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(71) Applicant: **FOSECO INTERNATIONAL LIMITED**
Central Park
Barlborough Links
Derbyshire S43 4XA (GB)

(72) Inventor: **Franke, Steffen**
45721 Haltern am See (DE)

(74) Representative: **Bailey, Jennifer Ann**
Marks & Clerk LLP
Alpha Tower
Suffolk Street Queensway
Birmingham B1 1TT (GB)

(54) FEEDER SYSTEM

(57) Provided is a two-part feeder system comprising a body and a base for use in metal casting operations utilising casting moulds. The base comprises a first connection region, and the body comprises a second connection region. One of the first and second connection regions has a radially outer surface comprising at least one curved section, and the other of the first and second connection regions has a radially inner surface comprising at least one curved section. When one of the first and second connection regions is received within the other, the base and the body are relatively rotatable from an unlocked position to a locked position in which an area of contact between the first connection region and the second connection region extends over at least a part of the outer and inner curved sections, thereby providing a friction lock.

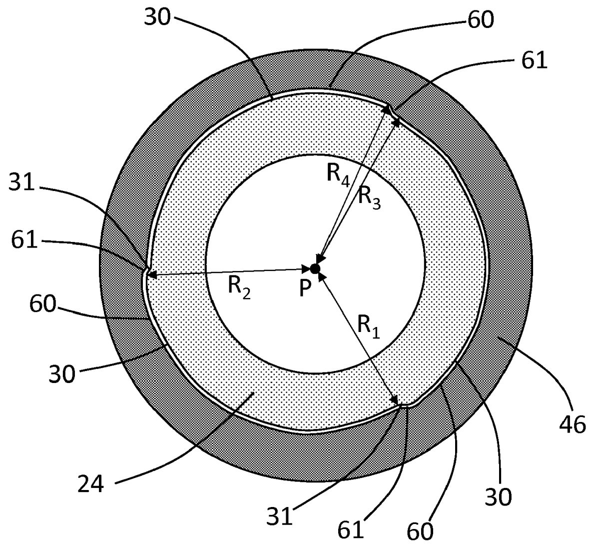

Figure 4

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Description

[0001] The present invention relates to a feeder system for use in metal casting operations utilising casting moulds. More particularly, the invention relates to a two-part feeder system comprising a body and a base.

[0002] In a typical casting process, molten metal is poured into a pre-formed mould cavity which defines the shape of the casting. However, as the metal solidifies it shrinks, resulting in shrinkage cavities which in turn result in unacceptable imperfections in the final casting. This is a well-known problem in the casting industry and is addressed by the use of feeder sleeves or risers which are integrated into the mould during mould formation. Each feeder sleeve provides an additional (usually enclosed) volume or cavity which is in communication with the mould cavity, so that molten metal also enters into the feeder sleeve. During solidification, molten metal within the feeder sleeve flows back into the mould cavity to compensate for the shrinkage of the casting. It is important that metal in the feeder sleeve cavity remains molten longer than the metal in the mould cavity, so feeder sleeves are made to be highly insulating or more usually exothermic, so that upon contact with the molten metal additional heat is generated to delay solidification.

[0003] After solidification and removal of the mould material, unwanted residual metal from within the feeder sleeve cavity remains attached to the casting and must be removed. In order to facilitate removal of the residual metal, the feeder sleeve cavity may be tapered towards its base (i.e. the end of the feeder sleeve which will be closest to the mould cavity) in a design commonly referred to as a neck down sleeve. When a sharp blow is applied to the residual metal it separates at the weakest point which will be near to the mould (the process commonly known as "knock off"). A small footprint on the casting is also desirable to allow the positioning of feeder sleeves in areas of the casting where access may be restricted by adjacent features.

[0004] Feeder sleeves may be applied directly onto the surface of the mould cavity, or they may be used in conjunction with a breaker core. A breaker core is typically a disc of refractory material (typically a resin bonded sand core or a ceramic core or a core of feeder sleeve material) with a hole in its centre which sits between the mould cavity and the feeder sleeve. The diameter of the hole through the breaker core is designed to be smaller than the diameter of the interior cavity of the feeder sleeve (which need not necessarily be tapered) so that knock off occurs at the breaker core close to the casting.

[0005] Moulding sand can be classified into two main categories; chemical bonded (based on either organic or inorganic binders) or clay-bonded. Chemically bonded moulding sand binders are typically self-hardening systems where a binder and a chemical hardener are mixed with the sand and the binder and hardener start to react immediately, but sufficiently slowly enough to allow the sand to be shaped around the pattern plate and then allowed to harden enough for removal and casting. Clay-bonded moulding systems use clay and water as the binder and can be used in the "green" or undried state and are commonly referred to as greensand. Greensand mixtures do not flow readily or move easily under compression forces alone and therefore to compact the greensand around the pattern and give the mould sufficient strength properties, a variety of combinations of jolting, vibrating, squeezing and ramming are applied to produce uniform strength moulds at high productivity.

[0006] Moulding practices are well known and are described for examples in chapters 12 and 13 of Foseco Ferrous Foundryman's Handbook (ISBN 075064284 X). A typical process known as the no-bake or cold-setting process is to mix the sand with a liquid resin or silicate binder together with an appropriate catalyst, usually in a continuous mixer. The mixed sand is then compacted around the pattern by a combination of vibration and ramming and then allowed to stand, during which time the catalyst begins to react with the binder resulting in hardening of the sand mixture. When the mould has reached a handleable strength, it is removed from the pattern and continues to harden until the chemical reaction is complete.

[0007] EP-A-1184104 describes a two-part feeder sleeve. During the moulding operation, pressure is applied to the top of the sleeve and one element of the sleeve telescopes into the other. One of the sleeve parts is always in contact with the pattern plate, and the outer upper sleeve element moves towards the pattern plate and compresses the moulding sand underneath it and adjacent to the pattern plate. One of the advantages of this telescoping sleeve is the small contact area with the pattern plate. Such telescoping sleeves have therefore become popular for hand moulding applications. However, a drawback of such sleeves is that, prior to use, the telescoping sleeve has a long feeder neck which can cause problems in hand moulding applications. Foundry workers therefore have to pre-compress the sleeve, but there is a risk of inhomogeneous pre-compression, which can result in inconsistent sleeve volumes and feeding properties.

[0008] US 5 158 217 describes a twist lock junction between refractory tubular shapes used in the bottom pouring of steel. The junction is formed by inserting a male polygonal projection of a first component into and a complementary polygonal female recess of a second component. Upon rotation of either the female or male joint, the corners of the male polygonal projection wedge against the flats of the female polygonal recess so as to cause a multi-point contact which locks the two components together.

[0009] It is an object of the present invention to provide an improved feeder which can be used in a cast moulding operation which mitigates one or more of the problems associated with known feeders.

[0010] According to a first aspect of the present invention there is provided a feeder system comprising:

a base comprising a first end for mounting on a mould pattern, an opposite second end and a bore between the first and second ends defined by a sidewall, the sidewall comprising a first connection region spaced from the first end; and

a body that is separate from the base, the body comprising a first end for mounting on the base, an opposite second end and a bore between the first and second ends defined by a sidewall, the sidewall comprising a second connection region spaced from the second end,

wherein one of the first and second connection regions has a radially outer surface comprising at least one curved section (outer curved section) of which the radius increases continuously from a smallest radial distance to a largest radial distance from a fixed centre point,

wherein the other of the first and second connection regions has a radially inner surface comprising at least one curved section (inner curved section) of which the radius increases continuously from a smallest radial distance to a largest radial distance from said fixed centre point,

wherein the largest radial distance of the inner curved section is greater than the largest radial distance of the outer curved section, and the smallest radial distance of the inner curved section is greater than the smallest radial distance of the outer curved section, such that one of the first and second connection regions is sized to receive the other, and

wherein the largest radial distance of the outer curved section is greater than the smallest radial distance of the inner curved section, such that when one of the first and second connection regions is received within the other, the base and the body are relatively rotatable from an unlocked position to a locked position in which an area of contact between the first connection region and the second connection region extends over at least a part of the outer and inner curved sections.

[0011] It will thus be understood that the base and the body are separate components, which may be assembled to form a feeder sleeve. The feeder sleeve is assembled by inserting the second end of the base into the first end of the body, until one of the first and second connection regions is received within the other in the unlocked position.

[0012] In the unlocked position, there is no contact between the outer and inner curved sections. In this position, the largest radial distance of the outer curved section may be radially aligned with the largest radial distance of the inner curved section, and the smallest radial distance of the outer curved section may be radially aligned with the smallest radial distance of the inner curved section.

[0013] As the base or the body is rotated relative to the other, the largest radial distance of the outer curved section is moved towards the smallest radial distance of the inner curved section, until the outer and inner curved sections are brought into area contact, thereby providing a friction lock.

[0014] Thus, unlike the multi-point contact formed in the polygonal locking system of US 5 158 217, the present invention provides an area of contact between the outer and inner curved sections of the connection regions. This design enables greater friction between the first and second connection regions, such that the base and the body of the sleeve are locked together more securely.

[0015] Furthermore, by providing a larger area of contact between the connection regions, the risk of over-twisting is prevented or at least significantly reduced. In the arrangement of US 5 158 217, if the male polygonal projection is too large, there is a risk of breakage or abrasion of the corners of the polygon on over twisting. If the projection is too small, there is a risk of over-twisting the two components, i.e. rotation past the locking point such that the junction becomes unlocked. In the present invention the provision of an area of contact, which extends in a circumferential direction over at least a part of the outer and inner curved sections, prevents loosening of the lock by over-twisting, since the greater the twisting (i.e. the more relative rotation of the base and body), the greater the locking.

[0016] A further advantage of the invention is that, by virtue of the friction lock, no additional attachment means, such as gluing, are required to secure the base and the body of the sleeve together.

[0017] In some embodiments, the outer and inner curved sections are complementary in shape. By "complementary", it will be understood that the shape of the curved sections are substantially the same (i.e. the shape of one of the curved sections matches that of the other), but that one of the curved sections must be dimensionally larger than the other so that the larger of the curved sections can receive the smaller of the curved sections therein. Thus, in the unlocked position and when the curved sections are fully aligned (i.e. when the largest radial distance of the outer curved section is radially aligned with the largest radial distance of the inner curved section, and the smallest radial distance of the outer curved section is radially aligned with the smallest radial distance of the inner curved section), a gap is formed between the outer curved section and the inner curved section, a width of the gap being unchanged over the extent of the sections in a circumferential direction.

[0018] In some embodiments, the first and second connection regions are complementary in shape. In these embodiments, the shape of the radially inner surface matches that of the radially outer surface around the entire circumference of the connection regions.

[0019] In some embodiments, relative rotation of the base and body through an angle of from 20° to 110°, from 30° to 90° or from 40° to 70° is required to move the feeder system from unlocked position to the locked position. It will be appreciated that the greater the number of curved sections in the connection regions, the smaller the angle of relative rotation is required to achieve locking.

[0020] In some embodiments, one of the first and second connection regions comprises at least 2, at least 3 or at least 4 outer curved sections, and the other of the first and second connection regions comprises at least 2, at least 3 or at least 4 inner curved sections. Preferably, the curved sections are equally spaced in the connection regions. It will be appreciated that the greater the area of contact between the first and second connection regions, the more friction is provided between the outer and inner curved sections, and the stronger the connection or lock between the base and the body. It will be understood that the number of inner curved sections in one of the connection regions is normally the same as the number of outer curved sections in the other connection region. For example, the first connection region may comprise 3 outer curved sections, and the second connection region may comprise 3 inner curved sections.

[0021] In some embodiments, each of the outer and inner curved sections extends over at least 60°, at least 75°, at least 90°, at least 120°, least 140°, at least 160°, or at least 180° in a circumferential direction. In some embodiments each of the inner and outer curved sections extends over the same angle in the circumferential direction, although.

[0022] In some embodiments, the inner and/or outer curved sections extend over substantially the entire circumference of the first/second connection regions. In other words, where one curved section ends, the next immediately begins.

[0023] Alternatively, the inner and/or outer curved sections may be spaced apart, such that there are gaps between adjacent curved sections. In these embodiments, the curved sections extend over only a portion of the circumference of the first/second connection regions.

[0024] In some embodiments, the outer curved sections extend, in total, over at least 180°, at least 200°, at least 220°, at least 250°, at least 270°, at least 300°, at least 330° or at least 350° in a circumferential direction. In some embodiments, the inner curved sections extend in total over at least 180°, at least 200°, at least 220°, at least 250°, at least 270°, at least 300°, at least 330° or at least 350° in a circumferential direction. The outer curved sections may extend in total over the same angle as the inner curved sections in total. For example, each of the first and second connection regions may comprise 3 outer/ inner curved sections, wherein each curved section extends over 100° such that the outer/ inner curved sections in total extend over 300° in the circumferential direction.

[0025] In some embodiments, the first and second connection regions each comprise no more than 6, no more than 5, no more than 4 or no more than 3 curved sections.

[0026] In some embodiments, in the locked position the area of contact between the first connection region and the second connection region extends over at least 90°, at least 120°, at least 150°, at least 180°, or at least 210° It will be appreciated that the extent of the area of contact will depend in part on how tightly the base and the body are locked together, and how 'soft' the material forming these components is. It will also be appreciated that 'the area of contact between the first connection region and the second connection region' refers to the total area of contact between the outer and inner curved sections. For example, in an embodiment wherein the first and second connection regions each comprise 3 curved sections, in the locked position 3 areas of contact will be formed between the outer and inner curved sections. If each area of contact extends over approximately 45°, the (total) area of contact between the first and the second connection region will extend over approximately 135° in a circumferential direction.

[0027] In some embodiments, the fixed centre point is coincident with the bore axis of the base and, optionally, the bore axis of the body. It will be understood that by "coincident", the fixed centre point may be exactly coincident with, or it may be at least within a few millimetres of the bore axis of the base and, optionally the bore axis of the body.

[0028] In some embodiments, the first connection region has a radially outer surface comprising the at least one outer curved section and the second connection region has a radially inner surface comprising the at least one inner curved section, such that the first connection region of the base is received within the second connection region of the body. This arrangement helps to ensure that the liquid metal correctly feeds the casting through the base portion.

[0029] In some embodiments, the area of the cross-section of the base decreases distally from the second end. In other words, the second end is wider than the first end such that the sidewall of the base is generally tapered. The first end being narrower than the second end is desirable since it provides a small footprint on the mould pattern, enabling easier and cleaner knock-off following casting. The base may be any suitable shape in cross section. In some embodiments, the base is circular or oval in cross section. In some embodiments, the base is substantially frustoconical.

[0030] An outer surface of the sidewall of the base may be inclined relative to the central bore axis. The angle of inclination may vary along the longitudinal axis of the base (i.e. from the first to the second end), or it may be substantially constant. In some embodiments, the sidewall may comprise two or more sidewall regions which differ in their inclination. For example, the base may comprise a lower region proximal to the first end and an upper region distal to the first end, wherein the inclination of the outer surface of the sidewall is greater in the lower region than in the upper region. Thus, in these embodiments, the taper of the sidewall is greater in the lower region than in the upper region.

[0031] It will be understood that the angle of inclination of the outer surface of the sidewall of the base will vary according to the intended application and requirements. If the angle is too small, it will result in a long base which may adversely affect the overall feed performance of the feeder system. If the angle is too large, it will be more difficult for the mixed sand to flow and be compacted under and around the base on moulding.

[0032] In some embodiments, an inner surface of the sidewall of the base is substantially parallel to the outer surface of the sidewall. Alternatively, in some embodiments the inclination of the inner sidewall surface is different to that of the outer sidewall surface.

[0033] In some embodiments, the inner surface of the sidewall of the base defines a substantially frustoconical bore. In some embodiments the inner surface of the sidewall of the base is flared at the first end, thereby defining a restriction in a lower part of the bore, adjacent the first end. This creates an indentation or notch in the solidified feeder close to the casting surface, which further improves knock off.

[0034] The base may provide the function of a breaker core. Thus, in some embodiments, the base constitutes a breaker core, or comprises an integral breaker core.

[0035] It will be appreciated that the first and second ends of the base are open to allow molten metal to flow between the body and the metal casting. The first end of the base comprises a first aperture, while the second end comprises a second aperture. The first and second apertures may be of any suitable shape, and they may be the same or different. In some embodiments, the first and/or second aperture is circular, oval or obround (i.e. having two parallel straight sides and two part-circular ends) in shape.

[0036] The body provides a bore or cavity for receiving molten metal, the cavity being enclosed by the sidewall. The body is open at the first end, so that molten metal can flow between the metal casting and the body, through the base. In some embodiments, the second end of the body is closed. The body may be formed with an integral end wall, or the feeder system may include a separate lid for closing the second end of the body.

[0037] Thus, in some embodiments, the feeder system further comprises a lid or cover to prevent moulding sand falling into the feeder and casting cavity during moulding. The lid may be formed either from the same material as the body, or from a different material.

[0038] In embodiments wherein the second end of body is closed, the end wall or lid may be flat topped, domed, flat topped domed or any suitable shape.

[0039] The body may be any suitable shape in cross section. In some embodiments, the body is circular or oval in cross section. The sidewall of the body may be substantially tubular, or cylindrical. The cross-section of an outer surface of the body may vary along the longitudinal axis of the body, or alternatively the body may have a substantially constant outer surface cross-section.

[0040] In use,, the feeder system may be placed on a support or moulding pin which is attached to the pattern plate, to hold the feeder system in the required position prior to moulding. In some embodiments the body is provided with a central bore for receiving an end of the moulding pin, the central bore extending partially through the end wall or lid (i.e. a blind bore) or completely through the end wall or lid to a top surface thereof. The central bore or blind bore may be conical or frustoconical in shape. In certain applications the feeder system is suspended away from the pattern plate on a fixed pin. During mould formation, and under the application of pressure, the sleeve moves downwardly and the moulding pin passes through the central bore (piercing the top surface of the end wall or lid in the case of a blind bore), and ensures that the feeder sleeve moves towards the moulding plate in a uniform direction without deviating from the longitudinal axis. This ensures that the base remains fully in contact with the mould plate and that sand is uniformly compacted under the body. In other applications, a feeder system with a blind bore may be used on a spring pin that compresses as the sleeve moves downwards under moulding pressure. Alternatively, the feeder system may sit directly on the pattern plate and moulding sand applied around it.

[0041] In some embodiments, the body comprises a Williams' wedge, i.e. a prism-shaped projection which extends into the top of the bore or cavity of the body. The Williams' wedge may be an insert or it may be an integral part of the body which may be situated on an interior of the end wall or lid of the sleeve. In some embodiments, the body comprises two or more Williams' wedges. A Williams' wedge prevents the premature formation of a casting skin in the upper region of the bore or cavity. On casting when the feeder system is filled with molten metal, an edge of the Williams' wedge ensures atmospheric puncture of the surface of the molten metal and release of the vacuum effect inside the feeder system to allow more consistent feeding.

[0042] The feeder system of the invention is modular, which enables the base and body to be independently selected for assembling the feeder sleeve, thereby providing flexibility in terms of the configuration of the feeder system, the materials used and stock-keeping. Users can assemble the feeder sleeve on site from stocks of bases and bodies, as required. This provides the additional benefit of reducing packaging and transport costs.

[0043] The base and body of the present invention may be formed from or may comprise any refractory insulating and/or exothermic material or composition from which known feeders may be formed; the skilled person will be able to select the appropriate materials for each particular requirement. The nature of the material is not particularly limited and it may be, for example, insulating, exothermic or a combination of both. Typically an insulating feeder is made from a mixture of high and low density refractory fillers (e.g. silica sand, olivine, alumino-silicate hollow microspheres and fibres, chamotte, alumina, pumice, perlite, vermiculite) and binders. An exothermic feeder further requires a fuel (usually aluminium or aluminium alloy) an oxidant (typically iron oxide, manganese dioxide, or potassium nitrate) and usually initiators/sensitisers (typically cryolite). Suitable feeder compositions include for example those sold by Foseco under the trade name KALMIN, FEEDEX and KALMINEX, made by both slurry and core-shot methods.

[0044] In some embodiments, the base and the body are formed from the same material. Alternatively, the base and the body may be formed from different materials. This enables the base and the body to have different properties as required.

[0045] In some embodiments, the base and/or the body is made from insulating, insulating-exothermic or exothermic material. In some embodiments the base and/or the body is made from high density highly exothermic material as sold by Foseco under the FEEDEX HD trade name. In some embodiments the base and/or the body is made from medium density exothermic-insulating material as sold by Foseco under the KALMINEX XP and KALMINEX 2000 trade name. In some embodiments the base and/or the body is made from low density insulating material as sold by Foseco under the KALMIN 600 trade name.

[0046] Additionally, the body and base of the feeder system may be formed by any of the known methods of forming feeders. For example, the body and/or the base may be formed by vacuum forming a slurry of the material around a former and inside an outer mould, followed by heating of the sleeve to remove the water and to harden or cure the material. Alternatively, the body and/or the base may be formed by ramming or blowing the material in a core box (core shot method), and curing the body and/or base via the passage of a reactive gas or catalyst through the sleeve to cure the binder, or via application of heat by using a heated core box, or by removing the body and/or base and heating in an oven. The preferred method of manufacture is core shot, as this typically gives sleeves of greater dimensional accuracy and strength.

[0047] The strength of the base and the body should be sufficient such that when they are twisted relative to each other to lock the feeder system, there is little or no abrasion leading to particles breaking off. Similarly, the material forming the body and the base should be sufficiently rigid and not deform easily, to prevent the locked assembled feeder system being weak or loose. In some embodiments, the strength of the base and body is at least 5kN, preferably at least 10kN and most preferably at least 15kN. For ease of comparison the strength of a component is defined as the compressive strength of a 50x50mm cylindrical test body made from the same material. A 201/70 EM compressive testing machine (Form & Test Seidner, Germany) is used and operated in accordance with the manufacturer's instructions. The test body is placed centrally on the lower of the steel plates and loaded to destruction as the lower plate is moved towards the upper plate at a rate of 20mm/minute. The effective strength of the actual body and base will not only be dependent upon the exact composition, binder used and manufacturing method, but also on the size and design of each component.

[0048] The invention therefore allows for specific feeder systems with specific feed performances to be readily and simply assembled to suit the requirements of individual castings. For example, the base component can be changed dimensionally and/or compositionally to suit the different requirements of different casting alloys. The body may also be changed dimensionally and/or compositionally, depending on casting size and whether the feed requirements are volume or modulus driven. By having a number of individual base and body units, users effectively have a kit allowing them to assemble feeder systems on demand to meet their changing requirements.

[0049] According to a second aspect of the present invention, there is provided a feeder sleeve assembled from the feeder system of the first aspect of the invention, wherein the body is mounted on the base, and wherein one of the first and second connection regions is received within the other of the first and second connection regions.

[0050] The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figures 1 a and 1 b show perspective views, Figure 1c shows a top view and Figure 1d shows a bottom view of a base of a feeder system in accordance with an embodiment of the present invention;

Figures 2a and 2b shows perspective views, and Figure 2c shows a bottom view of a body suitable for connecting to the base of Figure 1, in accordance with an embodiment of the present invention;

Figure 3 shows a cross-sectional view of a feeder system in accordance with an embodiment of the present invention, formed from the base of Figure 1 and the body of Figure 2;

Figure 4 shows a cross section of the feeder system of Figure 3, taken through line A-A, when the feeder system is in an unlocked position;

Figure 5 shows a cross section of the feeder system of Figure 3, taken through line A-A, after relative rotation of the body by 35° so as to place the feeder system in a locked position;

Figures 6a and 6b show two cross-sectional side views in perpendicular planes of a feeder system in accordance with an alternative embodiment of the present invention;

Figure 7 shows a cross-sectional view of a feeder system in accordance with an embodiment of the present invention, when the feeder system is in an unlocked position;

Figure 8 shows a cross-sectional view of a feeder system in accordance with a further embodiment of the present invention, when the feeder system is in an unlocked position;

Figure 9 shows the feeder system of Figure 8, after relative rotation of the body by 50° so as to place the feeder system in a locked position; and

Figure 10 shows a perspective view of a base of a feeder system in accordance with an embodiment of the present invention.

[0051] With reference to Figures 1a-1d, a base 10 comprises an open first end 12, an opposite, open second end 14 and a bore 16 between the first end 12 and the second end 14. The bore 16 is defined by a sidewall 18 having an outer surface 20 and an inner surface 22. The sidewall 18 comprises a first connection region 24 adjacent the second end 14. The sidewall 18 may be considered to comprise two further regions, a lower region 26 extending from the first end 14, and an upper region 28 between the lower region 26 and the connection region 24. The first connection region 24 is slightly larger in cross section than the upper region 28 of the sidewall 18, such that a lip 32 is formed therebetween.

[0052] The first end 12 of the base 10 is defined by a first annular mounting surface 25, which defines a circular aperture 27 through which molten metal flows into the casting. The annular mounting surface 25 contacts the mould pattern when the feeder system is in use. The second end 14 of the base 10 is defined by a second annular mounting surface 29 for receiving a body thereon.

[0053] The base 10 has an outer profile that is generally tapered from the wider second end 14 to the narrower first end 12. In the lower region 26, the outer surface 20 of the sidewall 18 is tapered (25° to the bore axis) to a greater extent than in the upper region 28 (10° to the bore axis). In the embodiment shown, the base 10 is circular in cross section.

[0054] In the embodiment shown, the inner surface 22 of the sidewall 18 is generally parallel to the outer surface 20, thereby defining a frustoconical bore 16, but is flared at the first end 12 of the base 10 to define a restriction 17 in the lower part of the bore 16. After casting, this results in a notch being formed in the residual metal in the feeder and facilitates knock-off.

[0055] With reference to Figures 2a-2c, a body 34 comprises an open first end 36, a closed second end 38 formed by an integral end wall, and a bore or cavity 40 extending between the first and second ends 36, 38, defined by a sidewall 42. The sidewall 42 has an inner surface 44 and an outer surface 46. The outer surface 46 may be considered to comprise a lower region 47, a middle region 50 and an upper region 52, each of which has a different angle between the outer surface 46 and a central axis of the bore or cavity 40. The middle region 50 is approximately tubular in profile, while the upper and lower regions 47, 52 are tapered or frustoconical. The closed second end 38 of the body 34 is continuous with the upper region 52. The first end 36 of the body 34 is defined by an annular surface 53.

[0056] Figure 3 shows a feeder system 54 formed from the body of Figure 2 mounted on the base of Figure 1. It can be seen that the inner surface 44 of sidewall 42 of the body 34 does not follow the same profile as the outer surface 46. Instead, the bore or cavity 40 within the body is generally tapered, narrowing in the direction of the second end 38 such that the thickness of the sidewall 42 increases from the first end 36 to the second end 38. In the embodiment shown, a blind bore 55 for receiving a moulding pin extends partially through the closed second end 38 of the body 34.

[0057] The inner surface 44 of the sidewall 42 is formed with a second connection region 48 adjacent the first end 36. In the second connection region 48, the inner surface 44 is parallel with the bore axis. The bore 40 also widens in the region of the second connection region, thereby forming an annular abutment surface 57 which rests on the second annular mounting surface 29 of the base 10.

[0058] Figure 4 shows the relationship between the first and second connection regions 24, 46, when the base 10 and body 34 of the feeder system 54 are in the unlocked position. In the first connection region 24 the outer surface 20 of the sidewall 18 comprises three outer curved sections 30, each extending over an angle of approximately 115° in a circumferential direction. The radius of each curve increases continuously from a smallest radial distance R_1 to a largest radial distance R_2, as measured from a fixed centre point P which is coincident with a central longitudinal axis of the bore 16. Similarly, in the second connection region 46 the inner surface 44 comprises three inner curved sections 60, each extending over an angle of approximately 115° in a circumferential direction. The radius of each curve increases from a smallest radial distance R_3 to a largest radial distance R_4, as measured from the fixed centre point P. In the embodiment shown the outer and inner sidewall surfaces 18, 20 are complementary in shape in the connection regions 24, 46, the second connection region 46 being dimensionally slightly larger than the first connection region 24 such that the first connection region 24 fits within the second connection region 46 with only a narrow gap therebetween.

[0059] At the boundary between the smallest radial distance R_1 of one outer curved section 30 and the largest radial distance R_2, a ridge 31 is formed. Similarly, at the boundary between the smallest radial distance R_3 of one inner curved section 60 and the largest radial distance R_4, an opposing ridge 61 is formed. The ridges 31, 61 function as stops so that relative rotation between the body 34 and the base 10 is only possible in one direction, towards the locked position. In the embodiment shown in Figure 4, the body 34 must be rotated clockwise relative to the base 10 to provide locking of the feeder system.

[0060] Figure 5 shows the first and second connection regions 24, 46 after rotation of the body 34 relative to the base 10 through an angle α of 35° to a locked position. It can be seen that as the body and the base are rotated relative to one another, the largest radial distance of each outer curved section is moved towards the smallest radial distance of each inner curved section. In other words, a region of the sidewall of continuously increasing width is moved into a space of continuously decreasing width. This causes the outer curved sections to wedge against the inner curved sections, thereby locking the first and second connection regions, and thus the base and body, together. In the embodiment shown in Figure 5, three areas of contact are formed between the outer and inner curved sections, each area θ extending over approximately 45° in a circumferential direction. Thus, the total area of contact between the first connection region 24 and the second connection region 26 extends over approximately 135° in a circumferential direction. The base and the body cannot be unlocked through over-twisting because the radius of each outer curved section continues to increase 'behind' the area of contact, such that it is not possible to force the outer curved sections passed the locking position.

[0061] Figures 6a and 6b shows an alternative embodiment of a feeder system 100 in accordance with the present invention, being two-cross sectional views in two different planes perpendicular to each other. The feeder system 100 comprises a base 110 and a body 134 mounted thereon. The base 110 comprises a first end 112, a second end 114 and a sidewall 118 therebetween having an outer surface 120 and an inner surface 122. A first connection region 124 is provided adjacent the second end 114. The base 110 is similar in shape to that of Figure 1, in that it is substantially frustoconical. However, unlike the embodiment of Figure 1, the outer surface 120 of the sidewall 118 is slightly curved, the angle of curvature changing from the first end 112 to the first connection region 124.

[0062] The body 134 comprises a first end 136, a second end 138 and a sidewall 142 therebetween, defining a cavity 140. The sidewall 142 has an inner surface 144 and an outer surface 146. The sidewall 142 is substantially tubular, having a slight taper towards the second end 138. In this embodiment, the second end 138 is closed by an end wall 170 in which two Williams' wedges 172a and 172b are formed which project into the cavity 140. A blind bore 150 for receiving a moulding pin is also formed in the end wall 170, between the two wedges 172a, 172b.

[0063] The first and second connection regions of this embodiment may have the same dimensions and shape as those of the embodiment shown in Figure 3.

[0064] Figure 7 is a cross-sectional view of a feeder system 200 in accordance with a further embodiment of the present invention, and shows the feeder system 200 in an unlocked position. The feeder system 200 comprises a base 210 and a body 234, and may have the same overall dimensions and/or shape as the feeder system 54 shown in Figures 1-4. In the embodiment of Figure 7, the base 210 has a first connection region 224 having two outer curved sections 230, each extending over an angle of approximately 175°, with associated ridges 231 formed at the boundary between the smallest radial distance and largest radial distance. Similarly, the body 234 has a second connection region 246 having two inner curved sections 260, each extending over an angle of approximately 175°, with associated ridges 261 formed at the boundary between the smallest radial distance and largest radial distance.

[0065] Figure 8 is a cross-sectional view of a feeder system 300 in accordance with another embodiment of the present invention, and shows the feeder system 300 in an unlocked position. The feeder system 300 comprises a base 310 and a body 334, and may have the same overall dimensions and/or shape as the feeder system 54 shown in Figures 1-4. In the embodiment of Figure 8, the base 310 has a first connection region 324 having three outer curved sections 330, each extending over an angle of approximately 115°. In this embodiment there is a notch or cut out 332 formed at the boundary between the smallest radial distance R_1 and largest radial distance R_2. Similarly, the body 334 has a second connection region 346 having three inner curved sections 360, each extending over an angle of approximately 115°, with notches or cut outs 362 formed at the boundary between the smallest radial distance R_3 and largest radial distance R_4. The notches are used to align the base 310 and the body 334 when the feeder system 300 is assembled. Figure 9 shows the first and second connection regions 324, 346 after rotation of the body 334 relative to the base 310 through an angle α of 45° to a locked position. Three areas of contact are formed between the outer and inner curved sections, each area θ extending over approximately 40° in a circumferential direction, such that the total area of contact between the first and second connection regions 324, 346 extends over approximately 120° in a circumferential direction.

[0066] Figure 10 shows an alternative embodiment of a base 410, the base 410 comprising an open first end 412, an opposite, open second end 414 and a bore 416 between the first end 412 and the second end 414. The bore 416 is defined by a sidewall 418 having an outer surface 420 and an inner surface 422.

[0067] The first end 412 of the base 410 is defined by a first obround mounting surface 425, which defines an obround aperture 427. The second end 414 of the base 410 is defined by a second annular mounting surface 429 for receiving a body thereon.

[0068] The base 410 has a first connection region 424 having three outer curved sections, each extending over an angle of approximately 115°, and ridges 431 formed at the boundary between the smallest and largest radial distance of the curved sections.

[0069] The base 410 has an outer profile that is generally tapered from the wider second end 414 to the narrower first end 412. The outer surface 420 of the sidewall 418 tapers outwardly from the bore axis from the first end 412 to the second end 414, such that the base 410 has an obround cross section at the first end 412 and a circular cross section at the second end 414.

Claims

1. A feeder system comprising:

   a base comprising a first end for mounting on a mould pattern, an opposite second end and a bore between the first and second ends defined by a sidewall, the sidewall comprising a first connection region spaced from the first end; and
   a body that is separate from the base, the body comprising a first end for mounting on the base, an opposite second end and a bore between the first and second ends defined by a sidewall, the sidewall comprising a second connection region spaced from the second end,
   wherein one of the first and second connection regions has a radially outer surface comprising at least one curved section (outer curved section) of which the radius increases continuously from a smallest radial distance to a largest radial distance from a fixed centre point,
   wherein the other of the first and second connection regions has a radially inner surface comprising at least one curved section (inner curved section) of which the radius increases continuously from a smallest radial distance to a largest radial distance from said fixed centre point,
   wherein the largest radial distance of the inner curved section is greater than the largest radial distance of the outer curved section, and the smallest radial distance of the inner curved section is greater than the smallest radial distance of the outer curved section, such that one of the first and second connection regions is sized to receive the other, and
   wherein the largest radial distance of the outer curved section is greater than the smallest radial distance of the inner curved section, such that when one of the first and second connection regions is received within the other, the base and the body are relatively rotatable from an unlocked position to a locked position in which an area of contact between the first connection region and the second connection region extends over at least a part of the outer and inner curved sections.

2. The feeder system according to claim 1, wherein the first and second connection regions each comprise at least 2 or at least 3 outer and inner curved sections, respectively.

3. The feeder system according to claim 1 or claim 2, wherein each of the outer and inner curved sections extends over at least 60° in a circumferential direction.

4. The feeder system according to claim 2, wherein the outer curved sections extend in total over at least 180° in a circumferential direction, and the inner curved sections extend in total over at least 180° in a circumferential direction.

5. The feeder system according to claim 4, wherein the outer curved sections extend in total over at least 300° in a circumferential direction, and the inner curved sections extend in total over at least 300° in a circumferential direction.

6. The feeder system according to any preceding claim, wherein the first and second connection regions each comprise no more than six curved sections.

7. The feeder system according to claim 6, wherein the first and second connection regions each comprise no more than three curved sections.

8. The feeder system according to any preceding claim, wherein the area of contact extends over at least 90° in a circumferential direction.

9. The feeder system according to any preceding claim, wherein the fixed centre point is coincident with the bore axis of the base and/or the body.

10. The feeder system according to any preceding claim, wherein the first connection region has a radially outer surface comprising the at least one outer curved section and the second connection region has a radially inner surface comprising the at least one inner curved section, such that the first connection region of the base is received within the second connection region of the body.

11. The feeder system according to any preceding claim, wherein the base and the body are made from different materials.

12. The feeder system according to any preceding claim, wherein the feeder system further comprises a lid for closing the second end of the body.

13. The feeder system according to any preceding claim, wherein the body comprises at least one Williams' wedge.

14. A feeder sleeve assembled from the feeder system of any one of claims 1 to 13, wherein the body is mounted on the base, and wherein one of the first and second connection regions is received within the other of the first and second connection regions.

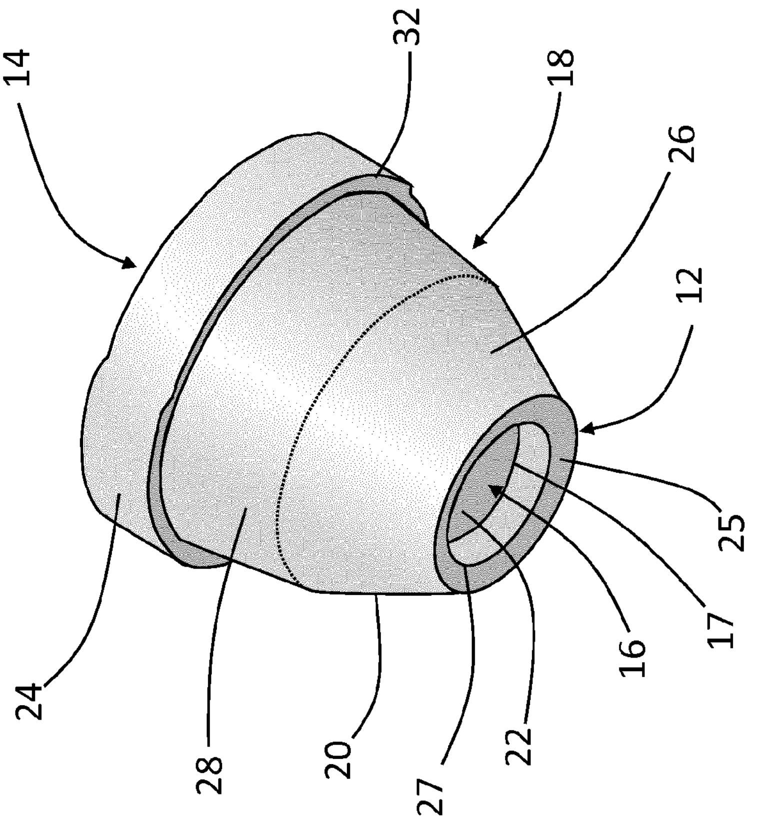

Figure 1b

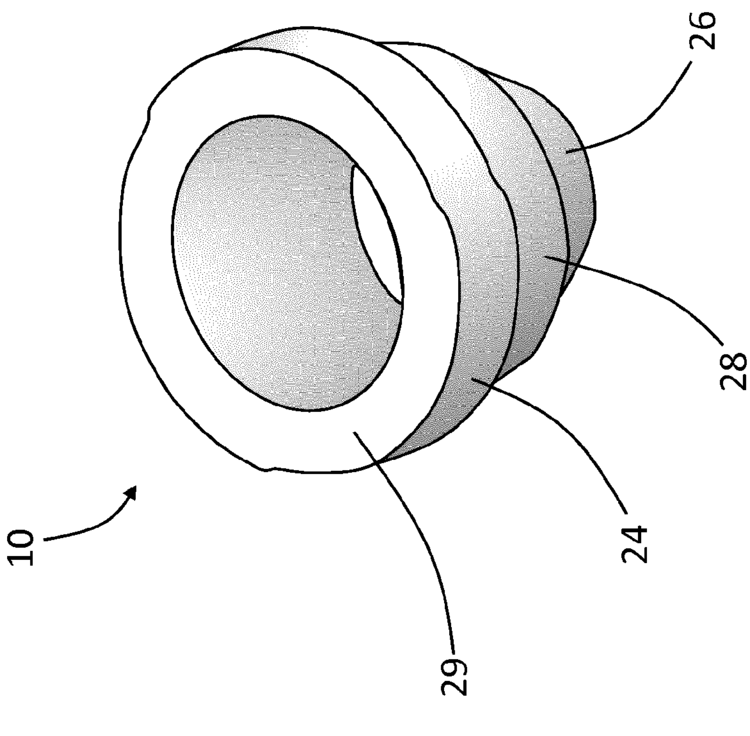

Figure 1a

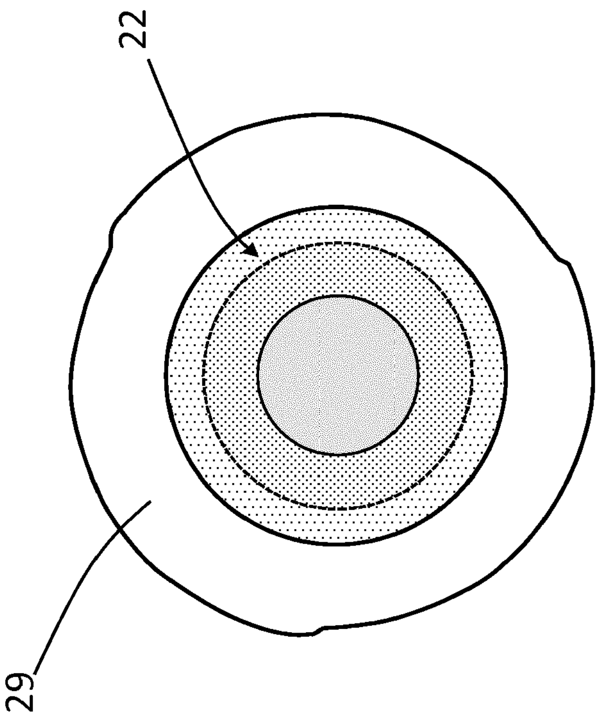

Figure 1c

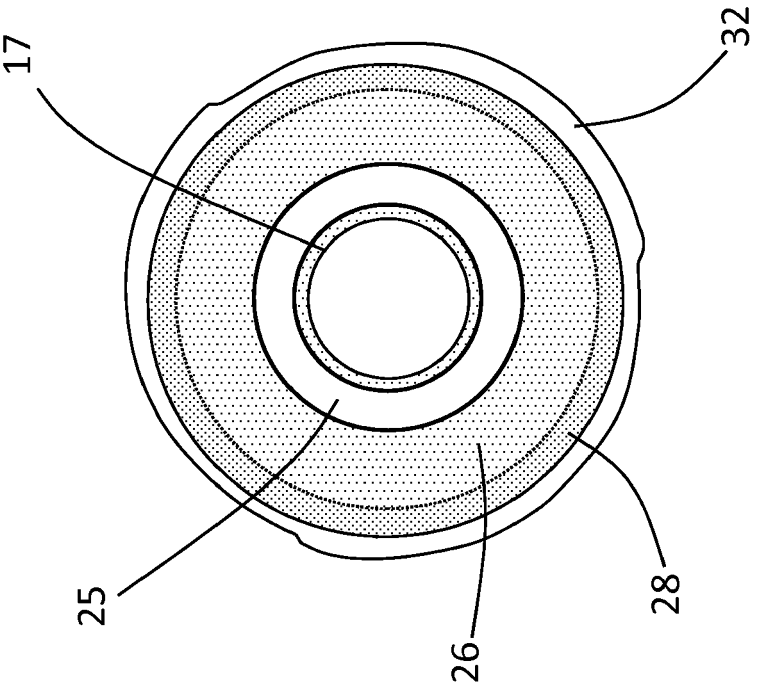

Figure 1d

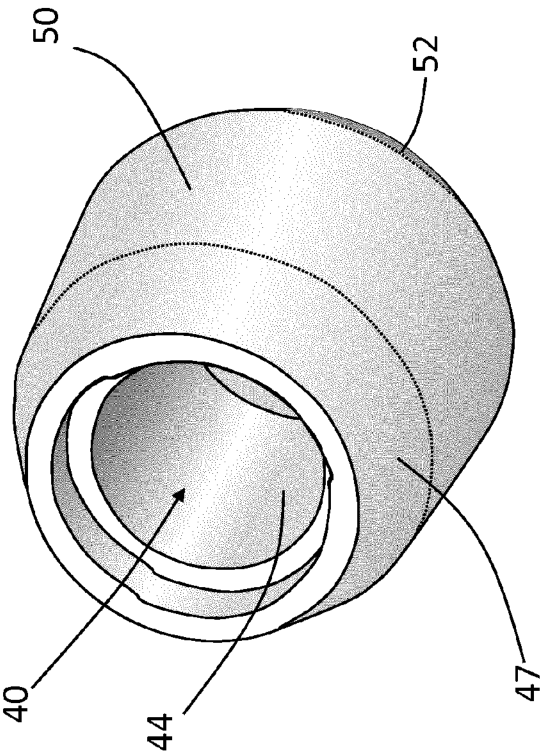

Figure 2b

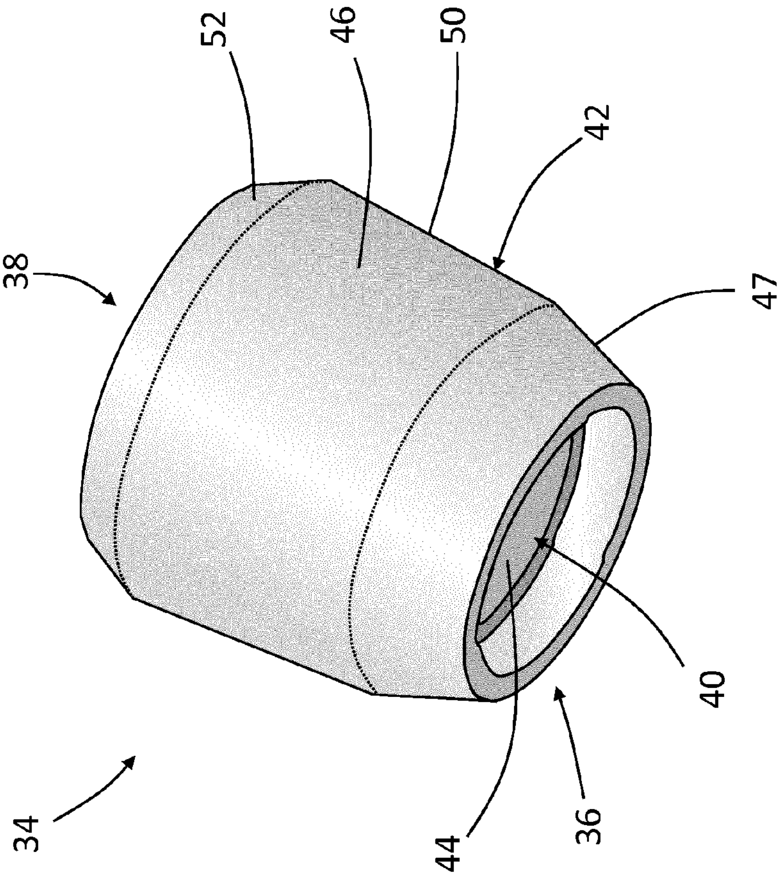

Figure 2a

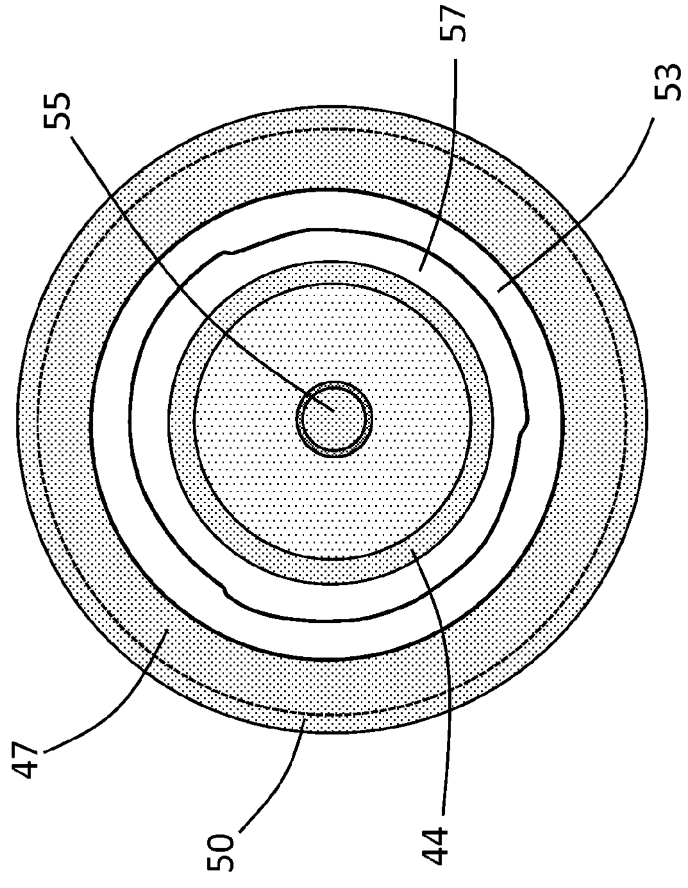

Figure 2c

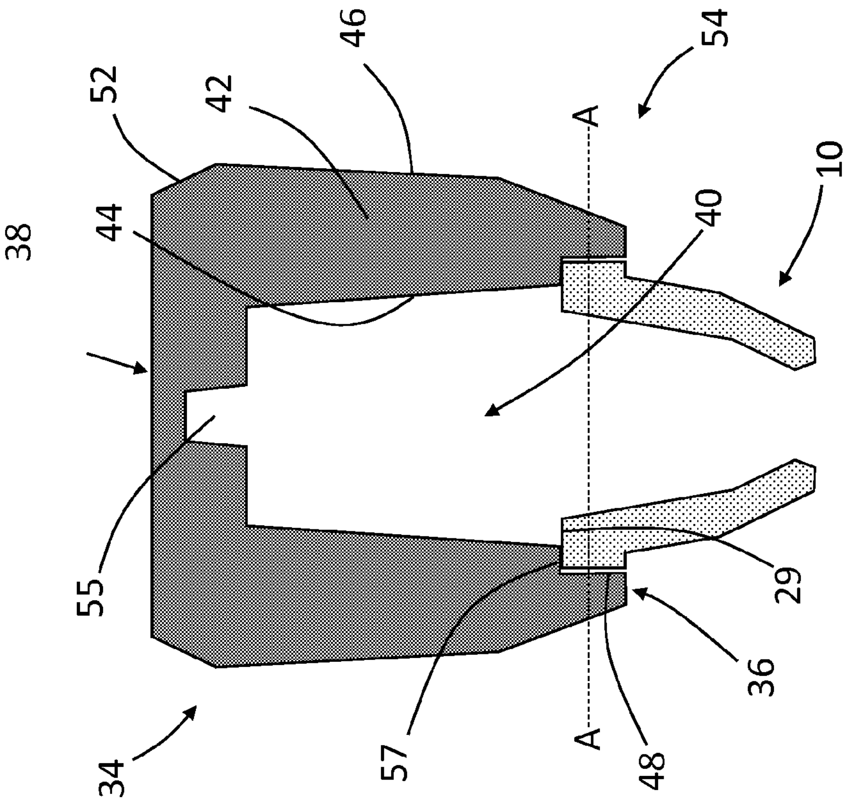

Figure 3

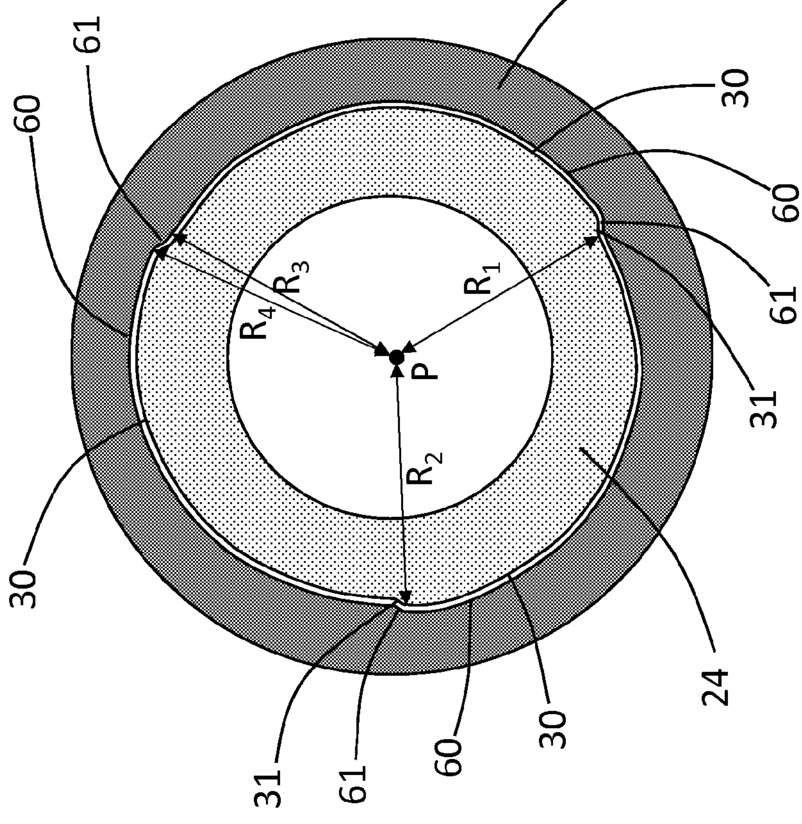

Figure 4

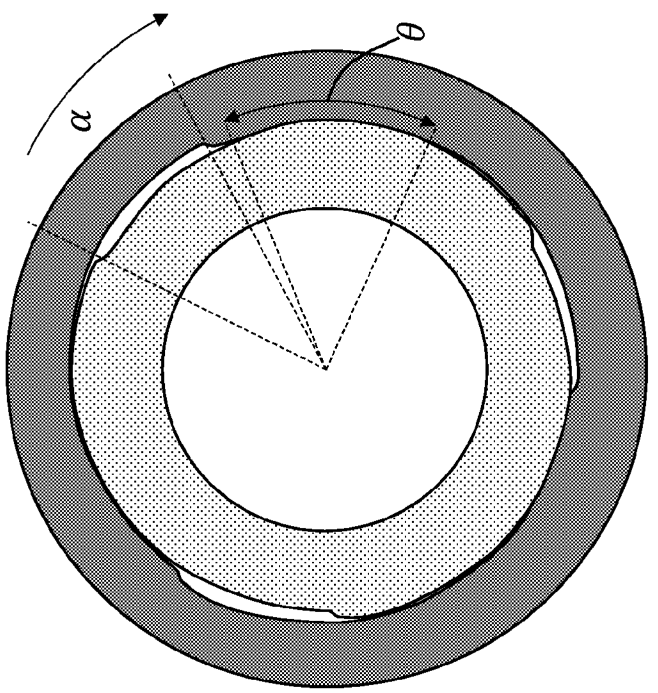

Figure 5

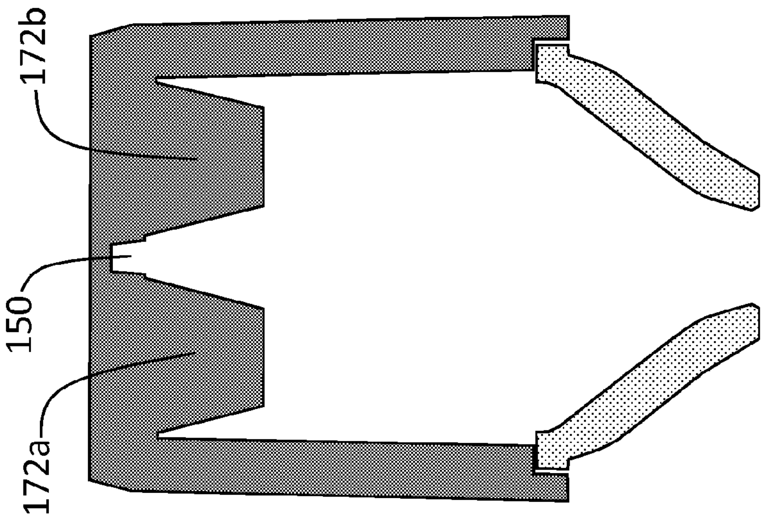

Figure 6b

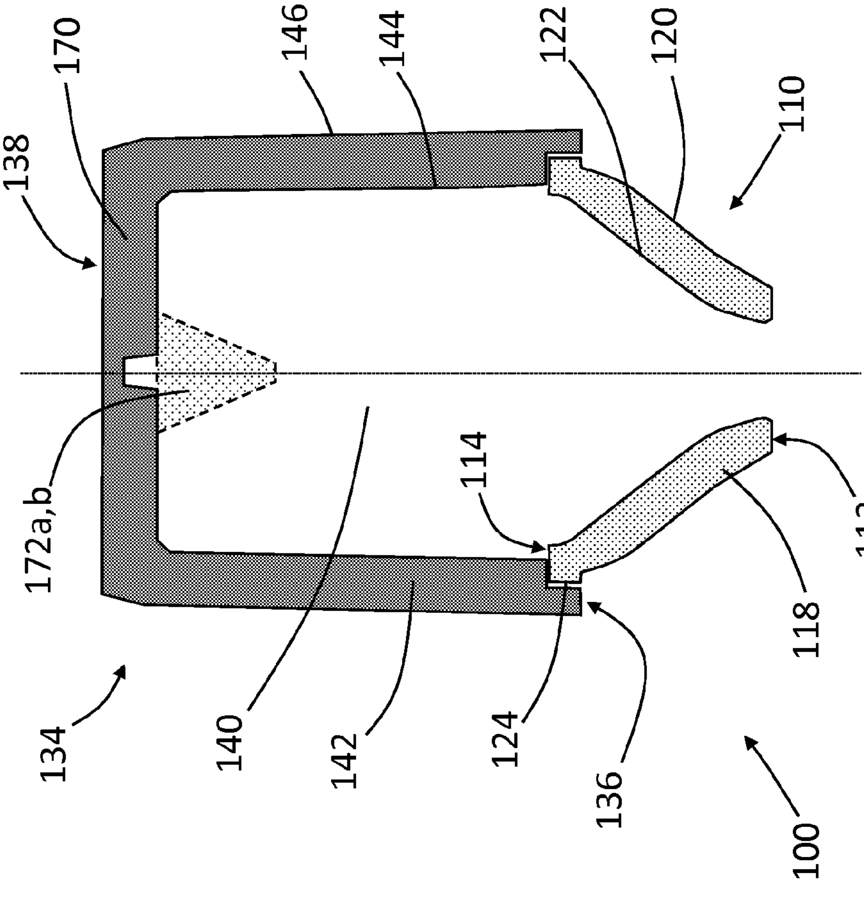

Figure 6a

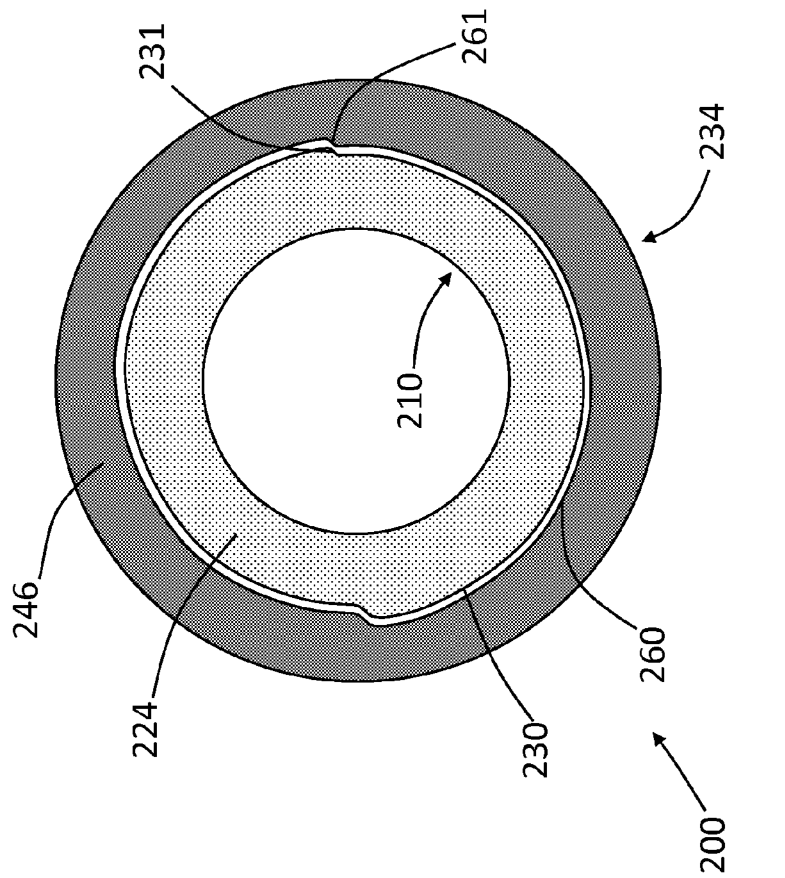

Figure 7

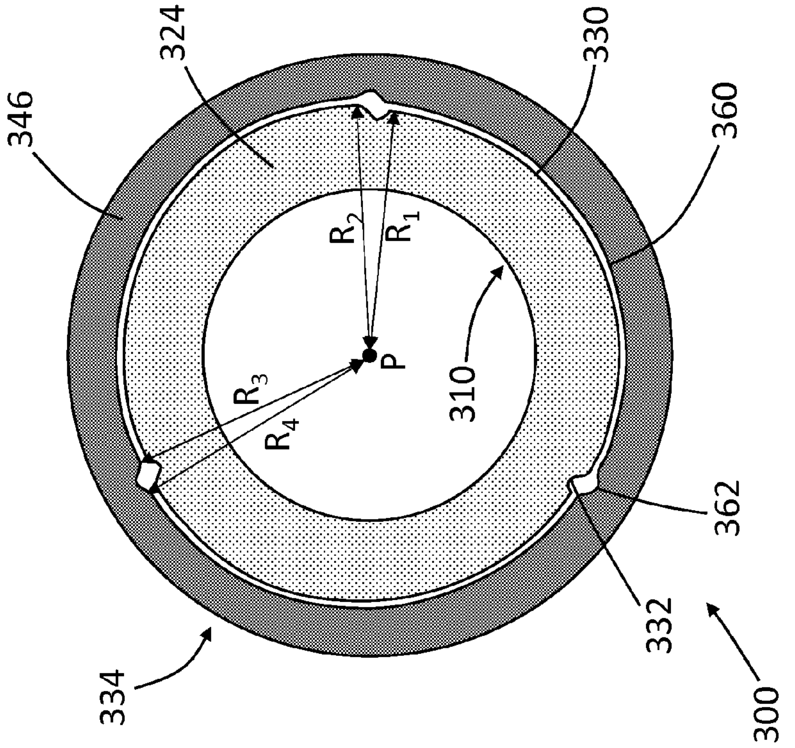

Figure 8

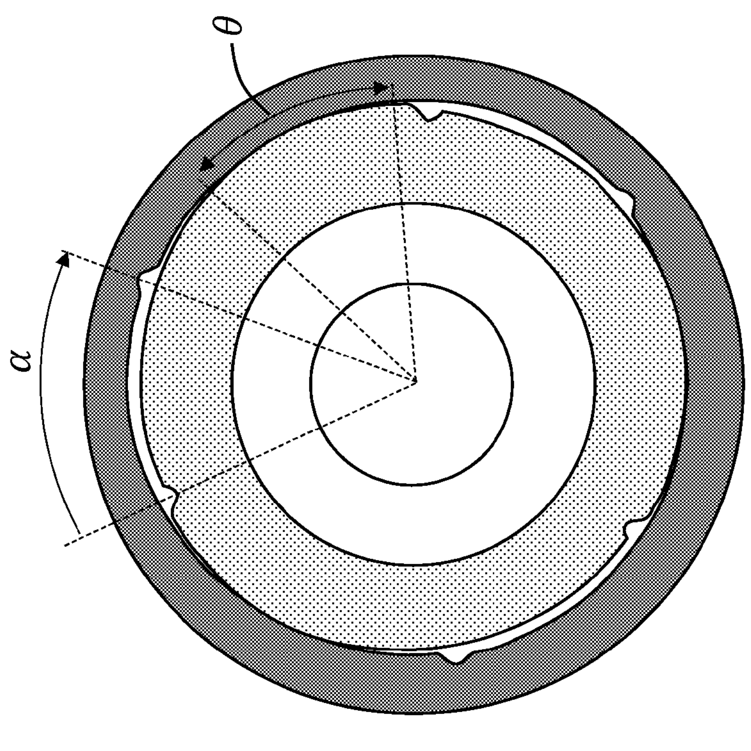

Figure 9

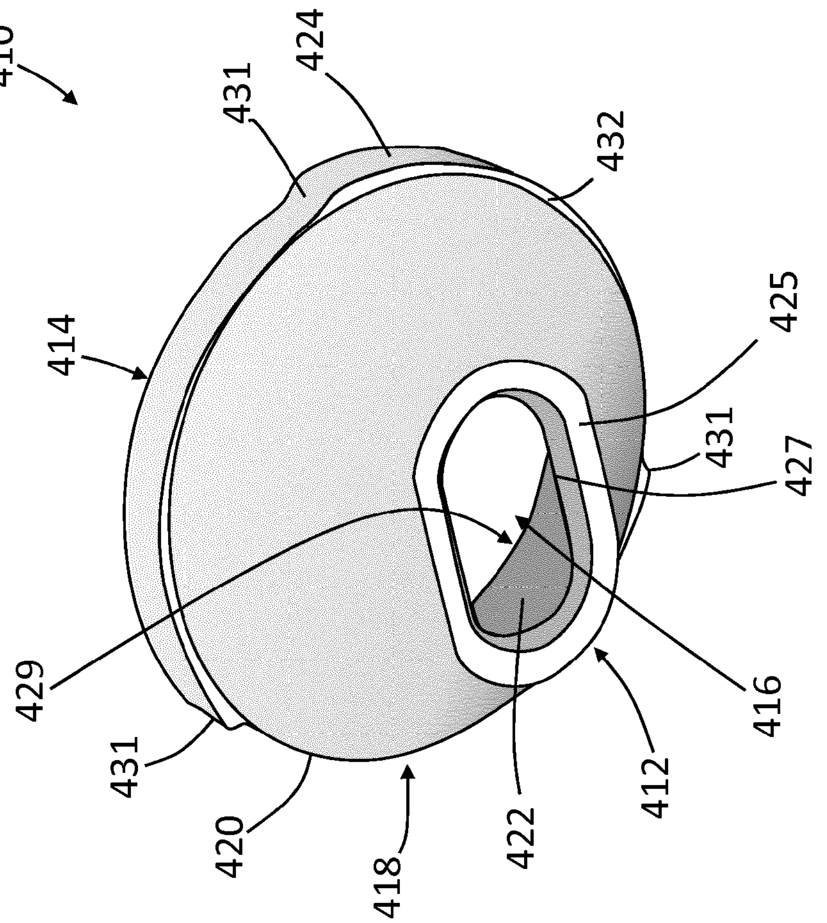

Figure 10

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EUROPEAN SEARCH REPORT

Application Number
EP 17 27 5061

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Place of search	Date of completion of the search	Examiner
Munich	6 October 2017	Baumgartner, Robin

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