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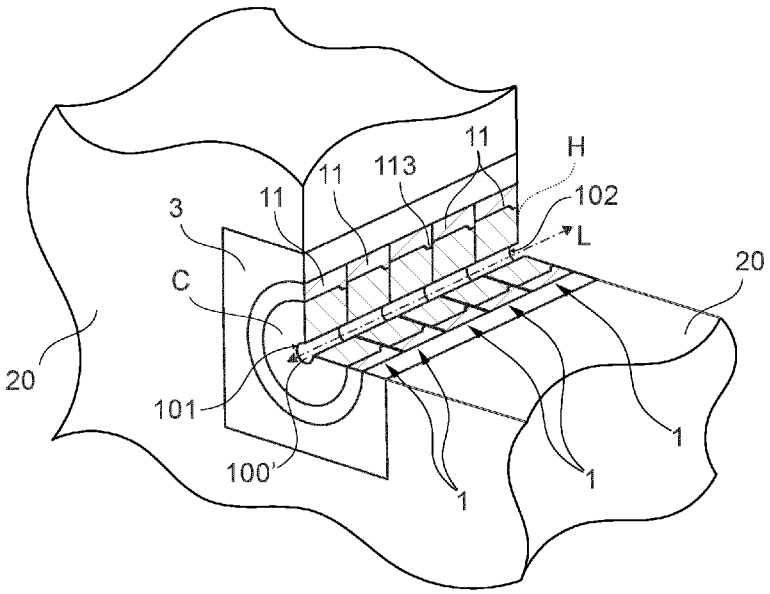


Fig. 3a

(57) **Abstract:** To increase safety accessing the inside of a metallurgical vessel during maintenance, a taphole system of a taphole socket (3) and at least one taphole insert (1) being inserted form-fittingly into the taphole socket (3) is provided. The at least one taphole insert (1) comprises a refractory body (10) having a first end (101) with a first end surface (C) and a second end (102) with a second end surface (H) and having an outer surface (O) connecting the first end (101) and the second end (102) in a throughout direction (L), the refractory body (10) comprising a through hole (100) for extracting molten material, connecting the first end (101) and the second end (102) in the throughout direction (L). The at least one taphole insert (1) comprises a hull (11), comprising metal and/or graphite, at least partially covering the outer surface (O) of the refractory body (10) and the taphole socket (3) is mountable in a wall (20) of a metallurgical vessel such that a hot side and a cold side of the metallurgical vessel are connected by the through hole (100).

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TAPHOLE SYSTEM

The current disclosure relates to a taphole system of a taphole socket and at least one taphole insert being inserted form-fittingly into the taphole socket.

To generally access the inside of a metallurgical vessel, a refractory material in form of one or more refractory bricks or sleeves having a through hole can be installed in a wall of said metallurgical vessel such that the cold side and the hot side of the metallurgical vessel and thus of the wall are connected by the through hole.

A taphole made of refractory material can be used to extract molten material, i.e., molten metal, molten slag, or both, from a metallurgical vessel. The taphole comprises a through hole and is installed in a wall of the metallurgical vessel, so that the through hole fully penetrates the wall and thus connects the cold side and the hot side of the metallurgical vessel. Molten material can be extracted from the metallurgical vessel through the through hole.

A cooling unit can be arranged around the taphole to cool said taphole. For example, a water-cooled copper cooler can be used as cooling unit. If the taphole penetrates the wall of the metallurgical vessel all the way to the hot side and the cooling unit is provided along the whole length of the taphole, the cooling unit itself is exposed to the hot side. If leakage of the cooling liquid of the cooling unit occurs, this can lead to risk of explosion.

If a taphole should be repaired or replaced, said taphole made of refractory material in form of one or more refractory bricks or sleeves can be broken out from the wall of the metallurgical vessel by a worker, e.g., by using a jackhammer. This leads to safety issues for the worker and if a cooling unit is used, it also might damage or destroy said cooling unit.

Alternatively, also a cooling unit without additional refractory material/bricks can be used as a taphole, the cooling unit having a through hole and being supplied with or without a non-cooled additional refractory element on the hot side. A protective layer consisting of solidified ("frozen") material (slag and/or metal) forms on the

inner surface of the through hole of the cooling unit during operation. However, in this case the lifetime of the cooling unit is reduced, and the cooling unit has to be changed more often which again leads to hazardous work for the operator.

For maintenance of the taphole's cold side, the cooling unit can also be used to completely block the through hole on the hot side by solidifying the molten material (slag and/or metal) inside the through hole. By doing this the metallurgical vessel does not have to be emptied during maintenance as the through hole is blocked by solidified material.

It is an object of the current disclosure to provide a taphole system for accessing the inside of a metallurgical vessel that increases safety during maintenance.

This object has been achieved by a taphole system of a taphole socket and at least one taphole insert, the at least one taphole insert being inserted form-fittingly into the taphole socket, wherein the at least one taphole insert comprises a refractory body having a first end with a first end surface and a second end with a second end surface and having an outer surface connecting the first end and the second end in a throughout direction. The refractory body comprises a through hole suitable for extracting molten material, connecting the first end and the second end in the throughout direction. The at least one taphole insert comprises a hull, comprising metal and/or graphite, at least partially covering the outer surface of the refractory body. The taphole socket is mountable in a wall, e.g., a side wall or a bottom wall, of a metallurgical vessel such that a hot side and a cold side of the metallurgical vessel are connected by the through hole.

The wall can comprise a lining layer on the hot side and a steel coating layer on the cold side. When the taphole socket is mounted in the wall, the throughout direction generally points from the cold side to the hot side of said wall. When the wall is a side wall, the throughout direction preferably generally points horizontally from the cold side to the hot side; when the wall is a bottom wall the throughout direction preferably generally points vertically from the cold side to the hot side of the wall. As the at least one taphole insert und thus at least part of the outer surface of the hull (depending on structure of the hull and coverage of the outer

surface of the refractory body) is in form-fitting contact to the inner surface of (the hole of) the taphole socket, the at least one taphole insert can easily be inserted and/or removed from the taphole socket. This is because metal and graphite allow for lower manufacturing tolerances compared to refractory material and therefore can be fitted to the taphole socket (which can comprise refractory material or metal) more exactly. Also, metal and graphite show less friction than refractory material and therefore the at least one taphole insert having a hull can be inserted and/or removed from the taphole socket in the wall with less friction and thus less force compared to tapholes without a hull. Thus, easy and quick maintenance is possible and therefore safety for the operators is increased. The taphole socket comprises a hole, having an inner surface. The refractory insert is inserted into said hole. As the taphole socket does not experience much wear during operation, it can be mounted in the wall either for the whole lifetime of the refractory lining or at least for an extended period whereas the at least one taphole insert, which experiences much more wear, can be changed easily and more often. Another benefit of using a hull is control of crack patterns by protection of the taphole insert against radial cracking. If a radial crack forms in the refractory body the hull stays intact and thus prevents or reduces radial propagation of the crack. Even if the refractory body is radially cracked, the hull still stays intact.

The taphole system can be provided in a side wall of a metallurgical vessel. Sometimes, when the wall has two short segments and two long segments, the long segments are called side wall, but the short segments are called end wall. The taphole system can also be provided in a bottom wall of a metallurgical vessel which can be particularly preferential for steel Electric Arc Furnaces (EAFs) due to subsequent process requirements or due to other requirements by casting vessels.

The at least one taphole insert of the taphole system can be changed quickly and can even be changed by a robot. The robot can be remotely controlled which leads to safe working environment without the immediate presence of operators.

The taphole system disclosed herein can be constructed to be compatible with other devices such as slide gates, mud-guns, drilling machines, robotics etc.

Usage of the taphole system disclosed herein is particularly beneficial for usage in walls of metallurgical vessels in form of industrial and/or metallurgical furnaces e.g., smelting and melting furnaces, converting furnaces, refining furnaces, slag cleaning furnaces, holding furnaces, induction furnaces, casting furnaces, through different industries e.g., iron and steel including green steel processes, copper, ferro-alloy, lead, nickel, precious metals incl. PGM, Ilmenite.

If a dimension in transverse direction (transverse to the throughout direction) refers to a spherical or cylindrical object (a through hole, a taphole insert etc.), the dimension in transverse direction equals the diameter of this object.

Preferably the at least one taphole insert has a dimension in transverse direction (transverse to the throughout direction) in the range of 220 mm to 400 mm, most preferably in the range of 260 mm to 325 mm. This is particularly beneficial for an easy and fast fitting into the taphole socket.

Preferably the through hole has a dimension in transverse direction (transverse to the throughout direction) in the range of 30 mm to 250 mm, most preferably in the range of 50 mm to 120 mm. This is particularly beneficial for extracting molten metal.

Preferably the through hole has a dimension in transverse direction (transverse to the throughout direction) in the range of 50 mm to 250 mm, most preferably in the range of 60 mm to 150 mm. This is particularly beneficial for extracting slag.

Preferably the through hole has a dimension in transverse direction in the range of 30 mm to 120 mm, the refractory body has a dimension in transverse direction in the range of 200 mm to 400 mm. This combination or dimensions is particularly beneficial for extracting metal.

Preferably the through hole has a dimension in transverse direction in the range of 120 mm to 250 mm, the refractory body has a dimension in transverse direction in the range of 300 mm to 500 mm. This combination of dimensions is particularly beneficial for extracting metal and slag.

Preferably the hull has a thickness in the range of 2 mm to 80 mm, most preferably in the range of 10 mm to 35 mm. This is particularly beneficial to allow proper stability, in particular during pulling on the taphole system by the hull, while having a refractory body containing a proper amount of refractory material.

Preferably the at least one taphole insert has a length in the throughout direction in the range of 100 mm to 250 mm, most preferably in the range of 125 mm to 175 mm. A plurality of taphole inserts might be used if a wall has a thickness, and thus the taphole socket has a length, greater than the length of a single taphole insert. Depending on the metallurgical vessel the wall thickness can be in the range of 250 mm up to 2500 mm.

One or more additional material layers can be provided between the refractory body and the hull. Additional material layers can be thermal insulating layers and/or filling layers. Using thermal insulating layers can be beneficial to adjust and optimize heat transfer between the refractory body and the hull and thus the taphole socket based on individual requirements, e.g., according to the industry or vessel the taphole system is being used in. A filling layer can be used to connect the refractory body to the hull to achieve a force-fitted contact. Preferably (refractory) mortar is used as additional material layer.

The hull can comprise, preferably at least 50%, most preferably at least 90% graphite or can be fully made of graphite which enables easy manufacturing.

The hull can comprise, preferably at least 50%, most preferably at least 90% metal, or fully be made of metal which enables easy and cost-efficient manufacturing. If metal is used, it can be chosen of at least one of steel, (casting) iron, titanium, copper. These metals allow particularly low manufacturing tolerances and low friction. Using steel is most preferable due to a good compromise of various properties as low cost, high mechanical strength and good processability.

The refractory body of the at least one taphole insert comprises refractory material, e.g., oxide and/or non-oxide refractory material. The refractory material of

the refractory body can be chosen according to properties of molten material to be extracted through the through hole. Preferably the material of the refractory body comprises at least one of the oxides magnesia, alumina, zirconia, chromium-oxide, silica, e.g., compounds containing one of those oxides, e.g., spinel and/or mullite. The refractory body can also comprise silicon carbide and/or carbon. If a plurality of refractory materials is used, said plurality of materials can be provided as various layers and/or mixed. Using a plurality of refractory materials can be beneficial because it allows to mix refractory materials with different properties, such as corrosion resistance, resistance to crack formation etc. Also, mixing high performance and low-cost materials is possible. The refractory body can comprise layers of different refractory materials in a direction transverse to the throughout direction (i.e., from the through hole to the hull), wherein, e.g., the inner (i.e., located closer to the through hole) refractory material shows high corrosion resistance, and the outer (i.e., located closer to the hull) refractory material shows high resistance to crack formation. Preferably (refractory) mortar is applied between different refractory layers.

While the material of the hull allows low manufacturing tolerances, the material of the refractory body is chosen appropriate for the molten material being channeled through the through hole.

Preferably, the hull completely covers the outer surface of the refractory body which allows for low friction and easy production of the at least one taphole insert. The hull can also, in addition to (at least partially) covering the outer surface, cover also the first and/or second end surface of the refractory body. Is can also be beneficial for the hull to only partly cover the outer surface of the refractory body to save material or to adjust heat transfer between the refractory body and the taphole socket.

The refractory body can have the shape of a (hollow) cylinder having an axis in throughout direction, preferably the through hole being arranged along the axis. In this case the hull can have the form of a tube and the taphole socket can have a circular hole for the taphole insert to be fitted. The refractory body may also have the shape of a cuboid or any other suitable shape.

Preferably the hull has a portion gripping into the refractory body, preferably at the second end. The portion gripping into the refractory body can ensure connection between the hull and the refractory body by which it can be assured that when the hull is pulled, the refractory body is pulled with the hull and the taphole insert is not disassembled. The portion can be arranged circumferential which allows even connection. Preferably the portion is circumferentially continuous, if the hull is rotationally symmetric (e.g., a cylinder) the portion might be ring-shaped. The portion might also be circumferentially non-continuous, e.g., in the form of teeth gripping into the refractory body.

The hull has an inner dimension in transverse direction, the inner dimension preferably being constant along the throughout direction, and an outer dimension which is preferably constant along the throughout direction. The thickness of the hull is the distance between the inner dimension and the outer dimension; preferably the hull has a thickness being constant along the throughout direction.

The abovementioned portion gripping into the refractory body can be embellished as an area with a reduced inner dimension, wherein preferably the outer dimension of the hull is not reduced in this area leading to an increased thickness of the hull in this area.

The hull can comprise at least one hole on the first end, preferably arranged along the throughout direction. The at least one hole can penetrate the hull partially or completely and can be used for positioning a sensor. The dimensions of the hole can be chosen based on to the hull thickness, preferably the dimension in transverse direction (i.e., transverse to the throughout direction) does not exceed 90%, preferably does not exceed 80% of the hull thickness, such that the hull integrity is not compromised.

Preferably a gripping pin is inserted in the at least one hole. By introducing the gripping pin, the taphole insert can be gripped and manipulated, in particular removed from the taphole socket, in an easier and safer way.

Preferably, the transverse dimension (transverse to the throughout direction) of the at least one hole is at least 5 mm, preferably at least 10 mm, in particular if a gripping pin is used, to enable sufficient structural stability when the gripping pin is grabbed to manipulate the taphole insert.

The hull can be even on its outer hull surface. If the inner surface of the hole of the taphole socket is also even, a perfect fit between the taphole socket and the at least one taphole insert can be achieved.

The hull can comprise on its outer hull surface at least one recess and/or at least one ridge arranged along the throughout direction. In particular, if the inner surface of the hole of the taphole socket is even, the at least one recess and/or at least one ridge in the throughout direction can be used for easier gripping and removal of the at least one taphole insert, e.g., by a robot, and/or for thermal insulation which can be beneficial to adjust and optimize heat transfer between the refractory body and the taphole socket based on individual needs, e.g., according to the industry or vessel the taphole system is being used in. Preferably the hull comprises on its outer hull surface a plurality of recesses and/or ridges arranged along the throughout direction.

Connecting the hot side and cold side of a wall of a metallurgical vessel by the through hole does not necessarily mean that the cold side and the hot side are directly and exclusively connected by the through hole of the at least one taphole insert. The taphole system can comprise one taphole insert but can also comprise a plurality of taphole inserts being inserted form-fittingly into the (hole of the) taphole socket, such that the first ends and second ends of adjacent refractory bodies are abutting, and the plurality of taphole inserts are arranged such that the through holes of adjacent taphole inserts are aligned to form a combined through hole, wherein the hot side and the cold side of the metallurgical vessel are connected by the combined through hole.

Preferably the taphole socket comprises a metal block, preferably a metal cooler. The metal block mainly comprises metal, in particular on the contact surface to the at least one taphole insert but can also comprise other materials than metal. The

metal block preferably is at least partially in form-fitting contact with the outer hull surface of the hull of the taphole insert or taphole inserts. A minor gap can be provided between the metal block and the outer hull surface. The metal block can be provided with thermal insulating inlays, e.g., in form of refractory inlays. Using thermal insulating inlays can be beneficial to adjust and optimize heat transfer between the taphole insert and the taphole socket based on individual needs, e.g., according to the industry or vessel the taphole system is being used with.

Thermal shock between a socket, comprising a metal cooling block, and the refractory body, experiencing heat from the hot side of the metallurgical vessel and/or the molten material extracted by the through hole, can be prevented by using thermal insulating inlays in the metal block and/or thermal insulating inlays in the at least one refractory insert. So, the cooling performance of a metal cooler can be reduced.

If the at least one taphole insert is inserted into a metal block, e.g., a cooling unit, the metal block serves as taphole socket. In this case the fit of the at least one taphole insert inside the taphole socket is even better adjustable as both the metal block and the metal hull of the at least one taphole insert can be manufactured having a defined tolerance whereas this might not be the case for a taphole socket made of refractory material.

The taphole socket can also comprise a metal block, preferably a metal cooler, and an adapter comprising metal and/or graphite. The metal block preferably is at least partially in form-fitting contact with the adapter and the adapter preferably is at least partially in form-fitting contact with the outer hull surface of the hull of the taphole insert or taphole inserts. A minor gap can be provided between the metal block and the adapter and/or the adapter and the outer hull surface of the hull of the taphole insert or taphole inserts.

Using a taphole socket comprising a metal block and an adapter comprising metal and/or graphite can be particularly useful when the wall of a metallurgical vessel already is provided with a metal block, e.g., having a hole arranged along the throughout direction and a square cross-section, and the at least one taphole

insert does not fit with this metal block hole, e.g., the at least one taphole insert has a different round cross-section and/or is smaller than the metal block hole. In this case the adapter has a hole having a round cross-section and a square outer cross-section, allowing thus better fit of the at least one taphole insert with the taphole socket. The adapter can also serve as thermal connector between the at least one taphole insert and the metal block.

Connecting the hot side and cold side of a wall of a metallurgical vessel by the through hole does not necessarily mean that the cold side and the hot side are directly and exclusively connected by the through hole of a taphole insert or the combined through hole of a plurality of refractory inserts. E.g., a non-cooled additional refractory element, e.g., a nozzle, (also having a through hole) can be provided on the hot side of the wall abutting to a taphole insert, wherein the through hole or the combined through hole is aligned with the through hole of the additional refractory element.

Using a non-cooled additional refractory element can help to reduce wear of the cooling unit and to prevent dangerous situations in case of cooling liquid leakage, as the cooling liquid is kept from the hot side.

It is preferred when an end stop, e.g., a stop collar, is provided at the socket to prevent the number of taphole inserts from sliding into the inside of the metallurgical vessel. The end stop is configured to hold the at least one taphole insert inside taphole socket.

The end stop can either be integrally provided at the taphole socket or by providing an additional taphole insert having an end stop, e.g., a non-cooled additional refractory element as mentioned above.

The taphole system may further comprise a fixing device for securing the taphole insert or inserts inside the taphole socket. The fixing device preferably is connectable to the taphole socket or to the wall of the metallurgical vessel and comprises a holding element being configured for securing the taphole insert inside the taphole socket. The fixing device is mounted on the cold side of the wall.

If one taphole insert is used the holding element is arranged at the taphole insert on the cold side. If a plurality of taphole inserts is used the holding element is arranged at the taphole insert located on the cold side. So, abutting taphole inserts are held together and secured inside the taphole socket. Building of gaps between adjacent taphole inserts and thus infiltration of the molten material between said adjacent taphole inserts is prevented. Also, mortar can be applied between adjacent taphole inserts.

Preferably the holding element has the shape of a collar and at least partially surrounds the taphole insert on the cold side. This allows the at least one taphole insert to be evenly fixed within the taphole socket.

The fixing device preferably comprises at least one spring-loaded element, e.g., at least one spiraled spring, for applying a spring force onto the at least one taphole insert. The spring-loaded element can be directly connected to the taphole socket or to the wall of the metallurgical vessel. The spring-loaded element applies a spring force to the at least one taphole insert in throughout direction towards the hot side of the wall, by which the at least one taphole insert is secured and tightened inside the taphole socket. Also, possible misalignments in throughout direction can be compensated due to the spring-loaded element which applies pressure and further pushes the at least one taphole insert into the taphole socket in case a gap would build, e.g., between abutting taphole inserts. The spring-loaded element also yields if thermal expansions occur in throughout direction, preventing expansion cracks.

The fixing device can comprise a connecting element, e.g., a metal bar, configured to connect the spring-loaded element and the holding element, wherein connecting element can be integral part of the holding element.

If a holding element in the shape of a collar, which at least partially surrounds the taphole insert on the cold side, and a spring-loaded element are provided, this allows the spring force to be evenly applied on the taphole insert.

The number of spring-loaded elements can be mounted closer to the hot side with reference to the fixing device. In this case the number of spring-loaded elements is mechanically protected. The number of spring-loaded elements can be mounted closer to the cold side with reference to the fixing device. In this case the number of spring-loaded elements is protected from the heat but might be exposed to mechanical influences on the cold side. Protective casings can be provided to protect the number of spring-loaded elements.

Incorporating a spring-loaded element with the fixing device is particularly preferable when used with an end stop at the hot side of the wall of the metallurgical vessel. The fixing device then tightens the taphole insert inside the taphole socket by applying the spring force in throughout direction. In case a plurality of taphole inserts is provided within the taphole socket, the fixing device fastens the taphole inserts by applying the spring force in throughout direction and thus pressing abutting first and second end surfaces of adjacent refractory bodies of taphole inserts together. This prevents building of gaps between adjacent taphole inserts and thus prevents infiltration of the molten material between said adjacent taphole inserts. Also, mortar can be applied between adjacent taphole inserts.

Abovementioned taphole system can be used when the molten material is extracted through the through hole or combined through hole from the metallurgical vessel. Thus, molten material can be extracted from the metallurgical vessel via the through hole through the wall from the hot side to the cold side.

The at least one taphole insert can easily be pulled out of the taphole socket, if necessary, e.g., due to excessive wear or clogging, preferably by a robot.

If no end stop is provided at the hot side of the wall, preferably a fastening device without a spring-loaded element is provided as applying a spring force in throughout direction would always push the at least one taphole insert inside the metallurgical vessel.

Abovementioned taphole system can also be used as a tuyere system in a wall of a metallurgical vessel, wherein gas is blown through the through hole or combined through hole into the metallurgical vessel. The wall can be a side wall, a bottom wall or even a roof wall. Thus, gas can be blown into the metallurgical vessel via the through hole through the wall from the cold side to the hot side. Preferably a conduit, e.g., comprising steel, is provided alongside the through hole. This can prevent gas leakage in radial direction through the taphole insert.

If no end stop is provided at the hot side of the wall, the taphole insert or taphole inserts can be pushed into the metallurgical vessel if necessary, e.g., due to wear or clogging. Thus, the taphole insert being pushed into the metallurgical vessel completely can be replaced with another taphole insert, preferably by a taphole insert inserted into the taphole socket on the cold side used to push the inner taphole insert into the metallurgical vessel. This is particularly preferential when the taphole system is used as tuyere system.

An alternative solution for the abovementioned problem would be providing a taphole system of a taphole socket and at least one taphole insert being inserted form-fittingly into the taphole socket, wherein the at least one taphole insert comprises a refractory body having a first end with a first end surface and a second end with a second end surface and having an outer surface connecting the first end and the second end in a throughout direction, the refractory body comprising a through hole, connecting the first end and the second end in the throughout direction, wherein the taphole system further comprises a fixing device for securing the at least one taphole insert inside the taphole socket, the fixing device being connectable to the taphole socket or to the wall of the metallurgical vessel, and comprising a holding element configured for securing the at least one taphole insert inside the taphole socket. Thus, if a fixing device is provided also a taphole insert not comprising a hull comprising metal and/or graphite and at least partially covering the outer surface of the refractory body, can be used and secured inside the taphole socket. Yet an alternative solution for the abovementioned problem would be a providing a fixing device for securing a taphole insert inside the taphole socket, the taphole insert not comprising

refractory material, with or without a hull comprising metal and/or graphite and at least partially covering the outer surface of the refractory body. In any case, molten material can be extracted through the through hole or combined through hole from the metallurgical vessel, but the taphole system might also be used as a tuyere system, wherein gas is blown through the through hole or combined through hole into the metallurgical vessel. The fixing device might comprise at least one spring-loaded element, for applying a spring force onto the at least one taphole insert. The holding element might have the shape of a collar and is at least partially surrounding the taphole insert. The refractory body might have the shape of a cylinder, having an axis in throughout direction and might comprise at least one of magnesia, alumina, zirconia, chromium-oxide, silica, most preferably spinel and/or mullite. The refractory body might also comprise silicon carbide and/or carbon. The taphole system also might comprise a plurality of taphole inserts being inserted form-fittingly into the taphole socket, such that the first ends and second ends of adjacent taphole inserts are abutting and the plurality of taphole inserts are arranged such that the through holes of adjacent taphole inserts are aligned to form a combined through hole, wherein the taphole socket is mountable in the wall of a metallurgical vessel such that the hot side and the cold side of the metallurgical vessel are connected by the combined through hole.

Figs. 1 to 4 show exemplary, schematic, and non-limiting advantageous embodiments of the invention wherein

Fig. 1a shows a first embodiment of a taphole insert,

Fig. 1b shows a second embodiment of a taphole insert,

Fig. 1c shows a third embodiment of a taphole insert,

Fig. 2a shows a plurality of taphole inserts from Fig. 1a,

Fig. 2b shows a plurality of taphole inserts from Fig. 1b,

Fig. 2c shows a plurality of taphole inserts from Fig. 1c,

Fig. 3a shows a first taphole system mounted in a wall of a metallurgical vessel and having a taphole socket and the plurality of taphole inserts from Fig. 2a,

Fig. 3b shows a second taphole system mounted in a wall of a metallurgical vessel and having a taphole socket and the plurality of taphole inserts from Fig. 2b,

Fig. 3c shows a third taphole system mounted in a wall of a metallurgical vessel and having a taphole socket and a plurality of taphole inserts from Fig. 2c,

Fig. 3d shows a fourth taphole system mounted in a wall of a metallurgical vessel and having a plurality of taphole inserts from Fig. 2a and a taphole socket comprising a metal block and a metal adapter,

Fig. 4 shows the taphole system of Fig. 3c comprising a fixing device.

Fig. 1a shows a first embodiment of a taphole insert 1 comprising a refractory body 10 having a first end 101 with a first end surface C and a second end 102 with a second end surface H. The taphole insert 1 further has an outer surface O connecting the first end 101 and the second end 102 in a throughout direction L. The refractory body 10 comprises a through hole 100 for extracting molten material connecting the first end 101 and the second end 102 in throughout direction L.

Further, the taphole insert 1 comprises a hull 11 comprising metal and/or graphite. Said hull 11 here only by way of example completely covers the outer surface O of the refractory body 10 but might also only partially cover the outer surface O of the refractory body 10.

The taphole insert 1 shown in Fig. 1a by way of example has a refractory body 10 in the shape of a cylinder, having an axis in throughout direction L. Therefore, the outer surface O of the refractory body 10 is the curved surface of the cylinder

(facing a radial direction T) and the first end 101 and second end 102 respectively are base surfaces of the cylinder. The refractory body 10 might also have any other shape, i.e., a cuboid shape.

According to the taphole system disclosed herein the taphole insert 1 is form-fittingly inserted in a taphole socket 3 (not shown in Fig. 1a, but shown in Fig. 3a), the socket being mountable in a wall 20 of a metallurgical vessel (not shown in Fig. 1a but shown in Fig. 3a).

The refractory body 10 might comprise at least one of magnesia, alumina, zirconia, chromium-oxide, silica, e.g., compounds as spinel and/or mullite. The refractory body 10 might also comprise silicon carbide and/or carbon. The hull 11 might comprise graphite and/or metal, e.g., at least one of steel, (casting) iron, titanium, copper.

Fig. 1b shows a second embodiment of a taphole insert 1 wherein, compared to the first embodiment shown in Fig. 1a, the hull 11 comprises holes 111 on the first end 101, by way of example in the throughout direction L, e.g., for positioning a sensor and/or for removal of the taphole insert 1 from a taphole socket 3 (not shown in Fig. 1b but shown in Fig. 3b).

Fig. 1c shows a third embodiment of a taphole insert 1 wherein, compared to the first embodiment shown in Fig. 1a, the hull 11 comprises recesses and ridges 112 in the throughout direction L, whereas the hull 11 in Fig. 1a (and Fig. 1b) is even on its outer hull surface.

Fig. 2a shows a plurality of taphole inserts 1 from Fig. 1a, whereas Fig. 2b shows a plurality of taphole inserts 1 from Fig. 1b and Fig. 2c shows a plurality of taphole inserts 1 from Fig. 1c. In each case the first end 101 and second end 102 of adjacent taphole inserts 1 are abutting and the plurality of taphole inserts 1 are arranged such that the through holes 100 of adjacent taphole inserts 1 are aligned to form a combined through hole 100'. Also, a quarter segment of the plurality inserts 1 is cut only for displaying reasons.

Preferably the hull 11 has a portion 113 gripping into the refractory body. In Figs. 2a, 2b, 2c this portion 113 is arranged circumferential at the second end 102.

The hull 11 has an inner dimension in transverse direction. Also, the hull 11 has an outer dimension. The thickness of the hull 11 is the distance between the inner dimension and the outer dimension. The outer dimension of the hull 11 shown in Fig. 2a, Fig. 2b and Fig. 2c is constant along the throughout direction L. The portion 113 of the hull 11 gripping into the refractory body here is embodied as area with decreased inner dimension on the second end 102. As the outer dimension of the hull is constant in throughout direction the thickness of the hull is increased at this portion 113. Because of the portion 113, it can be assured that when the hull 11 is pulled the refractory body 10 is pulled with the hull 11 and the taphole insert 1 is not disassembled. This increased thickness area 113 of the hull 11 in the throughout direction L can be circumferential or partial, e.g., in the form of teeth gripping into the refractory body.

Preferably the portion is circumferentially even but it might also be embodied in the form of teeth gripping into the refractory body.

Fig. 3a shows a first taphole system of a taphole socket 3 and the plurality of taphole inserts 1 from Fig. 2a being inserted form-fittingly into the taphole socket 3, whereas Fig. 3b shows a second taphole system of a taphole socket 3 and the taphole inserts from Fig. 2b being inserted form-fittingly into the taphole socket 3 and Fig. 3c shows a third taphole system of a taphole socket 3 and the taphole inserts from Fig. 2c being inserted form-fittingly into the taphole socket 3.

In each case the taphole sockets 3 are mountable in a wall 20, e.g., a side wall or a bottom wall, of a metallurgical vessel, the metallurgical vessel and thus the wall 20 having an inner hot side and an outer cold side. A quarter segment of the taphole sockets 3 as well as of the plurality inserts 1 is cut only for displaying reasons, wherein only also the wall 20 is cut accordingly. Generally, only a section of the wall 20 is shown for better depiction of the taphole system. The plurality of taphole inserts 1 are inserted form-fittingly into the taphole socket 3, such that the first end 101 and second end 102 of adjacent taphole inserts 1 are abutting and

the plurality of taphole inserts 1 are arranged such that the through holes 100 of adjacent taphole inserts 1 are aligned to form a combined through hole 100'. Thus, the hot side and the cold side of the side wall 20 are connected by the combined through hole 100'. The taphole inserts 1 are arranged such that the first end surfaces C respectively are facing the cold side (i.e., being closer to the cold side than to the hot side) and the second end surfaces H respectively are facing the hot side (i.e., being closer to the hot side than to the cold side).

Preferably, the taphole socket 3 of the taphole system is a metal block, most preferably a metal cooler, as shown in Figs. 3a, 3b and 3c.

The Figs 3a, 3b, 3c. show a taphole socket 3 mounted in a side wall of metallurgical vessel, wherein preferably the through hole 100' is arranged basically horizontally. The taphole socket 3 can also be mounted in a bottom wall of metallurgical vessel, wherein preferably the through hole 100' is arranged basically vertically.

Although a plurality of taphole inserts 1 is shown in Figs. 3a, 3b and 3c, also only one taphole insert 1 (e.g., the taphole insert shown in Fig. 1a, 2b or 1c) can be inserted form-fittingly into the taphole socket 3. In this case a through hole 100 connecting the first end 101 and the second end 102 in the throughout direction L connects the hot side and the cold side of the metallurgical vessel and thus of the wall 20. The taphole system can also comprise a plurality of different taphole inserts 1 being inserted into a taphole socket 3, i.e., taphole inserts 1 of a taphole system according to this invention do not have to be identical.

As the outer surface of the hull 11 (or at least part of it) of the taphole insert(s) 1, is in form-fitting contact to the inner surface of the hole of the taphole socket 3, the taphole insert(s) 1 can easily be inserted and/or removed from the taphole socket 3 in the wall 20, as the hull 11 comprises metal and/or graphite allowing for lower manufacturing tolerances compared to refractory material and therefore can be fit to the taphole socket 3 (which can comprise refractory material or metal) more exactly. Also, metal and graphite show less friction than refractory material and therefore the taphole insert 1 having a hull 11 comprising metal and/or graphite

can be inserted and/or removed from the taphole socket 3 in the wall 20 with less friction compared to taphole inserts 1 without a hull. Thus, easy and quick maintenance is possible and therefore safety for the operators is increased. The taphole insert 1 can be changed quickly and can even be changed by a robot. The robot can be remotely controlled which leads to safe working environment without the immediate presence of operators. An additional benefit of the hull 11 is protection of the taphole insert 1 against radial cracking.

Fig. 3d shows a fourth taphole system of a taphole socket 3 and the plurality of taphole inserts 1 from Fig. 2a being inserted form-fittingly into the taphole socket 3. In this case the taphole socket 3 comprises a metal block 3 and an adapter 3 comprising metal and/or graphite. The metal block 3 preferably is at least partially in form-fitting contact with the adapter 3 and the adapter 3 preferably is at least partially in form-fitting contact with the outer hull surface of the hull 11 of the taphole inserts 1. A minor gap can be provided between the metal block 3 and the adapter 3 and/or the adapter 3 and the outer hull surface of the hull 11 of the taphole insert or taphole inserts 1. Also, in this case the taphole socket 3 comprising a metal block 3 and an adapter 3 is mounted in a wall 20 of a metallurgical vessel.

Fig. 4 shows the taphole system 1 of Fig. 3c, wherein a fixing device 4 is provided on the cold side of the metallurgical vessel to secure the taphole inserts 1 inside the taphole socket 3. Here the fixing device 4 is connected to the taphole socket 3 but can also be connected to the wall 20 of the metallurgical vessel. The fixing device 4 comprises a holding element 42, preferably having the shape of a collar, being arranged at the taphole insert 1 for securing the taphole insert 1 inside the taphole socket 3. Here the holding element 42 holds the taphole insert 1 by surrounding it.

By way of example the fixing device 4 comprises two spring-loaded elements 41, e.g., spiraled springs, for applying a spring force F onto the taphole insert 1. By way of example in Fig.4 two spring-loaded elements 41 are shown on two opposite sides of the taphole socket 3 and are connected to the collar-shaped holding

element 42 partially surrounding the taphole inserts 1 via a metal bar connecting element 43.

In Fig. 4 the taphole socket 3 provides a stop collar 31 as end stop on the hot side of the metallurgical vessel to hold the taphole inserts 1 inside the wall 20 of the metallurgical vessel and prevent it from sliding into the inside of the metallurgical vessel. The number of spring-loaded elements 41 can be facing the hot side (with reference to the fixing device 4, i.e., closer to the hot side) as shown in Fig. 4 or can also be facing the cold side, i.e., being closer to the cold side.

In Fig. 4 the taphole socket 3 is provided with a thermal insulating inlays 32. Using thermal insulating inlays 32 can be beneficial to adjust and optimize heat transfer between the refractory body 10 and the taphole socket 3 based on individual needs, e.g., according to the industry or vessel the taphole system is being used with.

In Fig. 4 also a non-cooled additional refractory element 5 (also having a through hole) is provided on the hot side abutting to the refractory body 10, wherein the through hole 100 or the combined through hole 100' is aligned with the through hole of the additional refractory element 5. An end stop can also be provided at the additional refractory element 5 on the hot side of the metallurgical vessel to hold the taphole inserts 1 inside the taphole socket 3 being mounted inside the wall 20 and prevent it from sliding into the inside of the metallurgical vessel and also prevents building of gaps between adjacent taphole inserts and thus infiltration of the molten material between said adjacent taphole inserts.

Molten material can be extracted through the through hole 100 or combined through hole 100' from the metallurgical vessel.

The taphole system disclosed herein can also be used as a tuyere system, wherein gas and/or solid material, e.g., powder, is blown through the through hole 100 or combined through hole 100' into the metallurgical vessel.

If no end stop is provided, the taphole insert(s) 1 can be pushed into the metallurgical vessel if necessary, e.g., due to wear or clogging. Thus, the taphole

insert 1 being pushed into the metallurgical vessel completely can be replaced with another taphole insert 1. This can be done by aligning a taphole insert 1 with the taphole insert 1 being positioned inside the taphole socket 3 on the cold side and pushing it into the taphole socket 3 and thus pushing the taphole insert(s) 1 towards the hot side. The taphole insert 1 being at the hot side is then pushed into the metallurgical vessel. This is particularly preferential when the taphole system is used as tuyere system. If no end stop is provided, preferably a fixing device 4 without a spring-loaded element 41 is provided as applying a spring force F in throughout direction L would always push the taphole insert 1 inside the metallurgical vessel.

Claims

1. Taphole system of a taphole socket (3) and at least one taphole insert (1) being inserted form-fittingly into the taphole socket (3), wherein the at least one taphole insert (1) comprises a refractory body (10) having a first end (101) with a first end surface (C) and a second end (102) with a second end surface (H) and having an outer surface (O) connecting the first end (101) and the second end (102) in a throughout direction (L), the refractory body (10) comprising a through hole (100) for extracting molten material, connecting the first end (101) and the second end (102) in the throughout direction (L), wherein the at least one taphole insert (1) comprises a hull (11), comprising metal and/or graphite, at least partially covering the outer surface (O) of the refractory body (10) and wherein the taphole socket (3) is mountable in a wall (20) of a metallurgical vessel such that a hot side and a cold side of the metallurgical vessel are connected by the through hole (100).

2. Taphole system according to claim 1, **characterized in that** an additional material layer, preferably a thermal insulating layer and/or a filling layer, preferably mortar, is provided between the refractory body (10) and the hull (11).

3. Taphole system according to claim 1 or 2, **characterized in that** the hull (11) completely covers the outer surface (O) of the refractory body (10).

4. Taphole system according to any one of claims 1 to 3, **characterized in that** the refractory body (10) has the shape of a cylinder, having an axis in throughout direction (L).

5. Taphole system according to any one of claims 1 to 4, **characterized in that** the hull (11) has a portion (113) gripping into the refractory body (10), preferably at the second end (102).

6. Taphole system according to any one of claims 1 to 5, **characterized in that** the hull (11) comprises at least one hole (111) on the first end,

preferably in the throughout direction (L), wherein preferably a gripping pin is inserted in the at least one hole (11).

7. Taphole system according to any one of claims 1 to 6, **characterized in that** the hull (11) is even on its outer hull surface.

8. Taphole system according to any one of claims 1 to 6, **characterized in that** the hull (11) comprises on its outer hull surface at least one recess (112) and/or at least one ridge (112) arranged along the throughout direction (L).

9. Taphole system according to any one of claims 1 to 8, **characterized in that** a plurality of taphole inserts (1) are inserted form-fittingly into the taphole socket (3), such that the first ends (101) and second ends (102) of adjacent taphole inserts (1) are abutting and the plurality of taphole inserts(1) are arranged such that the through holes (100) of adjacent taphole inserts (1) are aligned to form a combined through hole (100'), wherein the taphole socket (3) is mountable in the side wall (20) of a metallurgical vessel such that the hot side and the cold side of the metallurgical vessel are connected by the combined through hole (100').

10. Taphole system according to any one of claims 1 to 9, **characterized in that** the taphole socket (3) comprises a metal block (3), preferably a metal cooler.

11. Taphole system according to any one of claims 1 to 10, **characterized in that** the taphole system further comprises a fixing device (4) for securing the at least one taphole insert (1) inside the taphole socket (3), the fixing device (4) being connectable to the taphole socket (3) or connectable to the side wall (20) of the metallurgical vessel, and comprising a holding element (42) being configured for securing the at least one taphole insert (1) inside the taphole socket (3).

12. Taphole system according to claim 11, **characterized in that** the fixing device (4) comprises at least one spring-loaded element (41), for applying a

spring force (F) onto the at least one taphole insert (1), the holding element (42) preferably having the shape of a collar at least partially surrounding the taphole insert (1) on the cold side.

13. Taphole system according to any one of claims 1 to 12, **characterized in that** an end stop (31), preferably a stop collar, is provided at the taphole socket (3) configured to prevent sliding of the number of taphole inserts (1) into inside of the metallurgical vessel.

14. Wall of a metallurgical vessel, comprising a taphole system according to any one of claims 1 to 13, wherein the taphole socket (3) is mounted in the wall (20) such that a hot side and a cold side of the wall (20) are connected by the through hole (100) or combined through hole (100').

15. Use of a taphole system according to any one of claims 1 to 13, wherein molten material is extracted through the through hole (100) or combined through hole (100') from a metallurgical vessel.

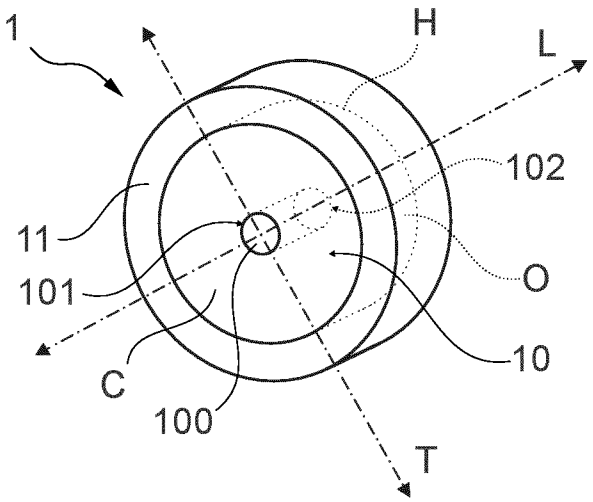


Fig. 1a

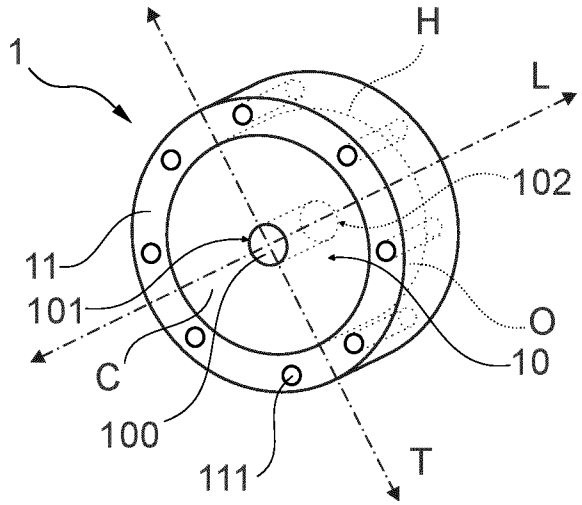


Fig. 1b

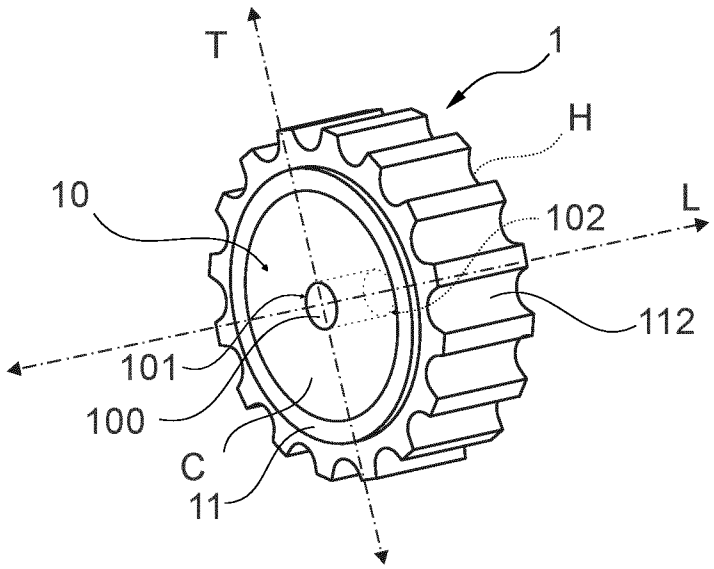


Fig. 1c

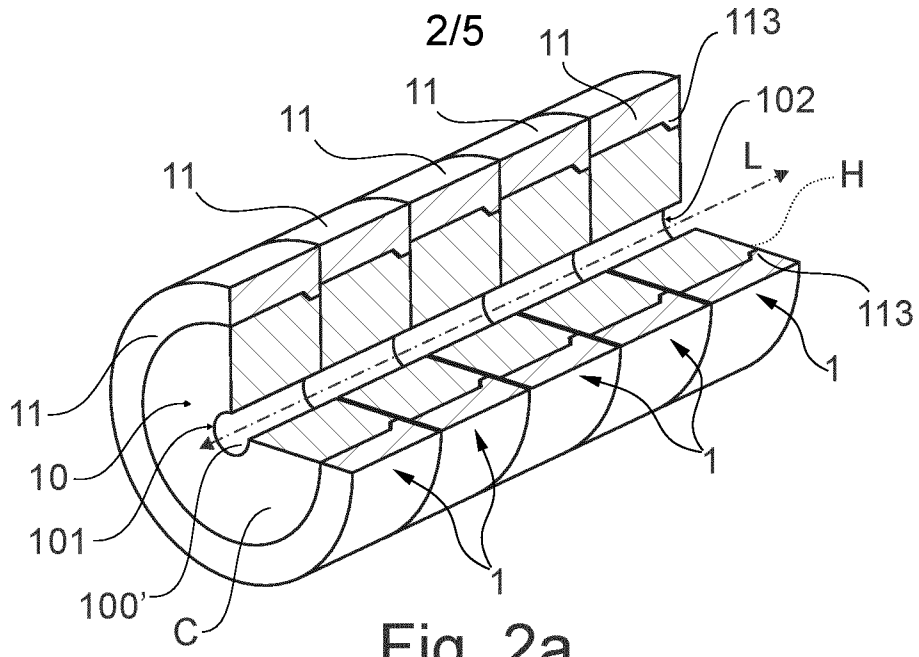


Fig. 2a

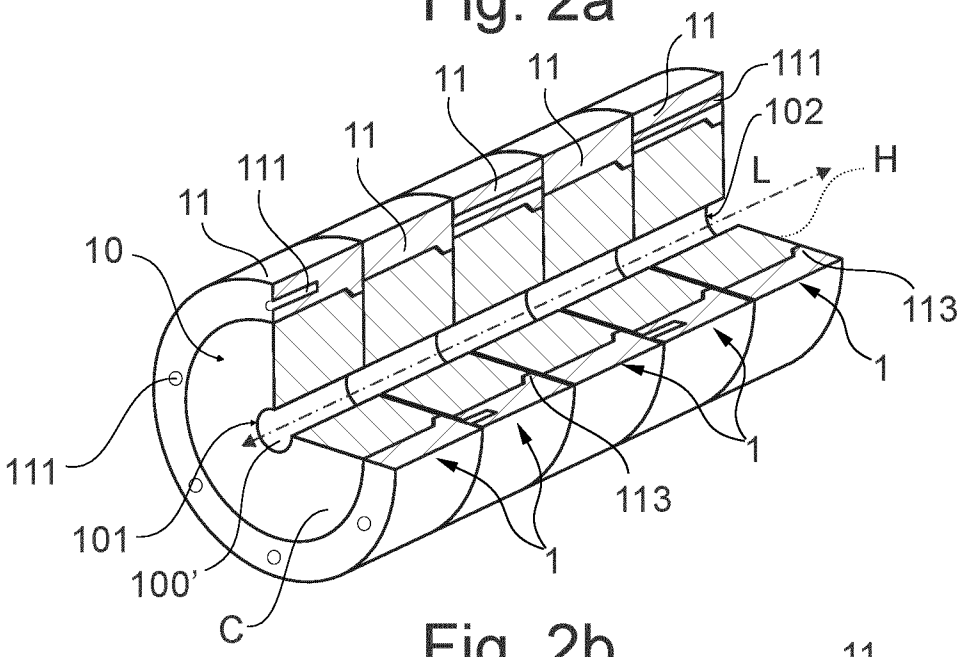


Fig. 2b

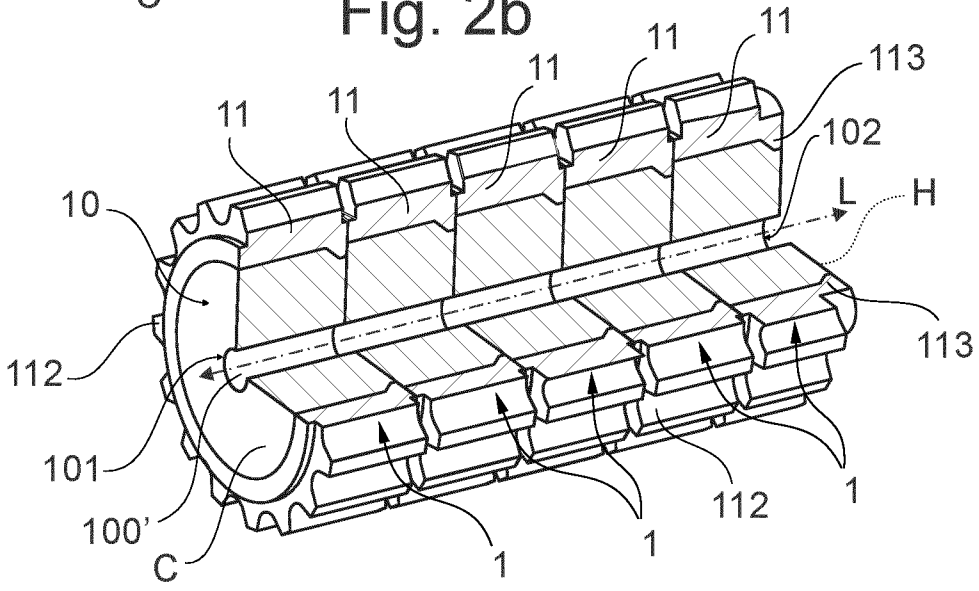


Fig. 2c

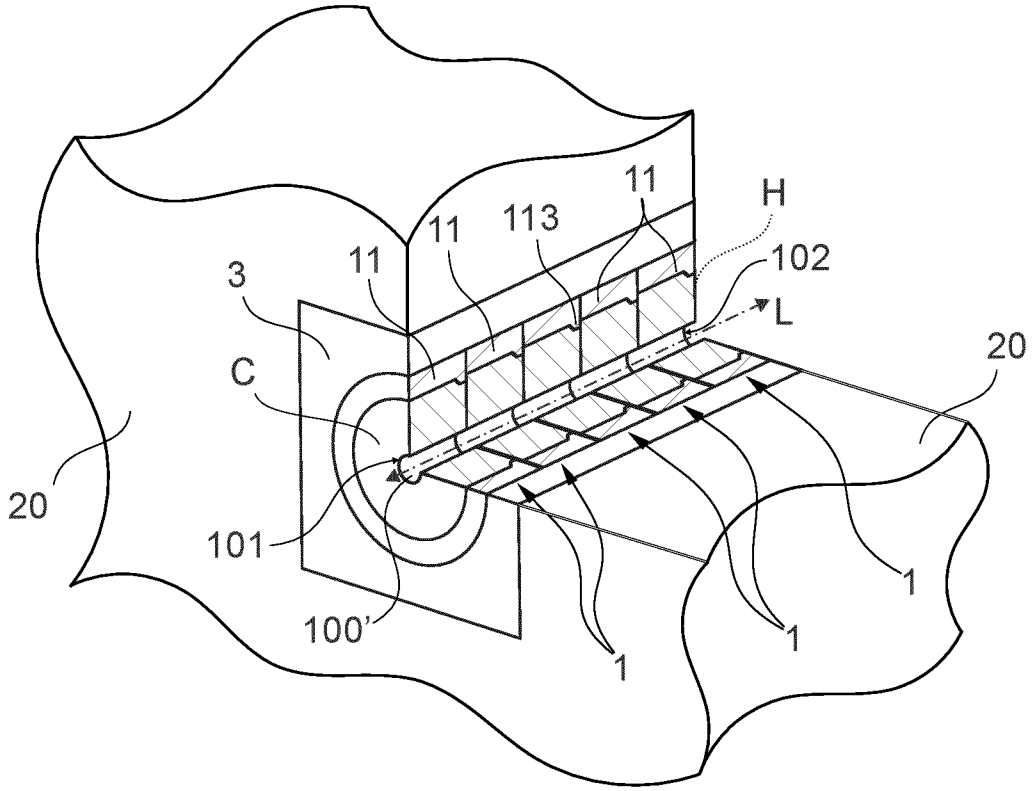

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Fig. 3a

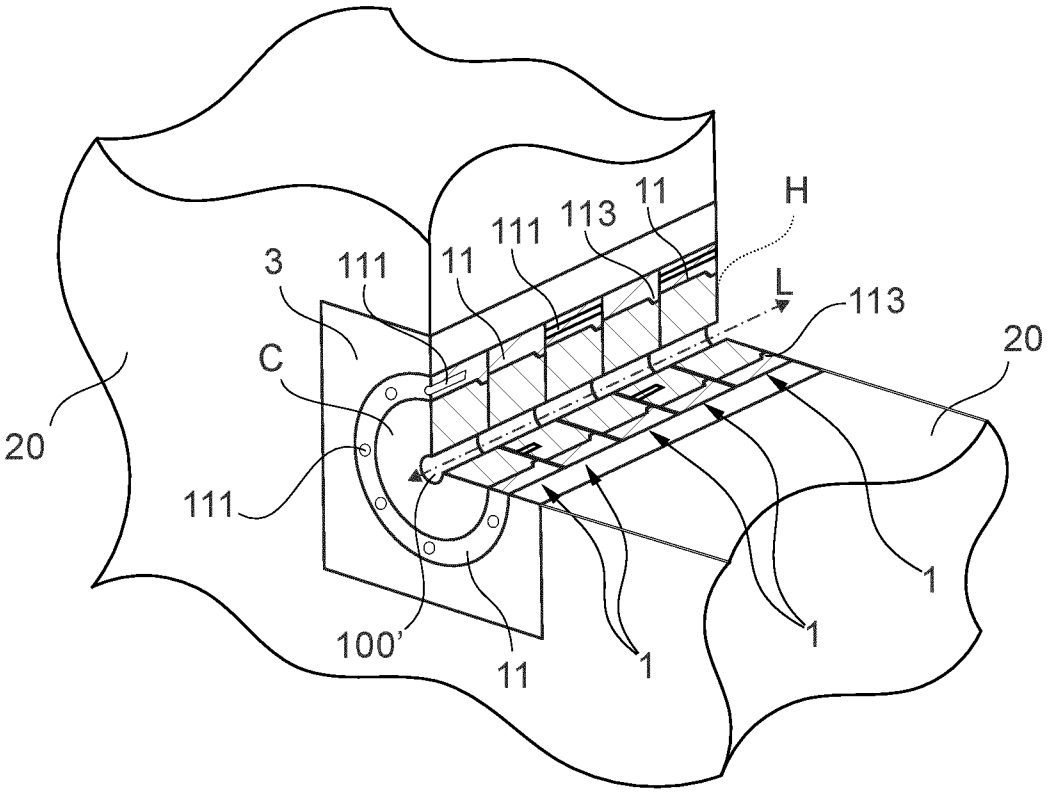

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Fig. 3b

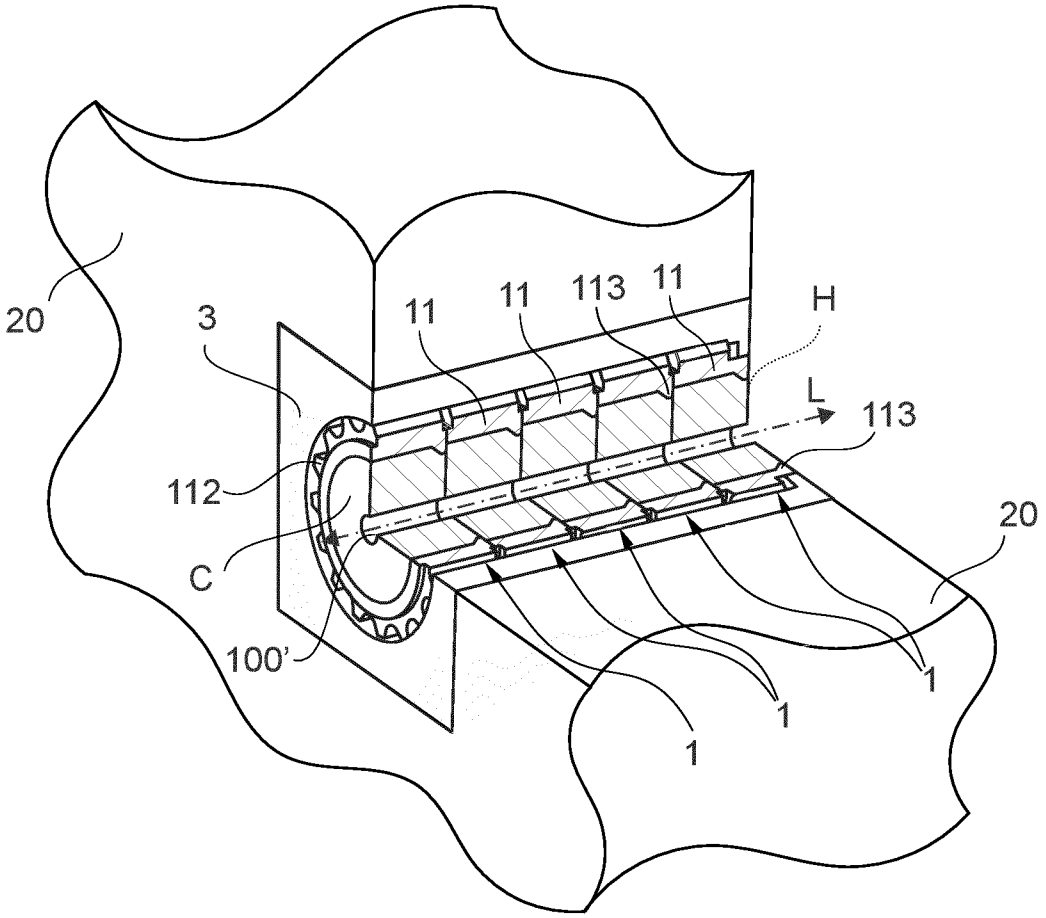

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Fig. 3c

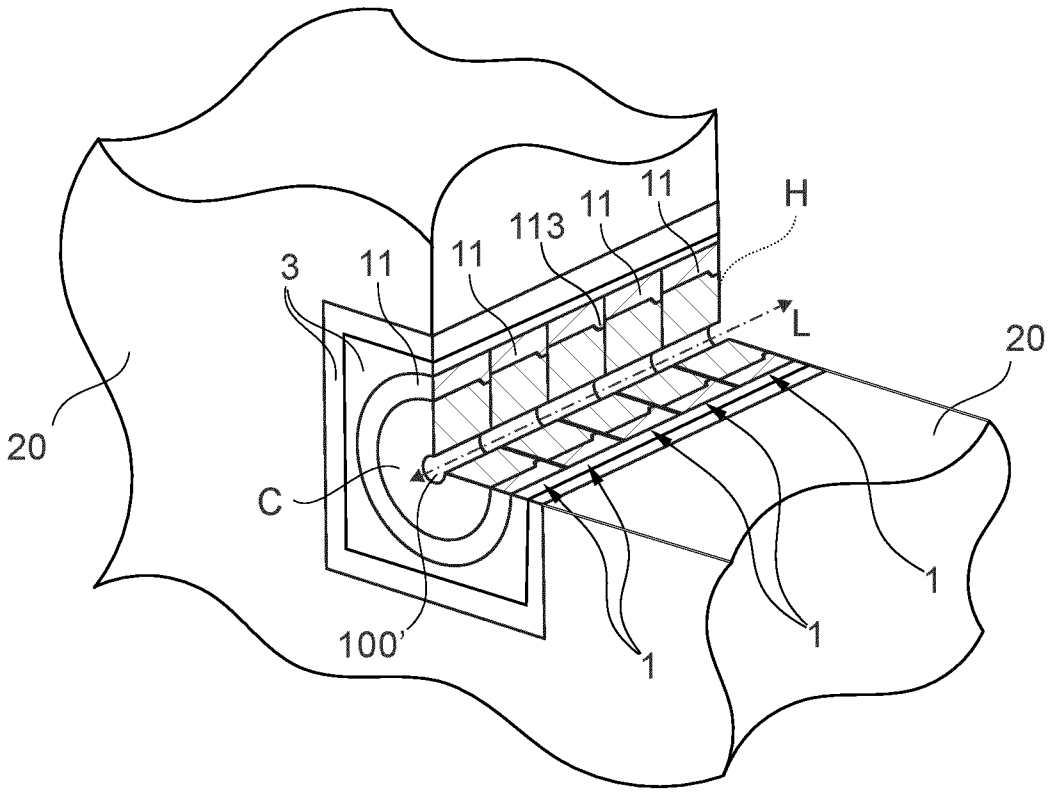

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Fig. 3d

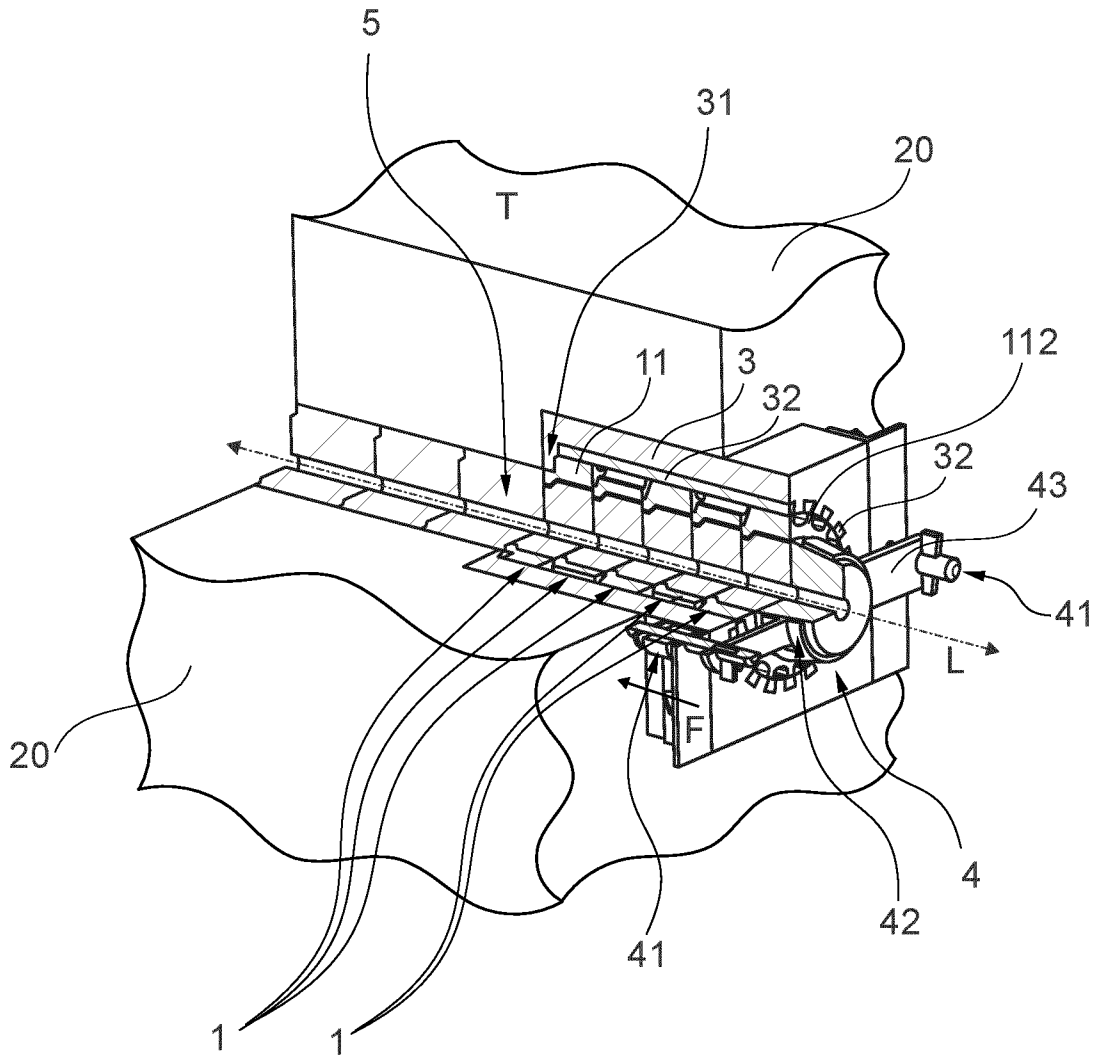


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/056772

A. CLASSIFICATION OF SUBJECT MATTER
INV. C21C5/46 F27D3/15
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21C F27D C21B F27B B22D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 984 769 A (BRUECKNER RAIMUND [DE] ET AL) 15 January 1991 (1991-01-15) column 2, line 49 - column 3, line 68; figures 1-6	1-10, 13-15 9,11,12
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2024	06/05/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Desvignes, Rémi

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/056772

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 4 365 731 A (FEHLING HANS R ET AL) 28 December 1982 (1982-12-28)	1-8,10, 13-15
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