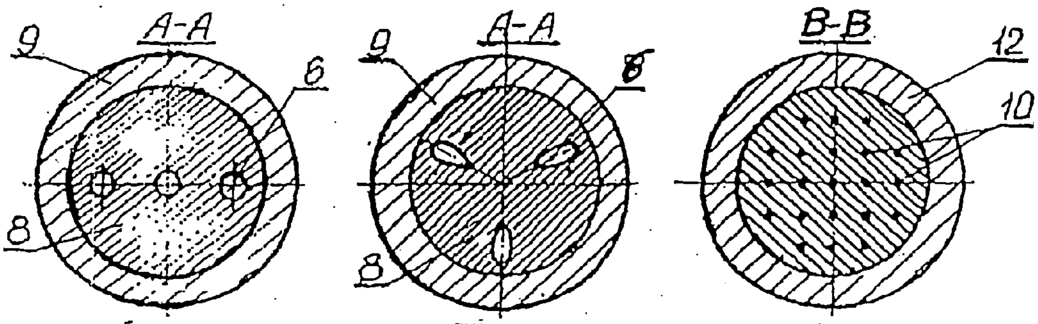


Fig.2 Fig.3 Fig.4

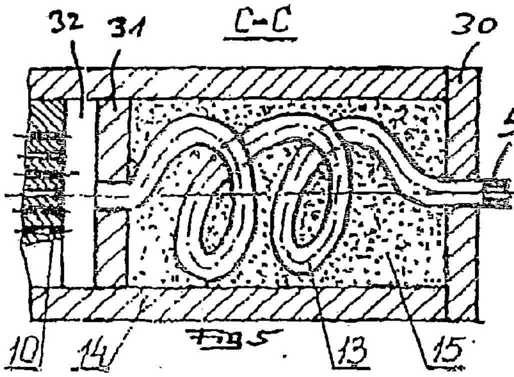


Fig.5

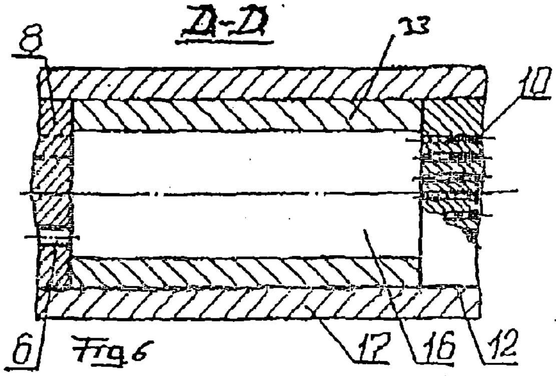


Fig.6

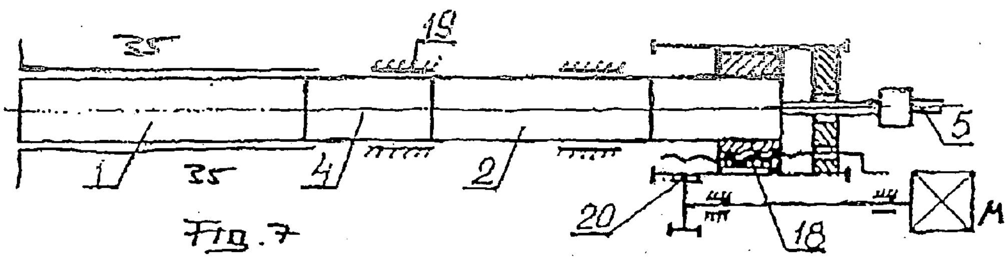


Fig.7

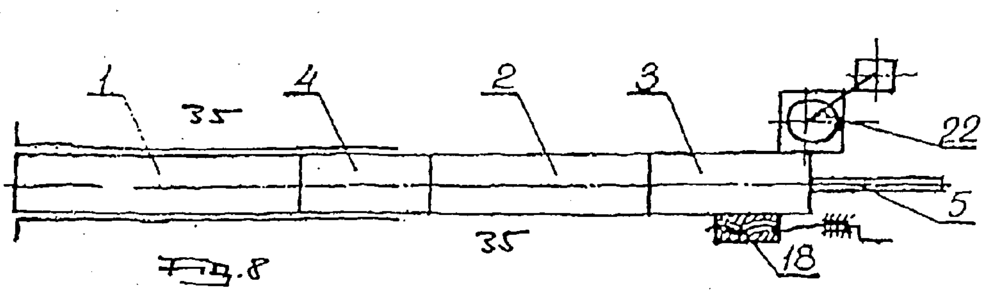


Fig.8

# GAS BUBBLING ELEMENT AND CORRESPONDING GAS BUBBLING SYSTEM

**[0001]** The present invention relates to a refractory ceramic gas purging element for a metallurgical melting vessel and an associated gas purging device having such a gas purging element.

**[0002]** Gas purging elements of the type cited have been known for many years. They are used for blowing gas, such as argon or nitrogen, into a metallurgical melt. The gas has different purposes: the metal melts may be homogenized using the gas. In addition, oxidation processes may be accelerated. One goal of the gas treatment may also be the removal of non-metallic inclusions in the melts or desulfurization and/or dephosphorization of a steel melt, for example.

**[0003]** Metallurgical melting vessels, in which gas purging elements of this type are used, are ladles or ladle furnaces, for example. Gas purging elements of the type cited are also used for vacuum treatment of a steel.

**[0004]** In this case, the gas is guided along the gas purging element between a first end, to which the gas is supplied, and a second end, at which the gas is released into the melt. Typically, the gas is conducted along via appropriate channels.

**[0005]** These channels may be implemented directly in the ceramic material through materials which may be burned out, for example. However, the channels may also be formed by pipes (tubes) which run in the ceramic material. These channels have different cross-sectional shapes. The flow cross-section is circular or slot-shaped, for example. The channels may run directly, i.e. axially, or even in a labyrinth from one end to the other end.

**[0006]** In addition, positioning a breakthrough guard at the first end of the gas purging element or in the gas purging element itself is known. Such a breakthrough guard is used for the purpose of stopping infiltration of metal melt into the gas purging element.

**[0007]** Known gas purging elements have a continuous circular cross-section, for example. In addition, gas purging elements shaped like truncated cones are also known, which are used as changeable purging elements. The gas purging elements may be inserted into a refractory framing block. This framing block is a component of the melting vessel, for example an electric arc furnace or a Siemens-Martin furnace. These purging elements are particularly installed into the bottom or the wall of the metallurgical melting vessel. Purging elements in the bottom may be positioned in such way that the gas is guided into the melt more or less perpendicularly to the surface of the bottom. However, positioning the purging elements diagonally in order to guide the gas to a specific point within the melt is also known. This is also true for the wall installation of the purging elements. The installation may be performed more or less horizontally, i.e., perpendicularly to the inner wall of the metallurgical vessel or inclined to the horizontal (to the melt bath surface).

**[0008]** The purging gas supply may be continuous or discontinuous. In any case, it is to be ensured that the gas purging device is always operational when it is required. This requires corresponding safety measures in order to prevent obstructions of the gas-conducting channels by metal melts or slag, for example.

**[0009]** In addition, it is to be ensured above all that the breakthrough of the metal melts already noted is prevented.

**[0010]** Accordingly, the present invention is based on the object of providing a gas purging element and an associated gas purging device which have a high safety standard, allow secure and regular gas supply into the metal melt, and may fulfill the desired metallurgical functions unrestrictedly.

**[0011]** In order to achieve this object, the present invention suggests a refractory ceramic gas purging element for a metallurgical melting vessel, which has the following sections, located between a first end, to which a gas is supplied, and a second end, at which the gas is released:

- **[0012]** at least one gas supply pipe discharges into the first end,
- **[0013]** the gas supply pipe discharges into a first gas distributor chamber,
- **[0014]** multiple capillary-type channels run from the first gas distributor chamber up to a second gas distributor chamber,
- **[0015]** at least one gas channel, whose cross-section is larger than that of a capillary channel, extends from the second gas distributor chamber up to the second end of the gas purging element.

**[0016]** Such a gas purging element has the following properties and advantages:

**[0017]** Although the gas purging element is divided into different, axially adjoining sections, continuous gas conveyance from the first (cold) end to the second (hot) end is ensured. The gas may be conducted via the gas supply pipe into the purging element. From there it reaches the first gas distributor chamber, from which the gas subsequently flows through multiple capillary-type channels in the direction toward the second end before it reaches a second gas distributor chamber. From there, the gas is guided via the cited larger channels up to the second end of the gas purging element and out of this end.

**[0018]** Such a gas purging element has multiple safety features:

**[0019]** If metal melt infiltrates into the gas channels which run from the second end in the direction toward the first end, the second gas distributor chamber is used as a "barrier" in order to prevent the further penetration of metal melt. Because the gas distributor chamber has a larger cross-section than the sum of the gas channels, the infiltrating metal melt may spread out, cool, and solidify. Further penetration in the direction toward the cold (first) end of the gas purging device is also prevented because capillary channels adjoin the other end of the second gas distributor chamber. These capillary channels are implemented having a significantly smaller flow cross-section than the gas channels in the region of the second end, so that the penetration of metal melt into the capillary channels is thus made more difficult.

**[0020]** For example, the gas channels in the region of the second end have an internal diameter>2 mm or >3 mm, while the internal-diameter of the capillary channels is selected as <1.0 mm.

**[0021]** However, even if metal melt should flow in and through the capillary channels, the gas purging element according to the present invention offers a further safety device by the first gas distributor chamber, in which a similar effect is achieved as already described on the basis of the second gas distributor chamber.

**[0022]** Finally, in one embodiment the present invention provides a fourth safety measure. This safety measure is that the gas supply pipe discharging into the first gas distributor chamber is implemented having a length which is greater than the axial distance between the first end of the gas purging element and the first gas distributor chamber. In other words: the gas supply pipe is not to run linearly, but rather is to have at least one, preferably multiple curved (angled) sections in order to lengthen the flow path. In this case, the gas supply pipe may be curved like a helix or spiral and/or meander. The flow path of the gas is lengthened by multiple "branches", which do not interfere in principle, but also lengthen the path for any penetrating metal melt, which is thus forced to cool and solidify.

**[0023]** In this case, the gas supply pipe may be made of a material which melts at a temperature below the temperature of a metallurgical melt to be treated. Therefore, if metal melt penetrates into this region, the gas supply pipe will melt. If the gas supply pipe is placed within a bulk material, as provided according to a further embodiment, the metal melt may diffuse into this section of the gas purging element, i.e., branch out, through which the solidification behavior is accelerated once again. It is obvious that the bulk material must be arranged in a corresponding external receiver (made of metal or dense ceramic, for example), so that the melt does not diffuse radially in an uncontrolled way. The receiver is in turn enclosed by refractory material.

**[0024]** As far as sections along the longitudinal axis are concerned, these do not have to be physically separated. The concept is rather to be understood functionally. Thus, the individual sections may have an identical cross-sectional shape, may be implemented having a circular cross-section, for example, so that an external cylindrical shape results overall for the gas purging element. The individual sections may be attached to one another.

**[0025]** However, all sections may also be assembled in a common refractory matrix. In this case, the gas purging element may have a constant cross-section over its entire length, such as a circular cross-section. It is also possible to vary the cross-section from the first end to the second end, to reduce it, for example, so that a type of truncated cone shape arises. In this way, the gas purging element may particularly be used as an exchangeable element.

**[0026]** In the event of a uniform cross-section, particularly a circular cross-section, the possibility suggests itself for the associated gas purging device of moving and/or rotating the gas purging element in the axial direction. For this purpose, the gas purging device is implemented having a corresponding drive. This drive may be implemented for alternating axial and/or rotational movement of the gas purging element. For example, the purging element may alternately be moved axially back and forth by a few millimeters (for example, +/−3 mm) or may be rotated by a few degrees in one and/or the other direction. The drive may also be used for the purpose of pushing the purging element in the axial direction, i.e., advancing it in the direction toward the melt when the purging element is partially worn in the region of the second end, for example.

**[0027]** As already noted, the cross-section of the first and second gas distributor chambers is to be larger than the sum of the cross-sectional areas of the adjoining capillary channels in order to produce a diffusion chamber for any penetrating melt and ensure gas supply into the capillaries and/or out of the capillaries.

**[0028]** According to one embodiment, the flow cross-section (i.e., the fluidically active cross-section) of a capillary channel is at least 50% smaller than the flow cross-section of a gas supply pipe at the first end and/or the flow cross-section of a gas channel at the second end. In this case, the flow cross-section of each capillary channel may also be significantly smaller than the 50% cited in relation to the gas supply pipe and/or the gas channels, for example, 70, 80, or 90% smaller.

**[0029]** According to one embodiment, the gas channels are designed slot like at the second end, i.e., they have a rectangular cross-section, for example. The gas channels may also be implemented having a triangular or drop-shaped flow cross-section. It has been shown to be favorable in this case if, with a drop-shaped cross-sectional geometry, the channels (tubes) are positioned in such a way that the narrower end faces toward the central longitudinal axis of the gas purging element, as also represented in the following description of the figures.

**[0030]** The gas distributor chambers may be implemented in situ in the ceramic matrix material of the gas purging element. However, the gas distributor chambers may also be formed by metallic cavities which the associated gas channels and/or capillary channels discharge into.

**[0031]** While the capillary channels may be positioned essentially axially, i.e., parallel and at a distance to one another, the gas channels in the region of the second end of the purging element may be positioned in different ways:

**[0032]** For example, with gas channels having the cited drop-shaped geometry, one embodiment provides that the channels are positioned distributed "symmetrically" over the cross-section. For example, with three channels, the individual channels may—in comparison to a clock—be positioned at the 6 o'clock, 10 o'clock, and 2 o'clock positions.

**[0033]** In another embodiment, particularly if gas channels having a circular cross-section or slot-type channels are selected, these channels may run along an imaginary line and at a distance to one another, this line running horizontally in a purger which is installed into a wall of the vessel, for example.

**[0034]** The channels and chambers are always enclosed by refractory ceramic material (matrix material). This material may be cast or pressed. An external envelope is not necessary. The ceramic purging element may be installed in this way.

**[0035]** Further features of the present invention are the disclosed in the subclaims and the other documents of the application.

**[0036]** The invention will be illustrated in the following on the basis of different figures, the figures being purely schematic for better illustration.

**[0037]** FIG. **1**: shows a side view of a gas purging element according to the present invention,

**[0038]** FIG. **2**: shows a section along line A-A shown in FIG. **1**,

**[0039]** FIG. **3**: shows an alternative embodiment to the exemplary embodiment shown in FIG. **2**,

**[0040]** FIG. **4**: shows a section along line B-B in FIG. **1**,

**[0041]** FIG. **5**: shows a section C-C in the longitudinal direction in the region of the first end of the purging element having attached first gas distributor chamber,

**[0042]** FIG. **6**: shows a section D-D in the longitudinal direction through the second gas distributor chamber,

**[0043]** FIG. **7**: shows a side view of a gas purging device having a purging element which is guided on bearings,

**[0044]** FIG. **8**: shows a view of a gas purging device having a gas purging element which is axially movable via a drive.

**[0045]** Identical or identically acting components are shown having identical reference numbers in the figures.

**[0046]** A gas purging element according to the present invention is illustrated in FIG. **1**. The construction of the gas purging element (from right to left) is as follows:

**[0047]** A gas supply pipe **5** discharges at E**1** into a first section **3**, which is delimited at its front face by a steel plate **30** and around its circumference by a steel pipe **14**. The gas supply pipe **5** continues in a helix behind the steel plate **30**, the helix being shown by the reference number **13**. The helix **13** runs in a space which is filled with a bulk material **15**, based on expanded perlite, for example, and is delimited at a distance to the steel plate **30** by a further steel plate **31**, through which the helix **13** is guided.

**[0048]** A first gas distributor (distribution) chamber **32**, which is delimited around the circumference by the extended steel pipe **14**, adjoins the steel plate **31**.

**[0049]** A section **2**, whose cross-section is shown in FIG. **4**, follows in the flow direction of the gas. A refractory ceramic material, in which multiple capillary channels **10** run in the axial direction of the purging element, is located within a cylindrical frame **12** made of steel (in the extension of the pipe **14**). The capillary channels (formed by steel tubes) have a circular cross-section having an internal diameter of 0.5 mm.

**[0050]** The gas guided via the gas supply pipe **5** in the helix **13** via the first gas distributor chamber **32** flows through the capillaries **10** into an adjoining first gas distributor chamber **16** (FIG. **6**), which is delimited on the inside by a tubular body **33**, which lies in an external envelope **17**. Tubular body **13** and envelope **17** may be made of metal or refractory ceramic.

**[0051]** The gas which was guided through the second gas distributor chamber **16** subsequently reaches gas channels **6**, which run axially and at a distance to one another in a ceramic matrix material **8** (FIGS. **2**, **3**) up to the front face of the second end E**2** of the gas purging element.

**[0052]** As shown in FIG. **2**, three gas channels **6** having a circular cross-section are positioned along an imaginary horizontal line. Each of the gas channels **6** has an internal cross-section of 2 mm. FIG. **3** shows an alternative embodiment, in which the three gas channels **6** each have a drop shape, the gas channels **6**—in comparison with a clock—being positioned at 6 o'clock, 10 o'clock, and 2 o'clock. The alignment of the gas channels **6** is such that the narrower, approximately triangular end always lies on the inside.

**[0053]** This section **1** of the purging element is in turn delimited around its circumference by a metal pipe **9**.

**[0054]** The external frames (pipe segments) of the individual sections, which are each made of ceramic or metal parts, are mechanically connected to one another, the end sections being designed as stepped and having corresponding threads. The purging element illustrated in FIG. **1** is completely mantled by refractory material. It is also possible to assemble the entire gas purging element within a continuous tubular envelope or to avoid the envelope completely. In this case, the gas distributor chambers **16**, **32** and the different channels are implemented within a ceramic matrix material.

**[0055]** The gas supply pipe **5**, the capillary channels **10**, and also the gas channels **6** are formed by metal tubes, but may also be implemented in situ, during manufacturing, for example, by arranging materials with corresponding cross-sections at the respective places, which materials are later burned out. This applies analogously for implementing cavities (gas distributor chambers) in the ceramic basic body.

**[0056]** The gas flows from the first end E**1** through the adjoining sections up to the gas outlet end, which is identified in FIG. **1** by E**2**.

**[0057]** The function of the purging element was already described in the explanation of the present invention. It is also to be noted that the helix **13** is made of copper here, i.e., a metal having a relatively low melting point.

**[0058]** As shown in FIG. **7**, the purging element is guided in the axial direction by multiple bearings **18**, **19**. These are roller bearings. The tubular purging element may be rotated alternately left and right via a motor M and a gear **20**. The drive is placed externally on the melting vessel.

**[0059]** In the exemplary embodiment shown in FIG. **8**, a gear **22** is illustrated, by which continuous oscillating movements (e.g., sinusoidal movements) may be transmitted to the purging element in order to move it back and forth a few millimeters at a time in the axial direction, for example.

**[0060]** It is obvious that the gas purging element must be positioned in a corresponding refractory frame in the bottom or the wall of an associated metallurgical vessel, and, in the exemplary embodiments shown in FIGS. **7** and **8**, in such a way that the rotational movement and/or axial movement of the purging element may be ensured. The refractory material of the wall and/or the bottom of the metallurgical vessel is symbolized in FIGS. **7** and **8** by the reference number **35**.

**1**. A refractory ceramic gas purging element for a metallurgical melting vessel, having sequential sections (**3**, **2**, **4**, **1**) between a first end (E**1**), to which the gas is supplied, and a second end (E**2**), at which the gas is released:

- a) at least one gas supply pipe (**5**) discharges into the first end E**1**,
- b) the gas supply pipe (**5**) discharges into a first gas distributor chamber (**32**);
- c) multiple capillary-type channels (**10**) run from the first gas distributor chamber (**32**) up to a second gas distributor chamber (**16**),
- d) at least one gas channel (**6**), whose flow cross-section is larger than that of a capillary channel (**10**), extends from the second gas distributor chamber (**16**) up to the second end (E**2**) of the gas purging element.

**2**. The gas purging element according to claim **1**, whose first and second gas distributor chambers (**32**, **16**) each have a cross-section which is larger than the sum of the cross-sectional areas of the capillary channels (**10**).

**3**. The gas purging element according to claim **1**, wherein the gas supply pipe (**5**) discharging into the first gas distributor chamber (**32**) has a length which is greater than the axial distance between the first end (E**1**) and the first gas distributor chamber (**32**).

**4**. The gas purging element according to claim **3**, wherein the gas supply pipe (**5**) is curved as a helix or spiral and/or meander.

**5**. The gas purging element according to claim **3**, wherein the gas supply pipe (**5**) is made of a material which melts at a temperature below the temperature of the metallurgical melt to be treated.

**6**. The gas purging element according to claim **3**, wherein the gas supply pipe (**5**) is arranged in a bulk material (**15**).

**7**. The gas purging element according to claim **1**, wherein the capillary channels (**10**) each have a flow cross-section which is at least 50% smaller than the flow cross-section of the gas supply pipe (**5**) at the first end (E**1**) and/or of the gas channel (**6**) at the second end (E**2**).

**8**. The gas purging element according to claim **1**, wherein the capillary channels (**10**) each have a flow cross-section which is at least 90% smaller than the flow cross-section of the gas supply pipe (**5**) at the first end (E**1**) and/or of the gas channel (**6**) at the second end (E**2**).

**9**. The gas purging element according to claim **1**, wherein the individual sections (**3**, **2**, **4**, **1**), which are connected to one another, are each arranged in a pipe (**14**, **12**, **17**, **9**) made of steel or refractory ceramic material.

**10**. The gas purging element according to claim **1**, wherein the sections (**3**, **2**, **4**, **1**) are arranged in a common pipe made of steel or refractory ceramic material.

**11**. The gas purging element according to claim **1**, wherein the gas channel(s) (**6**) at the second end (E**2**) has/have a slot-type, triangular, or drop-shaped flow cross-section.

**12**. The gas purging element according to claim **1** having multiple gas channels (**6**) at the second end (E**2**), which extend at a distance to one another along an imaginary line between the second gas distributor chamber (**16**) and the second end (E**2**).

**13**. The gas purging element according to claim **1**, which has a circular cross-section over its entire length.

**14**. The gas purging element according to claim **13**, whose cross-section is reduced from the first end. (E**1**) to the second end (E**2**).

**15**. A gas purging device having a gas purging element according to claim **1** and a drive (M) for the axial and/or rotational movement of the gas purging element.

**16**. The gas purging device according to claim **15**, wherein the drive (M) is designed for alternating movement of the gas purging element.

* * * * *