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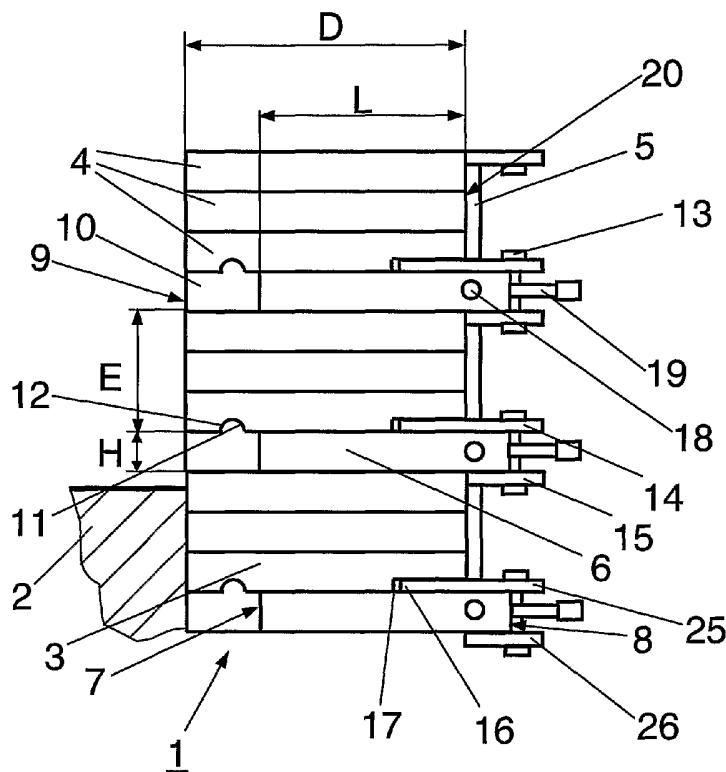
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[Continued on next page]

(54) Title: METALLURGICAL FURNACE



(57) Abstract: The object of the invention is a metallurgical furnace (1), the wall of which comprises an external steel structure (5) and a refractory lining (3) inside the steel structure, the lining (3) consisting of at least one course of bricks (4) in the direction of thickness of the wall of the furnace (1), and that essentially horizontal, ledge-like cooling elements (6) are arranged in the brick lining (3) of the wall of the furnace (1), extending to a length (L) from the outer surface (20) of the brick lining (3) of the furnace (1) towards its inner surface (9), the length (L) in the area of the molten material (2) of the furnace (1) and its vicinity typically being from 50 to 100% of the thickness (D) of the brick lining (3) and, elsewhere, typically from 20 to 100% of the thickness (D) of the brick lining (3), the cooling elements (6) being attached to the external steel structure (5) of the furnace (1) by fastening members (13).

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- *of inventorship (Rule 4.17(iv))*

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METALLURGICAL FURNACE

The invention relates to a metallurgical furnace that is provided with a refractory lining and an external furnace armour plate. To be more precise, the invention
5 relates to the wall structure of the metallurgical furnace.

Generally, the bottom structure of metallurgical furnaces, such as arc furnaces or flash smelting furnaces consists of bricks that are stacked in layers on top of a concreting or a steel base, the number of brick layers typically being about 2
10 to 5. Generally, the wall structure in the furnaces consists of one or more layers of bricks inside the furnace, and a steel surface, i.e., a steel mantle that surrounds and supports it on the outside. The temperatures in such furnaces typically rise to over one thousand degrees Celsius. In the case of copper or nickel, the temperature of the melt is about 1250 to 1300°C and that of iron is about
15 1500°C. Because of the high temperatures, it is necessary to arrange extra cooling in the furnaces. By cooling the furnace walls at a suitable efficiency, it is possible to make the molten material inside the furnace form an autogenous protective layer on the inner surface of the furnace. This protective autogenous layer extends the service life of the furnace by protecting the inner brick lining of
20 the furnace against wear. In prior art furnaces, it has been possible to arrange the cooling of the furnace jacket simply by pouring water on it. However, at high temperatures, this is not necessarily sufficient to cool the furnace wall. Another commonly used cooling method has been to arrange copper cooling elements between the lining and the steel mantle or partly inside the brickwork. Such
25 cooling elements additionally have a water circulation arranged therein to enhance and control the cooling. Publications that describe the prior art mentioned above include WO 01/20045, US 5904893 and US 6416708.

Publication WO 01/20045 describes a furnace, which is provided with a refrac-
30 tory lining and an external furnace armour plate and which has copper cooling plates. These cooling plates are provided with cooling pipes, through which the cooling agent, generally water, flows. The pipework is welded directly together

with the external armour plate of the furnace, or spacers are used between them to compensate for any thermal expansion. The cooling plates are arranged in a planar structure essentially in the direction of the furnace surface and directly next to the steel mantle. A space is left between the steel mantle
5 and the cooling plates/brick lining for the mass layer that is used in the furnaces. The purpose of the mass layer is to both receive any expansion in the radial direction of the furnace and the vertical movement of the brick lining in relation to the metal jacket; however, at the same time, it works as an insulating layer preventing the convection of heat through the furnace wall.

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Publication US 5904893 also presents a solution for the arrangement of copper cooling plates on the furnace wall to cool the same. These plates also have a circulation of cooling liquid arranged inside them, and the cooling plates are arranged in a planar structure essentially in the direction of the furnace surface.
15 Also in this solution, a space for the layer of mass is left between the steel mantle and the cooling element/brick lining, as in the previous solution.

Publication US 6416708 presents a furnace that is used in the manufacture of iron, and its wall structure. In this solution, metal bars are arranged inside the
20 brick course, being in contact with the hot brick courses all the time, and conducting heat away from the brick course. The metal bars can also contain a channel, through which cooling liquid is arranged to flow through the metal part. As the metal bars are fully inside the outer metal surface of the furnace, the water circulation thus also takes place essentially fully inside the outer surface.
25 The cooling of the external steel shell is arranged by pouring water along the outer surface of the steel mantle. These cooling parts are arranged essentially near the steel mantle of the furnace, and, in the radial direction of the furnace, they extend no further than to a length of about 1/3 from the first and the outermost brick, after which there is at least a second course of bricks arranged
30 inside the furnace. In particular, the publication warns not to manufacture cooling parts that extend far inside the brick layer. In addition, the furnace wall structure retains a mass layer between the furnace metal shell and the brick lin-

ing. The purpose of this mass layer is to enable the expansion of the brick lining both in the radial direction and the vertical direction of the furnace in relation to the steel mantle and to seal the furnace wall; however, it also works as an insulating layer between the brick lining and the shell and thus prevents any efficient heat transfer from the wall structures.

- Furthermore, it is well-known to manufacture furnaces including a thin steel flange that extends from the mantle towards the inside of the furnace, circulating around the furnace. The purpose of the flange is to support the brickwork.
- 10 There is no cooling arranged in such steel flanges. The cooling capacity of such solutions is of quite another order than that of copper solutions that contain a water circulation, because the heat conductivity of steel is only about one tenth of that of copper.
- 15 One problem in prior art solutions has been the quick wear of the lining inside the furnaces and, as a result, the collapse of the lining above the worn spot. By a suitably dimensioned cooling, an autogenous layer of molten material can be formed on the inner surface of the furnace to protect the brick lining, slowing down the wear of the lining. The quick wear of the lining causes an increasing
- 20 need for maintenance of the furnace, thus reducing the utilization rate of the furnace. It may also cause dangerous situations when using water-cooled cooling elements especially, if the cooling water in the pipes flows inside far from the outer surface of the furnace. The wear of the lining is especially quick at the upper surface of the melt, where the conditions for the brick lining are the most
- 25 disadvantageous. A lot of wear also takes place in the area below the surface of the melt, but the wear above the melt is less because of the environment that strains the lining to a lesser extent. Attempts have been made to decrease the wear of the lining by adding cooling elements according to the known technology to the furnace wall structure. Typically, the service life of the lining of prior
- 30 art furnaces is from 0.5 to 2 years, after which it must be renewed.

The task of the solution according to the invention is to prevent the rapid advance of wear in the wall lining, and the resulting collapse of the wall lining and, thus, to essentially lengthen the service life of the brick lining.

- 5 In addition, the new wall structure makes it possible to omit the mass layers of prior art furnaces from between the brick lining and the metal shell of the furnace.

The set task is solved by the furnace construction described in the independent
10 claim. The subclaims describe other preferred embodiments of the invention.

In the following, the invention is described in detail with reference to the appended drawings, wherein

- 15 Fig. 1 shows a partial cross-sectional view of the wall structure of the furnace, and
Fig. 2 shows a simplified view of the entire cross section of the furnace.

Fig. 1 shows the wall structure of a metallurgical furnace 1 as a partial cross-
20 sectional view. Typically, such metallurgical furnaces 1 have a cylindrical shape and their diameter can be as much as from 15 to 20 metres. Typically, the temperature in such a furnace 1 in the area of molten material 2 rises to about 1200 to 1500°C. The refractory lining 3 of the inner part of the wall is brickwork that is made of bricks 4 in layers. The thickness D of the refractory lining 3 in
25 the radial direction of the wall is typically from 1 to 3 bricks 4. The lining 3 is preferably made of one course of bricks. The external part of the wall consists of a steel structure 5 that surrounds the brick lining 3. Part of the bricks 4 are replaced by essentially horizontal ledge-like cooling elements 6, which are detachably attached to the steel structure 5 of the wall. One cooling element 6 is a
30 ledge-like piece, which is made of copper and has a length of about 1 metre, typically in the direction of the periphery of the furnace 1. There are several such cooling elements 6 arranged side by side and in contact with each other,

whereby an essentially continuous structure is provided to circulate the entire furnace 1. It is economic to manufacture the cooling element 6 so that it includes essentially straight inner and outer surfaces 7 and 8, whereby the radius of curvature of the furnace 1 wall sets certain limits to the length of the cooling elements. Alternatively, when manufacturing cooling elements 6 that have curved inner and outer surfaces 7 and 8, the length of the cooling elements in the direction of the periphery of the furnace 1 can be made longer than what was presented earlier. However, the manufacturing costs of such curved cooling elements 6 are higher than those of the straight elements. From the point of view of the replaceability of the cooling element 6, a theoretical maximum length of the curved cooling element is half of the circumferential length of the furnace 1.

It is preferable to render the ledge-like structures, which are formed from the cooling elements 6, an essentially continuous structure that circulates the furnace 1 at least in the area of the molten material 2, where the cooling required and the wear of the refractory lining 3 are the greatest. In this way, it is possible to support the lining 3 evenly around the entire furnace 1. Higher up in the furnace 1, where the wear and the temperature do not necessarily require such a massive cooling and support of the brick lining 3, the annular ledge structure can be made, when so desired, from the cooling elements 6 in the form of a discontinuous ring in the direction of the furnace periphery. This enables a more cost-effective structure in the upper part of the furnace 1.

The cooling elements 6 extend through the brick lining 3 to a distance L, which is dependent on the cooling required on the wall. The amount of cooling required, again, depends on whether the said spot in the brick lining 3 is in contact with the molten material 2, or if it is a spot higher up in the furnace 1, where the temperature will not rise as high. The properties of the material to be processed (e.g., copper, nickel, iron) also affect the temperature in the furnace 1. Typically, the ledge-like cooling elements 6 in the area of the molten material 2 inside the furnace 1 or its vicinity extend to a length of 50 to 100% of the thick-

ness D of the brick lining 3. They preferably extend to a length of 55 to 100% of the thickness D of the brick lining, and most preferably to a length of 60 to 100% of the thickness D of the brick lining. Between the cooling element 6 and the inner surface 9 of the brick lining 3 of the furnace 1, there is placed a brick 5 10, which is thinner in the direction of the wall thickness, in order to make the inner surface essentially even. If the cooling element 6 itself extends through the entire brick lining, the thinner brick, of course, is no longer necessary. The brick 10 preferably has a design 11, the brick 4 above it having a corresponding design 12. The purpose of the designs 11 and 12 is to keep the smaller brick 10 10 better in place in the brick lining 3. The designs 11 and 12 may vary in their shapes and locations. Only one possible alternative for the implementation is presented herein by way of an example.

Higher up in the furnace 1, where the need for cooling is not as great, the cooling 15 element 6 typically extends to a length of 20 to 100% of the thickness D of the brick lining 3. It preferably extends to a length of 25 to 100% and most preferably to a length of 30 to 100% of the thickness D of the brick lining.

The cooling elements 6 are preferably detachably attached by means of fasten- 20 ing devices, such as bolts 13, to the steel structure 5 above and below the cooling elements. The bolts 13 can go through the cooling elements 6 or they can be fitted to run outside the external surface 8 of the cooling element, as in Fig. 1. There are essentially horizontal parts 14 and 15 provided in the steel structure 5 above and below the cooling elements 6. The part 14 above the cooling 25 element 6 forms a projection 16, which is directed towards the inside of the furnace 1, and a projection 25, which is directed towards the outside of the furnace. The part 15 below the cooling element 6 forms a projection 26 outside the furnace 1. The cooling element 6 is placed and attached between the parts 14 and 15 by bolts 13. The outward-directed projections 25 and 26 of these 30 parts 14 and 15 can either be implemented as structures of the same dimension as the periphery of the furnace 1 or merely as lugs that are provided in the vicinity of the fixing point.

If the cooling element breaks and it must be replaced, the inner projection 16 of the part 14 that is above each cooling element 6 supports the brick lining 3 above the cooling element. The projection 16 is preferably manufactured so that it circulates the entire furnace 1 as a continuous peripheral structure, but it can also be made as a discontinuous peripheral structure. A corresponding recess 17 is formed in the brick 4 above the projection 16 for the projection. The length of the projection 16 can be freely selected and it may extend through the entire brick lining 13 at the maximum.

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The circulation of cooling liquid is arranged in the cooling elements 6 by providing them with the necessary channels 18 for liquid circulation and members 19 for feeding and discharging the cooling liquid. The channels 18 that run in the cooling elements 6 are preferably located so that they run essentially outside the outer surface 20 of the brick lining 3 of the furnace 1 or on the level of the outer surface. When needed, it is also possible to place the channels 18 so that they run near the outer surface 20 of the brick lining 3, however, inside its outer surface. In that case, we are talking about a length that is half of the thickness D of the brick lining 3, at the maximum. As in no way is the cooling liquid allowed to get in contact with the molten material 2, this also enables a safe structure for the cooling elements 6 in addition to an efficient cooling. Even if the cooling element 6 started to damage/wear near the interior of the furnace 1, its damage/wear would be noticed in time before a failure. The observation of the damage/wear and the monitoring of its advance can be implemented, for example, by following the temperature of the cooling liquid that circulates in the cooling elements 6. Typically, the cooling elements 6 are made of copper because of its good thermal conductivity, ensuring a sufficient cooling in the brick lining 3, but other metals can also be used in the manufacture of the cooling elements. The ledge-like cooling elements 6 prevent/decelerate the advance of the wear of the brick lining 3 because of the efficient cooling. An autogenous protective layer is formed, when the temperature of the molten material 2 near the wall of the furnace 1 decreases. At the same time, the ledge-like structure

of the cooling elements 6 also prevents the brick lining 3 from collapsing, although the lining thins to a greater extent in the area between the cooling elements (in the elevation of the furnace) as a result of using the furnace. The structure of the cooling elements 6 and the furnace wall according to the invention can be used to extend the service life of the brick lining 3 of the furnace 1, typically, to twice as long compared with the prior art furnaces.

The height H of the cooling elements 6 in the elevation of the furnace 1 is in relation to the height of the bricks 4 of the brick lining, and the cooling element is typically of a height of one brick 4. In that case, it is not necessary to manufacture bricks 10 of different thicknesses between the inner surface 7 of the cooling elements 6 and the inner surface 9 of the furnace 1. The typical thickness of a brick in the elevation of the furnace is 3 inches, i.e., about 76mm. If the cooling element 6 extends through the entire brick lining 3, its thickness in the elevation of the furnace is not tied to the thickness of the bricks 4 but it may be freely dimensioned in a desired way, taking into account the prevailing temperature and other conditions. In that case, the height of the cooling element is from 40 to 120mm, preferably from 50 to 110mm, and most preferably from 60 to 100mm.

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The distance E in the elevation between the cooling elements 6 also essentially depends on the cooling power needed. In the area of the molten material 2 or in its vicinity, the distance E is typically from 1 to 4 bricks 4, preferably from 2 to 3 bricks 4. When using typical bricks, this means that E is about 75 to 305mm. E is preferably about 150 to 230mm.

The distance E in the elevation between the cooling elements 6 higher up in the furnace is typically from 3 to 8 bricks 4, preferably from 4 to 6 bricks. When using typical bricks 4, this means that E is about 230 to 610mm, preferably about 305 to 460mm.

Fig. 2 shows a simplified cross section of the circular furnace 1 as viewed from above. In the middle, there is the molten material 2, which is surrounded by the brick lining 3 of the furnace. Outside the brick lining 3, there is the steel structure 5 of the furnace, supporting the brick lining on the outside. On the outer edge of the furnace 1, there is a projection 14, to which a cooling element (not shown in Fig. 2) is attached by fastening devices 13. The fastening devices 13 are illustrated on part of the flange-like continuous projection 14 only.

The invention is characterized in that the cooling of the brick lining of the furnace is arranged by the same element jointly with its support. The size of the element needed depends on the cooling power required and the location of the elements in the brick lining. Furthermore, the solution according to the invention makes it possible to omit the layer of mass used in prior art furnaces between the furnace brick lining and the steel mantle. It is obvious to those skilled in the art that by varying the dimensioning and the location of the cooling elements in the brick lining of the furnace, various alternatives can be provided to implement the needed cooling.

Some preferred embodiments of the invention are described above by way of an example. These examples are in no way limiting, but it is obvious to those skilled in the art that the preferred embodiments of the invention may vary within the scope of the claims presented below.

CLAIMS:

1. A metallurgical furnace (1) comprising a wall that has an external steel structure (5) and a refractory brick lining (3) inside the steel structure, the lining
5 (3) consisting of at least one course of bricks (4) in the direction of thickness of the furnace (1), **characterized** in that essentially horizontal ledge-like cooling elements (6) are arranged in the brick lining (3) of the wall of the furnace (1), extending to a length (L) from the outer surface (20) of the brick lining (3) of the furnace (1) towards its inner surface (9); the length (L) in the area of the molten
10 material (2) of the furnace (1) and its vicinity typically being from 50 to 100% of the thickness (D) of the brick lining (3) and, elsewhere, typically, from 20 to 100% of the thickness (D) of the brick lining (3); and the cooling elements (6) being attached to the external steel structure (5) of the furnace (1) by means of fastening members (13).
- 15 2. A furnace (1) according to Claim 1, **characterized** in that the cooling elements (6) extend to a length (L) from the outer surface (20) of the brick lining (3) of the furnace (1) towards its inner surface (9); the length (L) in the area of the molten material (2) of the furnace (1) or its vicinity preferably being from 55
20 to 100% and, elsewhere, from 25 to 100% of the thickness (D) of the brick lining (3), and most preferably, in the area of the molten material (2) or its vicinity from 60 to 100% and, elsewhere, from 30 to 100% of the thickness (D) of the brick lining (3).
- 25 3. A furnace (1) according to Claim 1 or 2, **characterized** in that the height (H) of the cooling elements (6) in the elevation of the furnace (1) is typically from 40 to 120mm, preferably from 50 to 110mm and most preferably from 60 to 100mm.
- 30 4. A furnace (1) according to any of the preceding Claims, **characterized** in that the distance (E) between the cooling elements in the elevation of the fur-

nace (1) in the area of the molten material (2) is typically about 75 to 305mm and preferably about 150 to 230mm.

5 5. A furnace (1) according to any of the preceding Claims, **characterized** in that the distance (E) between the cooling elements (6) in the elevation of the furnace (1) in areas other than that of the molten material (2) is about 230 to 610mm and preferably about 305 to 460mm.

10 6. A furnace (1) according to any of the preceding Claims 1 to 5, **characterized** in that, in the cooling elements (6), there are channels (18) provided for the circulation of cooling liquid and members (19) for feeding and discharging the cooling liquid.

15 7. A furnace (1) according to Claim 6, **characterized** in that the channels (18) of the cooling elements (6) are located on the level of the outer surface (20) of the brick lining (3) of the furnace (1) or outside the same.

20 8. A furnace (1) according to Claim 6, **characterized** in that the channels (18) of the cooling elements (6) are located inside the brick lining (3) of the furnace (1) and they extend to the midpoint of the brick lining (3) at the maximum.

25 9. A furnace (1) according to any of the preceding Claims 1 to 8, **characterized** in that the cooling elements (6) form an essentially continuous ring around the furnace (1) in the area of the molten material (2) and its vicinity.

30 10. A furnace (1) according to any of the preceding Claims 1 to 8, **characterized** in that the cooling elements (6) form an essentially continuous ring or a discontinuous ring around the furnace (1) in areas other than that of the molten material (2) or its vicinity.

11. A furnace (1) according to any of the preceding Claims 1 to 10, **characterized** in that the cooling elements (6) are replaceable.

12. A furnace (1) according to Claim 11, **characterized** in that the steel structure (5) of the wall has an essentially horizontal projection (16), which is directed towards the inside of the furnace (1), provided above the cooling element (6), supporting the brick lining (3) during the replacement of the cooling element (6), and that, in the brick (4) above the projection (16), there is a corresponding recess (17).

13. A furnace (1) according to Claim 12, **characterized** in that the inwards-directed projection (16) of the steel structure (5) of the wall is a continuous circular structure or a discontinuous circular structure.

14. A furnace (1) according to any of the preceding Claims 1 to 13, **characterized** in that the essentially horizontal projections (14, 15) of the steel structure (5) of the furnace (1), which are directed outwards, form a continuous or a discontinuous ring around the furnace (1).

15. A furnace (1) according to any of the preceding Claims 1 to 14, **characterized** in that the cooling elements (6) are made of copper or some other material that has a good thermal conductivity.

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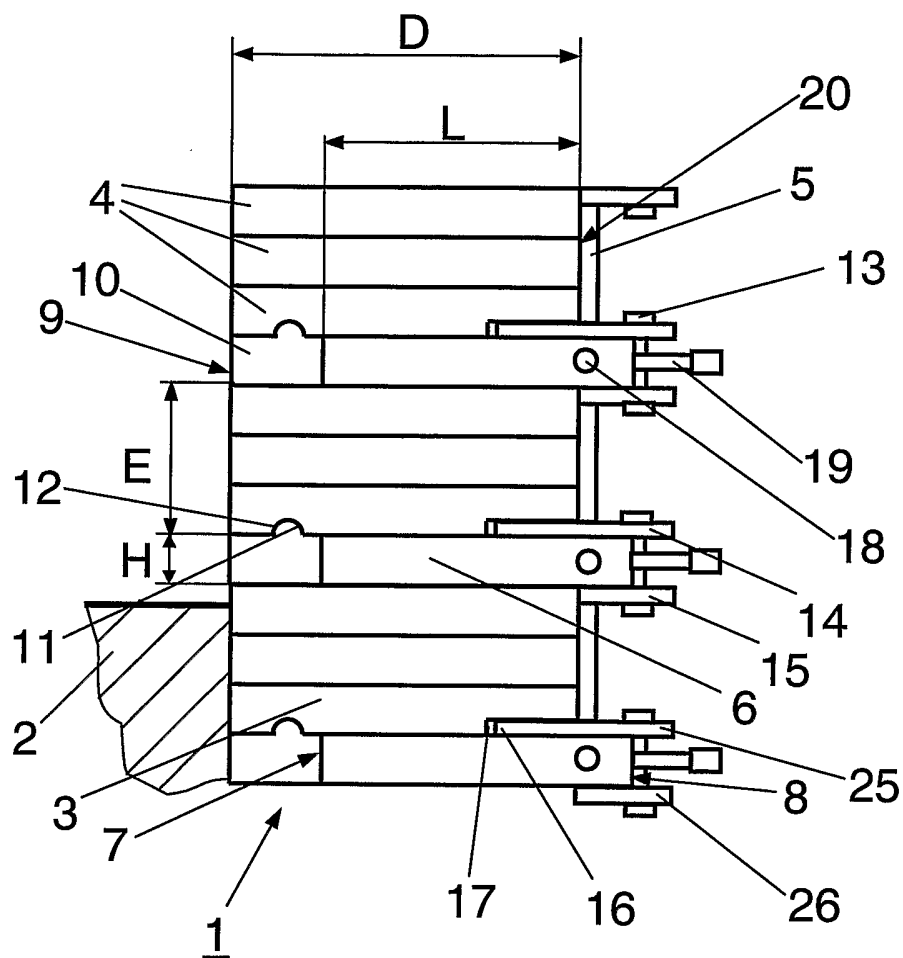


Fig. 1

2/2

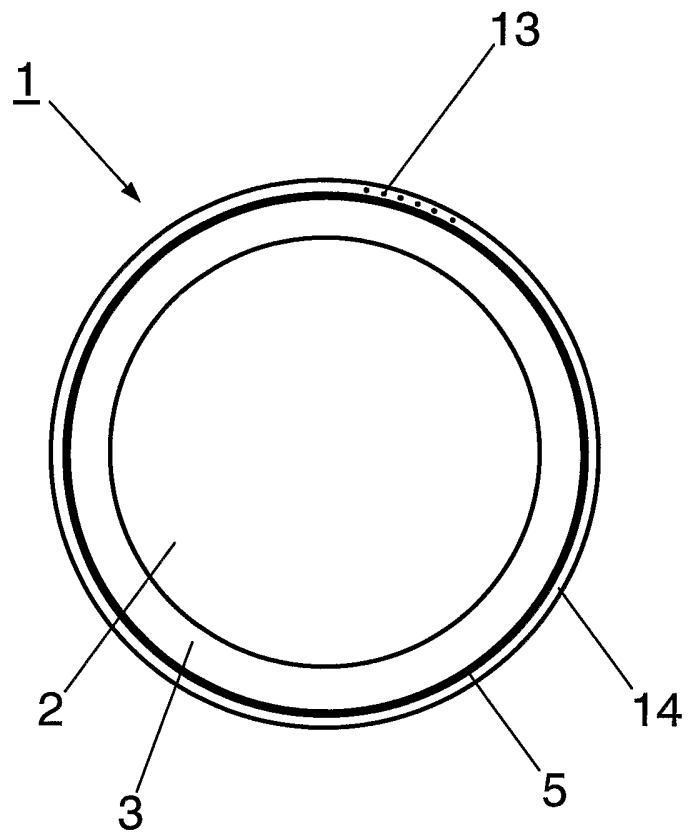


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 2005/000432

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: C21B, C22B, F27B, F27D

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE EPODOC/EPO abstract & JP 59 041404 A (KAWASAKI STEEL CO) 07 March 1984 (1984-03-07) figures --	1-15
X	DATABASE EPODOC/EPO abstract & JP 53 097905 A (NIPPON STEEL CORP) 26 August 1978 (1978-08-26) figures 1-4 --	1-15
X	US 3849587 A (GERALD GORDON HATCH ET AL), 19 November 1974 (19.11.1974), column 4, line 29 - line 34, figures 2-3, claims 2,11 --	1-15

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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24 February 2006

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 2005/000432

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE EPODOC/EPO abstract & JP 59 038312 A (NIPPON KOKAN KK) 02 March 1984 (1984-03-02) figures 1-2 --	1-15
X	US 3953007 A (JACOBUS VAN LAAR), 27 April 1976 (27.04.1976), column 3, line 51 - line 58, abstract --	1-15
X	EP 0032186 A1 (ANNAWERK KERAMISCHE BETRIEBE GMBH), 22 July 1981 (22.07.1981), figure 4, abstract --	1-15
A	US 3990686 A (MITSUYA IGUCHI ET AL), 9 November 1976 (09.11.1976), column 2, line 20 - line 24, abstract --	1-15
A	US 5565016 A (PEKKA HANNIALA ET AL), 15 October 1996 (15.10.1996), column 6, line 34 - line 40, figure 2, abstract -- -----	1-15

INTERNATIONAL SEARCH REPORT

International application No.
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F27D 1/12 (2006.01)

F27B 3/24 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

31/12/2005

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PCT/FI 2005/000432

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