(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 August 2011 (25.08.2011)

PCT

(10) International Publication Number
WO 2011/101313 A1

(51) International Patent Classification:
F27B 1/20 (2006.01) *F27D 3/10* (2006.01)
F27D 1/12 (2006.01) *C21B 7/20* (2006.01)

(21) International Application Number:
PCT/EP2011/052134

(22) International Filing Date:
14 February 2011 (14.02.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
91 653 19 February 2010 (19.02.2010) LU

(71) Applicant *(for all designated States except US)*: **PAUL WURTH S.A.** [LU/LU]; 32, rue d'Alsace, L-1122 Luxembourg (LU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LONARDI, Emile** [LU/LU]; 30, rue de Schouweiler, L-4945 Bascharage (LU). **FRANZISKUS, Lutwin** [DE/DE]; 7, Nikolausstrasse, 66706 Wochern (DE).

(74) Agents: **BRUCK, Mathis** et al.; Office Ernest T. Freylinger S.A., 234, route d'Arlon, L-8001 Strassen (LU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: DISTRIBUTION CHUTE FOR A CHARGING DEVICE OF A METALLURGICAL REACTOR

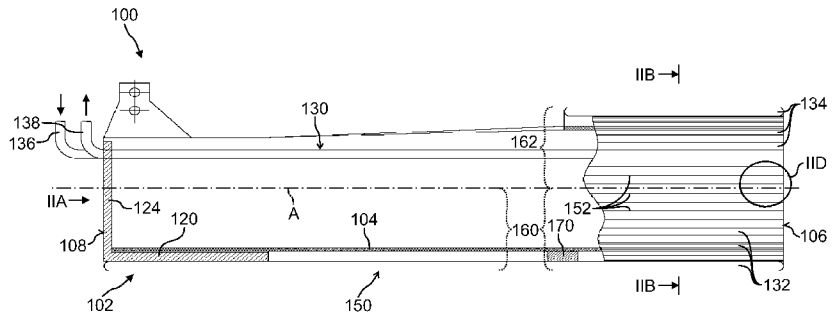

Fig. 1

(57) **Abstract**: A distribution chute (100) for a charging device of a metallurgical reactor comprises an inner wear protection (104) defining a sliding channel for charge material and an elongated chute body (102) supporting the wear protection and comprising mounting members (122) for mounting the chute to a charging device. The chute (100) includes a cooling arrangement (130) with tube sections (132) for protecting the distribution chute against heat. According to the invention, the chute body comprises a rigid structural frame (150) that incorporates the tube sections (132) as integral structural elements to support the inner wear protection (104).

WO 2011/101313 A1

DISTRIBUTION CHUTE FOR A CHARGING DEVICE OF A METALLURGICAL REACTOR

Technical field

[0001] The present invention generally relates to a distribution chute for a charging device of a metallurgical reactor, especially for a top-charging device of a shaft furnace.

[0002] More specifically, the invention relates to a distribution chute that comprises an inner wear protection, which defines a sliding channel for bulk charge material (burden), an elongated chute body, which supports the wear protection, and a cooling arrangement with tube sections that protects the chute against heat from inside the reactor.

[0003] Such a distribution chute may be used in particular in a bell-less charging device of a blast furnace, e.g. a charging device configured to rotate the distribution chute about the reactor axis and to pivot the chute about an axis perpendicular to the reactor axis. Early examples of such devices have been proposed by PAUL WURTH e.g. in U.S. patents No. 3,693,812 and 3,880,302. In the charging device, the chute typically constitutes the adjustable outlet component the variable orientation of which determines the location to which material is charged inside the reactor.

[0004] Moreover, a chute with reliable cooling may find use in any other type of reactor that operates at high-temperatures and requires burden distribution. A chute according to the invention may be used for instance in the charging device of a melter-gasifier that processes direct reduced iron.

Background Art

[0005] PAUL WURTH proposed a distribution chute equipped with a cooling arrangement in British patent no. GB 1 487 527. This chute has a body that supports an inner protection made of a plurality of wear-resisting elements superposed like scales or tiles. To allow cooling, the chute body is hollow and has an inner and an outer casing extending over the greater part of the chute length and forming a chamber there between. The casings are typically made of a welded assembly of curved steel plates. The chamber between the casings serves to allow circulation of a cooling fluid injected from a distribution piping at the upstream end of the chute.

[0006] In U.S. patent no. 5,252,063, PAUL WURTH proposed an improved cooling arrangement for a chute. The improvement mainly resides in an enhanced rotary connection for feeding coolant to the pivotally mounted distribution chute. The connection enables either a higher coolant gas throughput or, preferably, cooling of the chute with cooling water in a

closed cooling circuit. In one embodiment, US 5,252,063 thus proposes a closed-loop water-cooling circuit on the chute (see FIG.15). Instead of duplicating the casing, which causes a considerable increase in total weight of the chute, one or two U-shaped cooling ducts are longitudinally mounted on the underside of the chute body. These ducts may be provided with cooling fins in contact with the chute body and they may be embedded in refractory material (e.g. a heat-insulating concrete). While potentially reducing additional weight occasioned by the cooling arrangement when compared to GB 1 487 527, a chute according to US 5,252,063 still has considerable weight due in non-negligible proportion to the cooling arrangement.

[0007] US patent no. 5'513'835 proposes an improved arrangement for protecting a chute of the above type against heat from inside reactor. According to this patent, protection of the outside of the chute by means of refractory material is proposed in order to protect coolant tube sections as well as the underside of the chute more effectively. Accordingly, the improvement PAUL WURTH proposed in US 5,513,835 resides in a particular shape and mounting of heat-resistant ceramic tiles at the underside of the chute. These tiles are inserted in between and thus secured by the hollow tube sections that are attached externally to the chute body. The ceramic tiles have lateral grooves matching the profile of the tube sections. According to US 5,513,835 it is not easily feasible to avoid the external refractory layer at the underside of the chute, which obviously adds to the weight and cost of the chute.

[0008] Accordingly, several reliable cooling arrangements are known from the prior art. However, a first drawback of the prior art solutions resides in the considerable weight of distribution chutes equipped with cooling arrangements, whether or not the arrangement includes additional refractory. Depending on the total length, such chutes typically have an empty weight well in excess of 5t, of which a non-negligible proportion is due to the cooling arrangement as such.

[0009] A second drawback of the prior art resides in that a viable solution for high-temperature reactors that avoids the need for a complete heat insulation of the chute is presently still lacking.

Technical problem

[0010] It is hence a first object of the present invention to provide a configuration of a distribution chute that includes a reliable cooling arrangement but has reduced empty weight compared to prior art solutions. This object is achieved by a distribution chute as claimed in claim 1.

[0011] It is a second independent object of the present invention to provide a configuration of a distribution chute for high-temperature reactors that eliminates, or at least reduces in extent, the heat insulation of the chute. This independent object is achieved by a distribution chute as claimed in claim 13.

General Description of the Invention

[0012] The invention relates to a distribution chute for a charging device. The chute has an elongated inner wear protection and an elongated chute body, which supports the inner wear protection and comprises mounting members for mounting the distribution chute to a charging device. For protecting the chute against heat, it includes a cooling arrangement with one ore more coolant conduits that has different tube sections, i.e. longitudinal subdivisions of the conduit(s).

[0013] In order to achieve the above-mentioned first object, in a first aspect the present invention proposes a chute, in which the chute body comprises a rigid supporting frame that incorporates the tube sections of the cooling arrangement as integral structural elements, the frame supporting at least part of the inner wear protection, preferably a major part thereof. The tube sections that are integral constituents of the frame are rigidly interconnected by respective joints provided along and in between each pair of neighboring tube sections. In other words, the chute body comprises a rigid structural frame that includes or essentially consists of the tube sections and their interconnecting joints, the sections and joints serving as integral structural elements that support at least part of said inner wear protection.

[0014] As will be appreciated, the tube sections, which in the prior art are merely attached as separate dedicated components the supporting structure formed by the chute body, are – in accordance with the first aspect – used as integral components of at least a downstream load-resisting part of the chute body. The rigidly interconnected tube sections thus constitute structural components of the chute body and contribute significantly to its weight/effort-sustaining function. Consequently, as an incontestable merit of the invention, the overall weight of the chute is significantly reduced compared to a prior art construction that has the same proportion of dedicated tube sections.

[0015] Preferably, the tube sections are interconnected into a structural frame of welded unitary construction, i.e. that is made as a single rigid body. The frame may consist essentially or exhaustively of tube sections and their interconnecting joints.

[0016] Other preferred features of a chute according to the first aspect of the invention are defined in dependent claims 2-12.

[0017] A second aspect of the invention also relates to a distribution chute for use in a charging device. This chute also includes an elongated inner wear protection and an elongated chute body supporting the wear protection. According the second aspect, the chute body has a lower cross-section that is semi-circular with outer radius r_C. The cooling arrangement for protecting the chute against heat has tube sections with an inner diameter d_T.

[0018] In order to achieve the above-mentioned second object, the cooling arrangement comprises a number of n tube sections arranged in succession on the lower periphery of the chute body, with the number of tube sections satisfying

$$n \geq \tfrac{1}{2} [(\pi \cdot r_C) / d_T]$$

[0019] With a corresponding circumferential density of coolant channels, an external heat insulation may be eliminated or at least reduced in extent. As will be understood, eliminating part of or all of the heat insulation provides an alternative solution of reducing the weight of the distribution chute. Whilst being compatible and preferably combined, the first and second aspects are independent and may thus be applied separately.

[0020] Other preferred features of a chute according to the second aspect are also defined in dependent claims 2-11 respectively and in claim 14.

[0021] As will be understood, a chute according to either aspect as proposed herein is particularly suitable for application in a charging device of a metallurgical reactor, especially of a shaft furnace.

Brief Description of the Drawings

[0022] Preferred embodiments of the invention will now be described, in exemplary but not limiting manner, with reference to the accompanying drawings in which:

FIG.1 is a composed view illustrating a first embodiment of a distribution chute according to the invention, partially in longitudinal cross-section and partially in side view;

FIG.2A is rear view of the chute of FIG.1 according to arrow IIA in FIG.1;

FIG.2B is a lateral cross-sectional view of the chute of FIG.1 according to line IIB-IIB in FIG.1;

FIG.2C is an enlarged lateral cross-sectional according to region IIC in FIG.2B, illustrating a joint between neighboring tube sections that form integral structural;

FIG.2D is an enlarged side view according to region IID in FIG.1, illustrating a pipe elbow at the front end of two neighboring tube sections;

FIG.3 is a composed view illustrating a second embodiment of a distribution chute according to the invention, partially in longitudinal cross-section and partially in side view;

FIG.4A is rear view of the chute of FIG.3 according to arrow IVA in FIG.3;

FIG.4B is a lateral cross-sectional view of the chute of FIG.3 according to line IVB-IVB in FIG.3;

FIG.4C is an enlarged lateral cross-sectional according to region IVC in FIG.4B, illustrating a joint between neighboring tube sections that form integral structural;

FIG.4D is an enlarged side view according to region IVD in FIG.3, illustrating a pipe elbow at the front end of two neighboring tube sections.

[0023] Throughout the drawings, identical reference numerals and reference numerals with incremented hundreds digit identify similar parts.

Detailed Description with respect to the Drawings

[0024] In FIG.1 a first embodiment of a distribution chute is generally identified by reference numeral 100. The distribution chute 100 is configured for use in a charging device (not shown) installed on the top opening of a metallurgical reactor (not shown), e.g. on the throat of a blast furnace. The distribution chute 100 is particularly but not exclusively suitable for use in a charging device configured to control the rotational and pivotal position of the chute 100 e.g. according to the principles described in US 3,880,302, the disclosure of which is incorporated herein by reference.

[0025] The distribution chute 100 has an elongated chute body, generally identified by reference numeral 102, which has a longitudinal axis A. The chute 100 further has an inner wear protection, generally identified by reference numeral 104, that is arranged inside the chute body 102.

[0026] The inner wear protection 104 defines a wear-resistant internal sliding channel, in which material can slide toward an open outlet end 106 which is opposite an upstream end 108 of the distribution chute 100. During operation, bulk material falls vertically onto the inner wear protection 104 at a point that depends on the pivoting/inclination angle of the chute 100, then slides on the wear protection 104 towards the outlet 106 from where it is released into the reactor. The inner wear protection 104 is schematically shown since its actual configuration is not essential. It may consist e.g. of plates overlapping like scales, e.g.

according to US 3 889 791. Alternatively, the wear protection 104 may consist of a so-called "stone box arrangement", as disclosed e.g. in European patent EP 0640539, with chambers retaining a protective layer of material followed by a smooth sliding surface of wear-resistant steel. The wear protection 104 may also consist of any other suitable arrangement.

[0027] In the illustrated embodiments, the chute body 102 and the wear protection 104 have a generally cylindrical trough-shaped configuration. Other chute geometries, e.g. a "conical" tubular chute that tapers in the direction of flow, e.g. for a gimbal-type charging device as in European patent EP 0 627 69, may also be produced according to the present disclosure. Irrespectively of its cross-section, the total length of the chute 100 from the upstream end 108 to the outlet end 106, is typically in the range of 1,5 – 5m.

[0028] The chute body 102 will now be described in more detail with reference to FIG.1 & FIGS.2A-2D. It comprises a high-strength support member 120, typically made in one-piece from a thick steel plate that is cold bent into U-shaped cross-section with a semi-cylindrical lower portion, as best seen in FIG.2A. Preferably, the support member 120 is made of a high-strength heat-resistant special steel alloy. Alternatively, the support member 120 can be a cast metal body of suitable shape. Whereas a U-shaped support member is illustrated, it may have any suitable shape, e.g. cylindrically tubular or frusto-conical for a chute of a gimbal-type charging device. The support member 120 has two lateral mounting members 122 that are attached to or integrally formed with the support member 120. The mounting members 122 have any configuration suitable for secure but releasable mounting of the chute 100 to the distribution device (not shown), e.g. a duckbill shape as in US 5'513'835 or a plate-like shape with through holes as in US 3 889 791. As best seen in FIG.2A, at the upstream end 108, an end plate 124, which is welded transversally to the support member 120, closes the upstream end 108 to prevent material rebound out of the chute 100.

[0029] The chute body 102 is equipped with a cooling arrangement, generally identified at 130, for protecting the distribution chute 100 against heat inside the reactor. The cooling arrangement 130 comprises a plurality of tube sections, i.e. longitudinal conduit subdivisions of the cooling arrangement 130. In the illustrated embodiment, each tube section consists of a standard straight tube 132, 134 of appropriate length. Longer tubes 132 are arranged in a lower part of the chute body 102 whereas additional shorter tubes 134 are arranged in an upper part of the chute body 102, as described further below. The tubes 132, 134 extend with their axes B parallel to the longitudinal axis A of the elongated chute body 102. As will be understood, the tube sections could alternatively extend generally transversally to the longitudinal axis A, e.g. as U-shaped sections or spirally arranged sections, especially in case of a tapering tubular chute geometry. Of course, while tubes 132, 134 of circular cross-section are preferred, other cross-sections, e.g. oval or square, are not excluded.

[0030] The cooling arrangement 130 has at least one coolant inlet 136 and at least one coolant outlet 138 for circulating coolant, e.g. water, through the tubes 132, 134. As best seen in FIG.2D, the tubes 132, 134 are serially joined in fluid communication by way of pipe elbows 140 welded to the frontal ends of neighboring sections. The separate pipe elbows 140 have a minimal radius of curvature and permit arranging the tubes 132, 134 closely side-by-side. The tubes 132, 134 communicate in series in any appropriate manner so as to form, as desired, one or more independent cooling serpentines, which originate and terminate at the inlet(s) 136 and the outlet(s) 138 respectively. The inlet(s) and outlet(s) 136, 138 are connected to an external coolant circuit by means of suitable connections, e.g. flexible hoses or rotary connections passing through supporting shafts of the charging device (not shown) as in US 5,252,063. The cooling arrangement 130 protects the distribution chute 100 in general, and the wear protection 104 in particular.

[0031] As will be noted, the wear protection 104 is supported and maintained in proper shape by the chute body 102. Accordingly, the chute body 102 comprises a rigid structural frame 150 that supports at least part of the wear protection 104.

[0032] According to a first important aspect, this structural frame 150 is essentially made of the tube sections of the cooling arrangement 130. In other words, the tubes 132, 134 are not merely separate components attached to the chute body 102 but – in stark contrast – they are integrated into the structural frame 150 as main components necessary to the completeness and integrity of the structural frame 150. Hence, the tubes 132, 134 are integral structural elements of the structural frame 150 and therefore have a load-bearing function. In other words, the tubes 132, 134 contribute to the considerable section modulus of the chute 100 that is required inter alia in view of its cantilevered suspension via mounting members 122 at the upstream end 108. Consequently, the tubes 132, 134, contribute to resisting bending moments not only due to the weight of the inner wear protection 104 and charge material sliding thereon, but also as regards Coriolis and centrifugal forces. Considering typical weights of the chute body 102 and of material sliding on the chute (e.g. >5t), these loads are obviously substantial. Accordingly, high-temperature resistant and high-strength steel tubes 132, 134 are preferred. Depending on the loads, the use of appropriate copper tubes is not excluded however.

[0033] In a preferred embodiment as illustrated in FIG.1, the structural frame 150 preferably supports a major part of the elongated inner wear protection 104 (i.e. a lengthwise proportion exceeding 50% of the chute length). For example, the structural frame 150 supports a downstream part of the wear protection 104, e.g. 60-80% of its length extending upstream from the outlet end 106 as seen in FIG.1. As will be understood, when using a chute body 102 without dedicated support member 120, the structural frame 150 may

support all of the inner wear protection 104. In the latter case (not shown), the mounting members 122 can be attached directly to the structural frame 150. In alternative embodiments (not shown), the structural frame 150 may be configured to support only an upstream or intermediate part of the wear protection.

[0034] To ensure their load-bearing function, the tubes 132, 134 are rigidly connected to each other so as to form a rigid unitary body. To this effect, respective metal-joining joints 152 are arranged lengthwise along and laterally in between each pair of neighboring tubes 132, 134 in order to mechanically affix each pair together respectively. Accordingly, in lengthwise direction along axis A, as best seen in FIG.1, the tubes 132, 134 form a rigidly interconnected stack or pile of adjacent structural elements. In cross-section, as best seen in FIG.2B and FIG.2C, the tubes 132, 134 form a rigidly interconnected circumferential succession of structural elements.

[0035] As best seen in FIG.2C, preferred joints to interconnect the tubes 132, 134 are weld joints 152, whereas any suitable metal-joining joint can be used. Weld joints 152 forming a metal continuity by coalescence are preferred both for strength and resistance to high temperatures. Whereas spot welds or intermittent longitudinal (stitch) welds along the length of the tubes 132, 134 are possible, the mechanical joints 152 are preferably made as continuous longitudinal weld joints 152 that extend all along the length on which the pair tube sections 132, 134 is neighboring. In other words, the weld joints extend substantially along the total length of the chute 100 for a pair of neighboring long tubes 132 in the lower part, and all part of the length of the chute 100 for a pair of neighboring auxiliary tubes 134 of shorter length in the upper part (see below).

[0036] FIG.2C shows an enlarged detail of the structural frame 150 in the first embodiment. Each pair of neighboring tubes 132, 134 has closely adjacent facing tube wall portions 153, i.e. facing meaning the wall portions 153 defining a ")(- shape" with opposing inward half-cylinder surfaces. In order to optimize welding, neighboring tubes 132, 134 have their facing tube wall portions 153 contiguous i.e. nearly in abutment or in abutment. Minor interspaces are tolerable however. As seen in FIG.2C, the weld joints 152 are located laterally in between two tubes 132, 134, so as to cross the plane defined by their tube axes B, with minor transverse deviations being also tolerable. The welds 152 may be made by any suitable welding process, e.g. in the manner of a butt-type weld in the region where the two facing tube wall portions 153 are closest (as illustrated). A welding operation with minimal interspace between the facing tube wall portions 153 and using a suitable filler material is preferred to minimize affecting the integrity of the tubes 132, 134. As mentioned, in the direction perpendicular to FIG.2C, the joints 152 are preferably made as continuous longitudinal welds all along the length on which the tubes 132, 134 have facing wall portions

153, as partially seen in FIG.2D. Although not shown in FIG.2C, it will be understood that each and every pair of two neighboring tubes 132, 134, whether short or long, is rigidly connected by such a strong weld joint 152 so that a rigid and unitary structural frame 150 of interconnected tubes 132, 134 is obtained.

[0037] Turning back to FIGS.1&2B it will be noted that the structural frame 150 includes a first set of long length tubes 132 that form a lower main part 160 of the structural frame 150. The long tubes 132 in the lower part cover the total length from the upstream end 108 to the outlet 106. Furthermore, the structural frame 150 includes a second set of auxiliary tubes 134 of short length. The auxiliary tubes 134 form an upper reinforcing part 162 of the structural frame 150 and extend over a partial length of the chute 100, e.g. 20%-33% of the total length, preferably from the outlet end 106 in upstream direction so as to cover a downstream fraction of the chute length. Both the lower main part 160 and the upper reinforcing part 162 have a generally cylindrical shape of semi-circular cross-section and are rigidly interconnected by respective weld joints 152 at their interface on either lateral side of the chute, i.e. where a short tube 134 neighbors a long tube 132 as illustrated schematically in FIG.2D. Accordingly, the structural frame 150 is circumferentially closed to have a fully circular cross-section at the outlet end 106 as best seen in FIG.2B. Thereby, the lower main part 160 of the structural frame 150 is reinforced against deformation, especially against widening in downstream direction.

[0038] As further seen in FIG.2B, the inner lining 104 is also circumferentially closed at the outlet end 106 to protect the upper reinforcing part 162 against material impact, especially in center charging positions (when the chute 100 is pivoted to a vertical or nearly vertical position). The inner lining 104 is supported on the structural frame 150 through intermediate holding members 170 arranged in between the inner lining 104 and the structural frame 150. The holding members 170 may be equi-circumferentially spaced and installed at an intermediate position between the outlet end 106 and the upstream end 108. The intermediate holding members 170 are attached on one side, either to the structural frame 150 or to the inner lining 104, so as to allow different extents of thermal dilatation. Accordingly, the rigid structural frame 150 bears the greater part of the wear protection, whereas a minor upstream part may be supported by the support member 120 as shown in FIG.1. The structural frame 150 is preferably fastened safely in releasable manner, e.g. by bolts, to the support member 120 so as to facilitate maintenance and repair of the cooling arrangement 130. As will be appreciated, the structural frame 150 constitutes a major part of the chute body 102. Because the tubes 132, 134 constitute an integral structural part of the chute body 102, the latter does not have any significant additional weight occasioned by the cooling arrangement 130.

[0039] A second embodiment of a chute, generally identified at 200, will now be described by reference to FIGS.3-4D. Components of the chute 200 that are identical or similar to those described hereinabove are identified by reference numerals with incremented hundreds digit. Accordingly, only the main differences with respect to the previous embodiment will be detailed below.

[0040] The chute 200 has a chute body 202 with a structural frame 250 that also includes tube sections of the cooling arrangement 230 as integral structural elements. The structural frame 250 of FIGS.3-4D is of similar overall shape but has a different construction.

[0041] As best seen in FIG.4B & FIG.4C, the straight tubes 232, 234 that constitute structurally integrated tube sections have a different type of joint 252 provided for connecting each pair of neighboring tubes 232, 234 and thus interconnecting the tubes 232, 234 into a unitary structural frame 250.

[0042] As best seen in FIG.4C, the neighboring pairs of tubes 232, 234 are arranged with facing tube wall portions 253 that are spaced apart by a relatively small gap, which is however larger than the minimal gap of FIG2C. The mechanical joints 252 that respectively interconnect each pair of neighboring tubes 232, 234 include a web 254 that is welded with either lateral side to one of the two facing tube wall portions 253 by respective longitudinal welds 256, 258. One or two welds 256, 258 may be provided on either side of the web. Whereas stitch or spot-welding is not excluded, the longitudinal welds 256, 258 preferably extend all along the length along which the pair of tubes 232, 234 is neighboring. Preferably, the web 254 is welded laterally in between the neighboring tubes 232, 234 so as to lie in the plane defined by their longitudinal axes B as seen in FIG.4C. Accordingly, the facing tube wall portions 253 together with their respective joint 252 define a “)-(- shape” in cross-section. In a preferred embodiment, the web 254 is a flat steel bar having a width w smaller than the inner diameter d_T of the tube sections, in order to optimize mechanical strength versus cooling efficiency. Other positions, in which the web 254 is radially shifted with respect to axis A, are not excluded however, provided the web 254 is arranged within the space delimited by the convexly facing tube walls 253 and the two planes of common tangents of the neighboring tubes 232, 234.

[0043] Other aspects of the chute 200 are identical to those described above in relation to FIGS.1-2D. As will be noted, the chute 200 requires a reduced number of tubes but still warrants a rigid structural frame 250, and more importantly, reliable cooling and reduced total weight when compared to the prior art.

[0044] In the illustrated embodiments of FIG.1 & FIG.3, each tube section 132, 134; 232, 234 of the cooling arrangement 130; 230 is an integral structural element of the structural

frame 150; 250. As will be understood, alternative embodiments (not shown) may have a cooling arrangement 130; 230 in which some tube sections do not have a load supporting function, i.e. are not integrated into the structural frame 150; 250.

[0045] If required, a distribution chute 100 according to FIG.1 or 200 according to FIG.2 can be provided with external heat insulation (not shown) of thermally insulating material, e.g. in the form of a lining of refractory concrete, ceramic elements or fiber material. Heat insulation enables lower velocities of coolant flow through the cooling arrangement 130; 230. Alternatively, in order to achieve additional weight reduction, the cooling arrangement 130; 230 forms an outer cooling jacket devoid of external heat insulation.

[0046] Another independent aspect of the invention that applies to both above embodiments is now described. According to this second aspect, the chute bodies 102; 202 are provided in the lower main part 160; 260 with a certain minimum density of coolant channels in circumferential direction. To ensure reliable cooling a sufficient number of n tube sections is provided in circumferential succession in the semi-cylindrical lower part 160; 260 so as to satisfy:

$$n \geq \tfrac{1}{2} [(\pi \bullet r_C) / d_T]$$

with n being the amount of tube sections in the lower part 160, 260 (seen in cross-section), r_C the outer radius of the chute body 102, 202 and d_T the inner diameter of the tube sections. In other words, at least 50% of the lower circumference consists of coolant passages. The tube sections 132, 134; 232, 234 may be equi-circumferentially distributed on the circumference of the lower main part 160; 260 as illustrated in FIG.2B & 4B. In an alternative embodiment (not shown), they may cover only part of the lower circumference, e.g. tube sections interconnected according to FIG.2C but covering a lowermost cross-sectional sector of only 120° completed by lateral steel plates welded to either side to form a semi-circular lower portion. Such steel plates, as opposed to the tube sections, may be covered with external heat insulation. Whereas the lightweight construction of a chute body 102; 202 according to the first aspect also preferably has the required minimum density of coolant channels in circumferential direction, a chute according to the second aspect need not necessarily take advantage of using tube sections as integral structural elements to support the wear protection.

[0047] A corresponding minimum of tube sections according to the second aspect warrants efficient and reliable cooling of the underside and may avoid the need for a protective refractory layer on the outside of the cooling arrangement 130, 230 at the level of the tube sections 132, 134; 232, 234 even for very high-temperature applications, e.g. with the chute operating at an ambient temperature above 800°C.

Legend:

FIG.1-2D

100 distribution chute
102 chute body
104 inner wear protection
106 outlet end
108 upstream end
120 support member
122 mounting members
124 end plate
130 cooling arrangement
132 long tubes
134 short tubes
136 coolant inlet
138 coolant outlet
140 pipe elbow
150 structural frame
152 longitudinal weld joint
153 facing tube wall portions
160 lower main part (of 150)
162 upper reinforcing part (of 150)
170 holding members
A chute axis
B tube axis
d_T inner tube diameter
r_C chute radius

FIG.3-4D

200 distribution chute
202 chute body
204 inner wear protection
206 outlet end
208 upstream end
220 support member
222 mounting members
224 end plate
230 cooling arrangement
232 long tubes
234 short tubes
236 coolant inlet
238 coolant outlet
240 pipe elbow
250 structural frame
252 mechanical joint
253 facing tube wall portions
254 web (of 252)
256 longitudinal weld joint (of 252)
258 longitudinal weld joint (of 252)
260 lower main part (of 250)
262 upper reinforcing part (of 250)
270 holding members
A chute axis
B tube axis
d_T inner tube diameter
r_C chute radius
w web width (of 254)

Claims

1. A distribution chute (100; 200) for a charging device of a metallurgical reactor, said distribution chute comprising:
an elongated inner wear protection (104; 204) defining a sliding channel for charge material;
an elongated chute body (102; 202) supporting said inner wear protection and comprising mounting members (122; 222) for mounting said distribution chute to a charging device; and
a cooling arrangement (130; 230) for protecting said distribution chute against heat, said cooling arrangement comprising tube sections (132, 232);
characterized in that
said tube sections (132; 232) are rigidly fixed to each other in interconnected manner by respective joints (152; 252) arranged lengthwise along and laterally in between each pair of neighboring tube sections (132; 232);
so that said chute body comprises a rigid structural frame (150; 250) including said tube sections (132; 232) and said joints (152; 252) as integral structural elements that support at least part of said inner wear protection (104; 204).

2. The distribution chute according to claim 1, characterized in that each respective joint connecting a pair of neighboring tube sections comprises at least one longitudinal weld joint (152; 256, 258).

3. The distribution chute according to claim 2, characterized in that neighboring tube sections (132) have facing tube wall portions (153) that are contiguous and connected by a longitudinal weld joint (152), preferably by a continuous weld joint extending all along said neighboring tube sections (132).

4. The distribution chute according to claim 2, characterized in that neighboring tube sections (232) have facing tube wall portions (253) that are spaced-apart and connected by a joint (252) that comprises a web (254) and two longitudinal weld joints (256, 258), preferably continuous weld joints extending all along said neighboring tube sections (232), connecting each of said facing tube wall portions (253) to said web (254) respectively.

5. The distribution chute according to claim 4, characterized in that said tube sections have an equal inner diameter (d_T) and said webs (254) are flat steel bars that have equal width (w) of no more than twice the inner diameter (d_T) of said tube sections, preferably a width (w) smaller than or equal to (d_T) said inner diameter.

6. The distribution chute according to any one of claims 1 to 5, characterized in that said rigid structural frame (150; 250) supports a major lengthwise part of said inner wear protection (104; 204).

7. The distribution chute according to any one of claims 1 to 6, characterized in that said rigid structural frame (150; 250) comprises:

a first set of rigidly interconnected long tubes (132; 232) that extend in lengthwise direction of said chute body and form a lower main part (160; 260) of said rigid structural frame (150; 250);

a second set of rigidly interconnected short tubes (134; 234) that extend in lengthwise direction and form an upper reinforcing part (162; 262) of said rigid structural frame (150; 250);

said first set and said second set being rigidly connected so that said structural frame (150; 250) is circumferentially closed on the length of said reinforcing part (162; 262).

8. The distribution chute according to claim 7, characterized in that said lower main part (160; 260) and said upper reinforcing part (162; 262) of said structural frame respectively have a cylindrical shape of semi-circular cross-section.

9. The distribution chute according to any one of claims 1 to 8, characterized in that neighboring tube sections are serially communicating at their ends by means of pipe elbows (140; 240) so as to form one or more cooling serpentines.

10. The distribution chute according to any one of claims 1 to 9, characterized in that said chute body (102; 202) comprises a high-strength support member (120; 220), said mounting members (122; 220) being attached to or integrally formed with said support member.

11. The distribution chute according to claim 10, characterized in that said structural frame (150; 250) is fixed to said support member (120; 220), said structural frame (150; 250) supporting a major downstream part of said inner wear

protection (104; 204) and said support member supporting a minor upstream part of said of said inner wear protection (104; 204).

12. The distribution chute according to any one of claims 1 to 11, characterized in that

said chute body (102; 202) has a lower cross-section (160; 260) that is semi-circular and has an outer radius r_C;

each tube section (132; 232) has an inner diameter d_T;

said cooling arrangement (130; 230) comprises a number of n tube sections (132; 232) arranged side-by-side on the periphery of said lower cross-section (160; 260) of said chute body, with

$$n \geq \frac{1}{2} [(\pi \cdot r_C) / d_T].$$

13. A distribution chute (100; 200) for a charging device of a metallurgical reactor, said distribution chute comprising:

an elongated inner wear protection (104; 204) defining a sliding channel for charge material;

an elongated chute body (102; 202) supporting said inner wear protection and comprising mounting members (122; 222) for mounting said distribution chute to a charging device, said chute body having a lower cross-section that is semi-circular and has an outer radius r_C; and

a cooling arrangement (130; 230) for protecting said distribution chute against heat, said cooling arrangement comprising tube sections (132; 232) each having an inner diameter d_T;

characterized in that

said cooling arrangement comprises a number of n tube sections (132; 232) arranged side-by-side on the periphery of said lower cross-section (160; 260) of said chute body, with $n \geq \frac{1}{2} [(\pi \cdot r_C) / d_T]$.

14. The distribution according to claim 13, characterized in that said chute body (102; 202) comprises a rigid structural frame (150; 250) including said tube sections (132; 232) as integral structural elements, wherein

- said rigid structural frame (150; 250) supports at least part of said inner wear protection (104; 204), and

- said tube sections (132; 232) are rigidly interconnected by respective joints (152; 252) arranged lengthwise along and laterally in between each pair of neighboring tube sections.

15. A distribution chute (100; 200) for a charging device of a metallurgical reactor, said distribution chute comprising:
an elongated inner wear protection (104; 204) defining a sliding channel for charge material;
an elongated chute body (102; 202) supporting said inner wear protection and comprising mounting members (122; 222) for mounting said distribution chute to a charging device; and
a cooling arrangement (130; 230) for protecting said distribution chute against heat, said cooling arrangement comprising tube sections (132, 232);
characterized in that
said chute body comprises a rigid structural frame (150; 250) including said tube sections (132; 232) as integral structural elements, wherein
- said rigid structural frame (150; 250) supports at least part of said inner wear protection (104; 204), and
- said tube sections (132; 232) are rigidly interconnected by respective joints (152; 252) arranged lengthwise along and laterally in between each pair of neighboring tube sections (132; 232).

16. The distribution chute according to any one of claims 1 to 15, characterized in that said tube sections are interconnected into a structural frame of welded unitary construction that consists essentially of said tube sections and their interconnecting joints.

17. Charging device for a metallurgical reactor, in particular for a shaft furnace, said device comprising:

a distribution chute according to any one of claims 1 to 16.

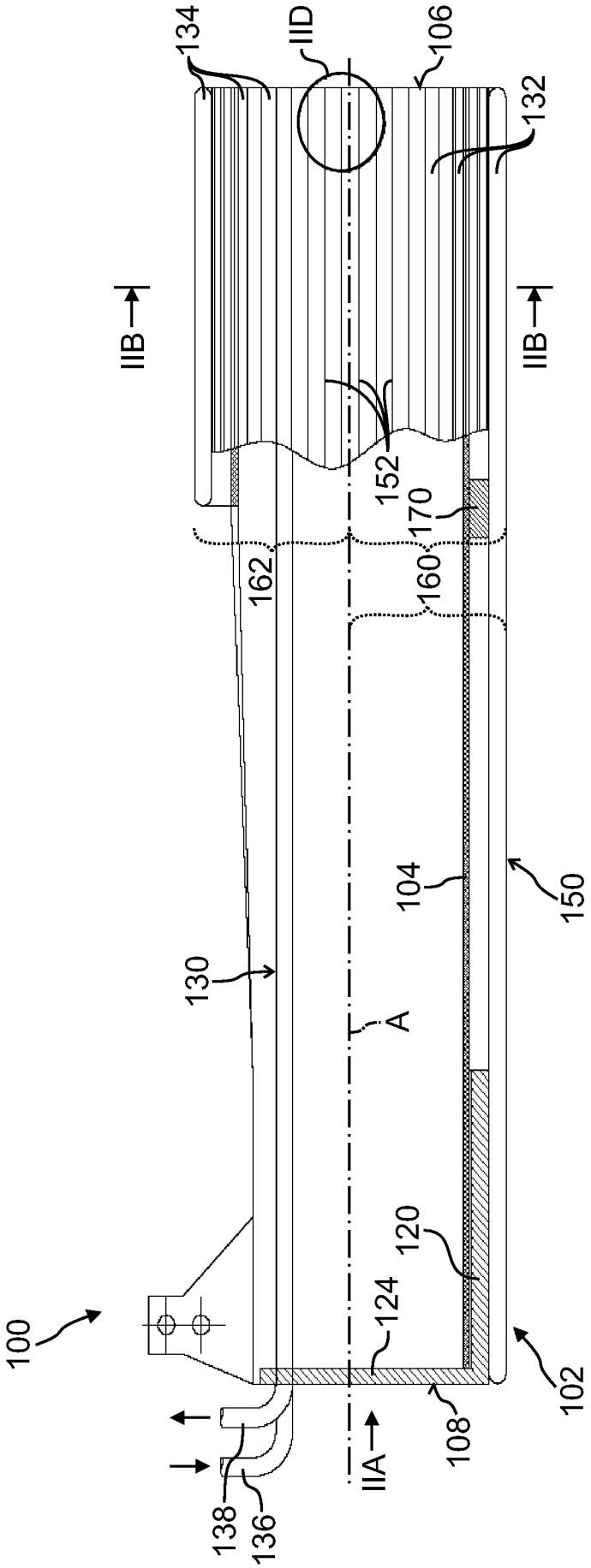
134
IID
106
132
IIB
IIB
152
170
162
160
104
150
130
A
120
124
100
102
108
IIA
138
136

Fig. 1

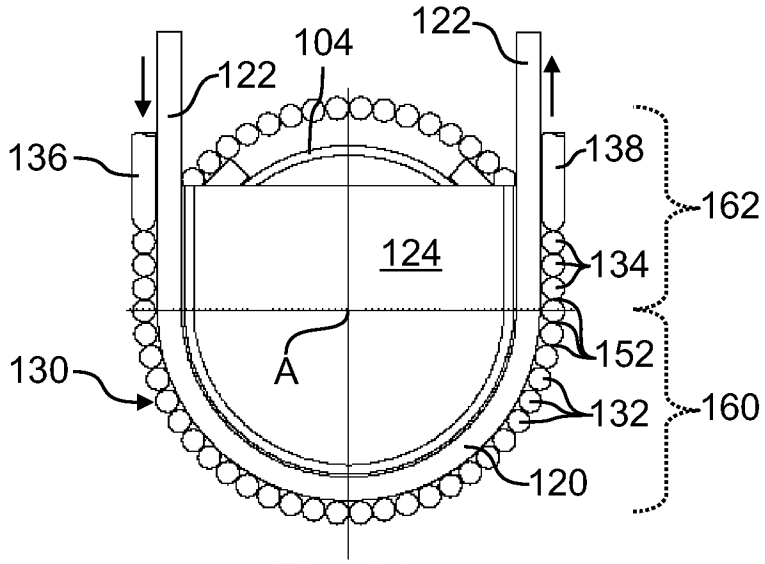

Fig. 2A

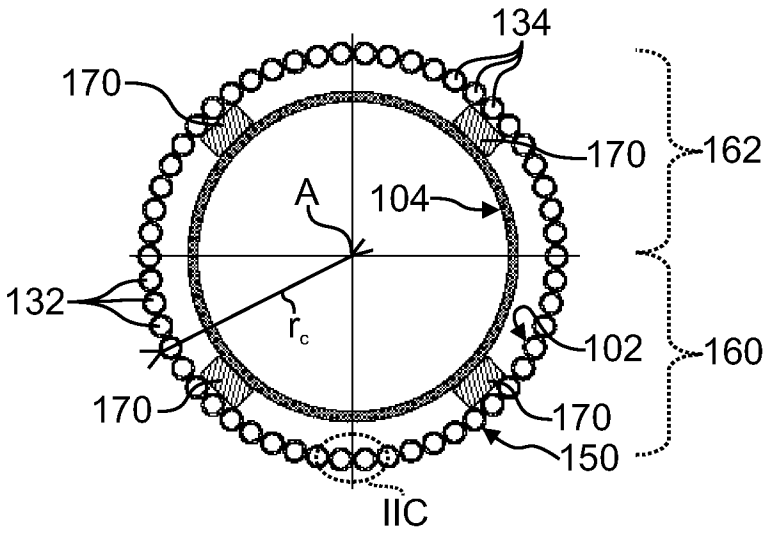

Fig. 2B

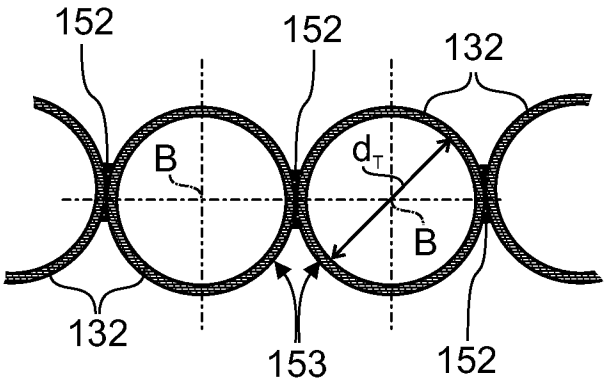

Fig. 2C

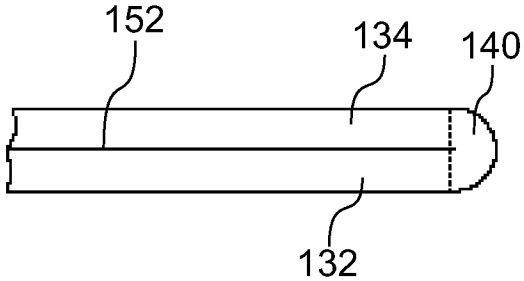

Fig. 2D

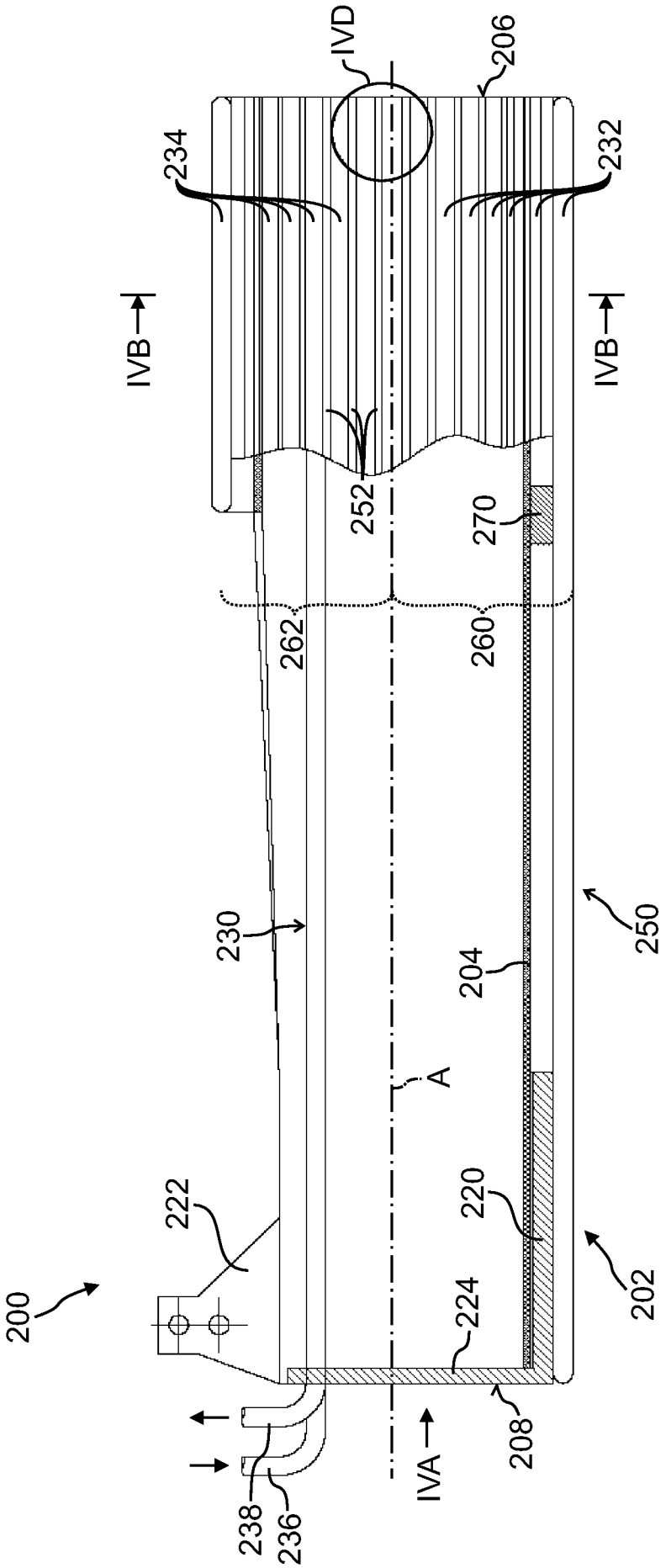
IVD
206
234
232
IVB
IVB
252
270
262
260
230
204
250
A
222
220
200
224
202
208
IVA
238
236

Fig. 3

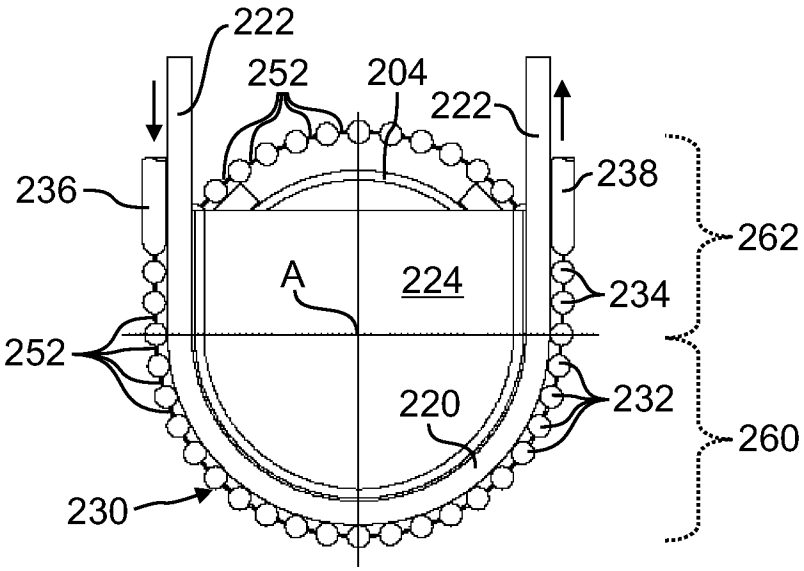

Fig. 4A

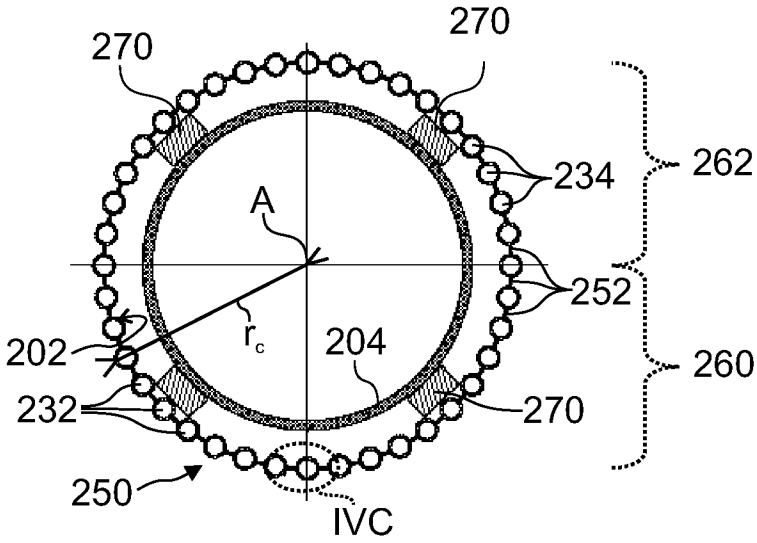

Fig. 4B

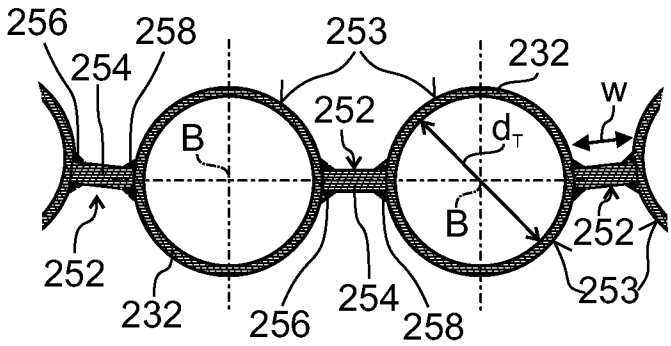

Fig. 4C

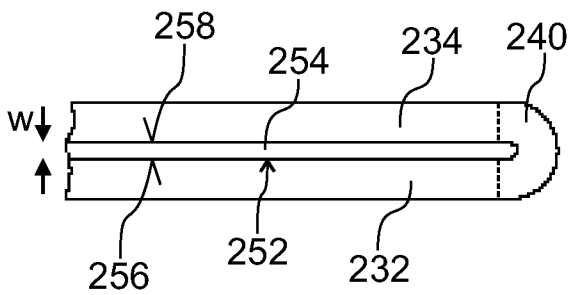

Fig. 4D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2011/052134

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/052134

A. CLASSIFICATION OF SUBJECT MATTER
INV. F27B1/20 F27D1/12 F27D3/10 C21B7/20
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)
F27B F27D C21B

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 513 835 A (LONARDI EMILE [LU] ET AL) 7 May 1996 (1996-05-07) cited in the application	1,15,17
A	column 5, line 25 - column 6, line 18; figures 1-5 column 6, line 50 - column 7, line 24 claims 1,15,18	13

A	EP 0 771 880 A1 (GUTEHOFFNUNGSHUETTE MAN [DE] SMS DEMAG AG [DE]) 7 May 1997 (1997-05-07) column 3, line 1 - column 4, line 45; figures 1-4 claims 1-6	1,13,15,17

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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 document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2011	20/05/2011

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	Gavriliu, Alexandru

4

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/052134

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 252 063 A (THILLEN GUY [LU] ET AL) 12 October 1993 (1993-10-12) cited in the application the whole document	1-17
A	JP 9 071803 A (SUMITOMO METAL IND) 18 March 1997 (1997-03-18) abstract; figures 1-3	1-17
A	JP 4 358015 A (ISHIKAWAJIMA HARIMA HEAVY IND) 11 December 1992 (1992-12-11) abstract; figures 6-8	1-17
A	EP 1 640 461 A2 (ROAM 2000 S R L [IT]) 29 March 2006 (2006-03-29) the whole document	1-17

4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/052134

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5513835 A	07-05-1996	DE 4430265 A1	02-03-1995
		GB 2281610 A	08-03-1995
		LU 88399 A1	05-04-1995
		RU 2122034 C1	20-11-1998
EP 0771880 A1	07-05-1997	AT 206468 T	15-10-2001
		DE 19540504 C1	28-11-1996
		ES 2166419 T3	16-04-2002
		PT 771880 E	28-03-2002
US 5252063 A	12-10-1993	CA 2070506 A1	13-12-1992
		CN 1067683 A	06-01-1993
		DE 4216166 A1	17-12-1992
		JP 3213631 B2	02-10-2001
		JP 5179327 A	20-07-1993
		LU 87948 A1	15-01-1993
		RU 2078831 C1	10-05-1997
JP 9071803 A	18-03-1997	NONE	
JP 4358015 A	11-12-1992	NONE	
EP 1640461 A2	29-03-2006	NONE	

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12, 15, 16(completely); 17(partially)

A distribution chute comprising:
- an elongated inner wear protection defining a sliding channel;
- an elongated chute body supporting said inner wear protection and comprising mounting members for mounting said distribution chute to a charging device;
- a cooling arrangement for protecting said distribution chute against heat comprising tube sections rigidly fixed to each other in interconnected manner by joints,
- said chute body comprises a rigid structural frame which includes said tube sections and joints as integral structural elements supprting a part of the inner wear protection.

---

2. claims: 13, 14(completely); 17(partially)

A distribution chute comprising:
- an elongated inner wear protection defining a sliding channel;
- an elongated chute body supporting said inner wear protection and comprising mounting members for mounting said distribution chute to a charging device, said chute body having a semicircular lower cross-section with an outer radius rc;
- a cooling arrangement for protecting said distribution chute against heat comprising n tube sections each having an inner diameter dT arranged side-by-side on the periphery of said lower cross-section of chute body so that $n < 1/2 ((Pi \times rc)/dT)$.
