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(54) **Arc furnace pressure ring assembly**

(57) The invention provides for a pressure ring assembly [10] suitable for use in an electric arc furnace, wherein the pressure ring assembly [10] comprises at least two pressure ring segments [22] engaging each other, at least one contact shoe [50] arranged between the pressure ring [20] and an electrode, and a piston arrangement [40] between the pressure ring segment [22] and the contact shoe [50] for forcing the contact shoe [50] into electrical contact with the electrode. The pressure ring assembly [10] is characterised therein that it is made of a metal alloy wherein a first metal of the alloy is copper,

and a second metal is selected from a group comprising of chrome and silver. The pressure ring assembly [10] is further characterised therein that each pressure ring segment [22] includes two tapered engagement formations [27] defined within the pressure ring segment [22] and being adapted to be engaged by complementarily tapered connecting means [60] such that the pressure ring segments [22] are drawn towards each other during installation of the pressure ring assembly. The pressure ring assembly [10] further provides for a sealing arrangement between the pressure ring and the contact shoe [50].

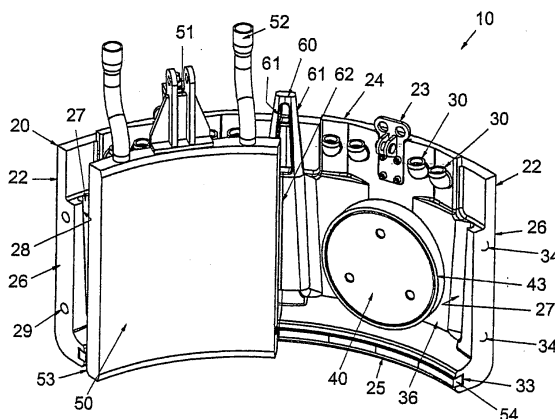


FIGURE 1

Description

TECHNICAL FIELD

[0001] The invention relates to a pressure ring assembly suitable for use in an electrical arc furnace, and more particularly, but not exclusively, to a pressure ring assembly suitable for use on a lower section of an electrode column.

BACKGROUND ART

[0002] Electric arc furnaces are commonly used in the steel and ferro alloy production industry during pyrometallurgical smelting operations. An electric arc furnace includes one or more electrodes that extend into the furnace and that are arranged in use proximate a furnace load for supplying the energy required during smelting operations. Electric transformers are generally located outside the furnace and electric power is conducted from such transformers to the electrodes by means of contact shoes that are circumferentially arranged about and releasably engaged with the electrodes.

[0003] It will be appreciated that for optimal power conductivity, the contact shoes must at all relevant times be maintained in proper electrical contact with the electrodes. In order to maintain proper electrical contact between the contact shoes and the electrode during generally harsh operating conditions, a pressure ring is commonly arranged circumferentially about the contact shoes and dimensioned to maintain a number of contact shoes in electrical contact with the electrode.

[0004] Various pressure ring arrangements are encountered in the industry, including continuous pressure rings (commonly referred to as solid rings), and segmented pressure rings, which comprise of a number of arcuate segments that are interconnected to form a circular ring. Segmented pressure rings are often preferred due to the maintenance difficulties associated with the replacement of components of the contact shoes when a solid ring is used.

[0005] One of the difficulties encountered with segmented pressure rings concerns connecting mechanisms with which adjacent ring segments are connected to each other. A first difficulty is that available connecting mechanisms are often difficult to connect and disconnect, and once disconnected even more difficult to reconnect. This is particularly problematic in a case where a hinge-and-pin-type connecting mechanism is used. A further problem associated with most known connecting mechanisms is that adjacent segments of the pressure ring need to be perfectly aligned for such mechanisms to be used and these mechanisms are not configured to aid in aligning the segments upon installation thereof. Also, known connecting mechanisms, including hinge-and-pin-type and parallel-pin-type connecting mechanisms, are designed merely to prevent segments from being displaced away from each other in use, but contributes nothing

to drawing adjacent segments closer to each other during installation.

[0006] A further important requirement pertaining to the contact shoes is that they must preferably be located relatively low down on the electrodes. However, this implies that the contact shoes, and thus the pressure rings, are to be located in close proximity of the high temperature section of the arc furnace. The pressure rings are therefore exposed to harsh environmental conditions. Contrary to the electrodes, the pressure rings are not classified as consumables, and must therefore be able to withstand the harsh furnace operating conditions for extended periods of time.

[0007] Given the conditions in which the pressure rings operate, the overriding design parameters dominating pressure ring life are generally effective heat dissipation through the pressure rings and adequate mechanical strength. Various solutions have been proposed to extend the life of the pressure rings by optimising and/or manipulating the above design criteria.

[0008] A first solution, which is implemented in a so-called "split design", suggests providing a heat shield around an outer peripheral and bottom surface of the pressure ring which is most exposed to the severe operating conditions. The heat shield is manufactured of a material that has good heat-conductivity characteristics, such as copper. The heat shield can be of limited mechanical strength, as the pressure ring, and not the heat shield, will absorb the force exerted on the contact shoes. The heat shield will thus, protect the pressure ring from being exposed to excessive furnace temperatures, and the heat-conductivity of the pressure ring becomes less critical. The solution is however complex, not always cost efficient and often not feasible due to size complexities.

[0009] A second solution, which is generally implemented in a so-called "compound design", suggests a pressure ring manufactured from a material having good heat-conductivity characteristics, such as pure copper. However, pure copper lacks the mechanical strength to withstand the forces imparted on the pressure ring by the contact shoes, and is especially prone to creep. The occurrence of creep is furthermore proportional to the temperature of the pressure ring, which renders pure copper generally unsuitable for use. In order to overcome the shortcomings in mechanical strength, a pressure ring made from pure copper would have to be of substantial size to allow the maximum stresses in the pressure ring to be reduced to levels where the occurrence of creep will be below acceptable limits. However, this results in the pressure ring becoming heavy and bulky, and consequently expensive to manufacture and difficult to handle. Such a pressure ring is also not compatible with standard furnace set-ups, as there is generally insufficient space for the larger pressure ring.

[0010] As a compromise one may consider using a material having better mechanical strength than that of pure copper, but which as a trade-off has lower heat conductivity characteristics than pure copper. A pressure ring

made from such material would thus be able to handle the stresses caused by the contact shoes, whilst still being reasonably compatible with the harsh temperature conditions. Materials such as carbon steel, stainless steel and aluminium bronze are widely used in industry, but such materials all suffer from the common disadvantage of having sub-optimal heat conductivity characteristics, thus adversely affecting the life of the pressure rings.

[0011] A further aspect of pressure ring assemblies that are often problematic is the interface between the pressure ring and the contact shoes. A contact shoe is pushed away from the pressure ring towards the electrode in order to engage the same. This is generally achieved either by using a hydraulic piston arrangement, or some other mechanical drive system.

[0012] A number of hydraulic piston arrangements are known in the industry. In most arrangements the piston is located in a pressurisation cavity defined in a concave face of a pressure ring segment. A fluid is introduced under pressure into the pressurisation cavity by way of flow channels that are embedded in the pressure ring segment, and imparts an outwardly directed hydraulic force on the piston, which in turn relays a force to an adjacent contact shoe to force the contact shoe into engagement with the electrode. It will be appreciated that this arrangement will only work optimally if the pressurisation cavity between the pressure ring segment and the piston is properly sealed, as it will otherwise not be possible to raise the pressure in the cavity to actuate the piston sufficiently. In addition, the sealing arrangement between the pressure ring segment and the piston should be able to accommodate relative displacement between the pressure ring and the piston.

[0013] Various seals have previously been used in this application. Rubber diaphragms have for instance been used due to their inherent resilience, but have proven to be susceptible to premature failure due to incompatibility with the high temperature conditions.

[0014] A further type of resilient seal that has been used with some success in pressure ring assemblies is metal bellows. The prior art provides for two types of metal bellows in pressure rings, namely formed bellows and plate or diaphragm bellows. Formed bellows is produced by shaping a uniform metal tube or sleeve into a continuously convoluted bellows, whilst diaphragm bellows is formed by a single thin plate that deforms under pressure.

[0015] However, a number of problems have been encountered with the use of both formed and diaphragm bellows. Firstly, formed bellows takes up a relatively large space, thus resulting in the piston having to be of smaller diameter in order to fit inside the pressurisation cavity in the pressure ring segment. The smaller piston diameter necessitates higher hydraulic pressure in order to exert the same force on the contact shoes.

[0016] A second problem associated with both formed and diaphragm bellows is that only a limited number of convolutions can be accommodated in the small space between the piston and the pressurisation cavity and this

relatively small number of convolutions must satisfy the displacement requirements of the piston. This results in the convolutions being expanded beyond optimal design criteria, which in turn results in high stresses and metal fatigue in the bellows, and necessitates higher hydraulic pressure to obtain sufficient piston movement. Also, diaphragm bellows suffer from low displacement possibilities and high stresses, leading to metal fatigue and premature failure.

[0017] As an alternative to hydraulic arrangements, mechanical drive systems have also been implemented to push the contact shoes towards the electrode. However, these systems suffer from the disadvantage of being complex and prone to failure, thus not providing a suitable alternative to hydraulic arrangements.

[0018] Those engaged in the industry will appreciate that an electrical arc furnace operates under negative pressure, which means that there is a tendency for atmospheric air to be sucked into the furnace. This may result in unwanted combustion of CO, resulting from pyrometallurgical reaction processes in the furnace, in the vicinity of the electrode where it protrudes through a furnace roof, thus increasing temperatures in the vicinity of the pressure rings. This may cause the pressure rings, contact shoes and pistons to overheat and break.

[0019] It will further be understood that the electrode and its components are pressurised by means of a fan, directed at blowing air down the electrode so as to create a gas seal above the furnace for preventing escape of furnace gasses and resultant formation of a gas chimney upwards along the electrode. In a case of improper sealing about the pressure ring assembly, the undesired escape of furnace gasses may degrade the gas seal, causing further damage to the electrode components.

[0020] The prior art makes little provision for a seal between the pressure ring and the contact shoes and at best suggests stuffing heat resistant wool or soft refractory clay into the gap between the pressure ring and the contact shoes. This makeshift seal is usually of low integrity and is often blown out of position when a sudden pressure increase occurs in the furnace interior, such as in the case of explosions in the furnace.

OBJECT OF THE INVENTION

[0021] It is accordingly an object of this invention to provide a pressure ring assembly that will, at least partially, alleviate the disadvantages associated with existing pressure ring assemblies, and/or will provide a novel and useful alternative to existing pressure ring assemblies.

DISCLOSURE OF THE INVENTION

[0022] According to the invention there is provided a pressure ring assembly suitable for use in an electric arc furnace, the pressure ring assembly comprising a pressure ring characterised therein that it is made of a metal

alloy wherein a first metal of the alloy is copper, and a second metal is selected from a group comprising of chrome and silver.

[0023] The alloy may comprise at least 97% of copper. When the second metal is chrome, the alloy may comprise between 0.5% and 3.0% chrome, and particularly 1.5% chrome. When the second metal is silver, the alloy may comprise between 0.05% and 0.5% silver, and particularly 0.15% silver.

[0024] A further feature of the invention provides for the use of a metal alloy wherein a first metal is copper, and a second metal is selected from a group comprising of chrome and silver in the manufacture of a pressure ring suitable for use in an electric arc furnace.

[0025] According to a second aspect of the invention there is provided a pressure ring assembly suitable for use in an electric arc furnace, the pressure ring assembly comprising at least two pressure ring segments dimensioned to engage each other to form a pressure ring around an electrode, each pressure ring segment having a top end, a bottom end, two opposing side ends, an inner face facing the electrode, and an opposite outer face; the pressure ring assembly being characterised therein that each pressure ring segment includes two engagement formations located proximate the opposing side ends and extending at least partially between the top and bottom ends, each engagement formation further being characterised therein that it is defined within at least one face of the ring segment and is at least partially tapered relative to the side ends, the engagement formations being adapted to be engaged by connecting means such that the pressure ring segments are drawn towards each other during installation of the pressure ring assembly.

[0026] Each engagement formation may be a substantially continuous elongate formation and may be defined either by a recess embedded in or a protrusion protruding from a face of the pressure ring segment. The engagement formation may include a lip dimensioned to cooperate with a complementarily dimensioned lip engaging formation defined in the connecting means so as to create a secure engagement between the engagement formation and the connecting means.

[0027] In a preferred embodiment of the invention, the engagement formations comprise of two elongate recesses defined in the inner face of the ring segments proximate the opposing side ends and tapering downwardly between the top and bottom ends. More particularly, the elongate recesses are tapered away from the side ends going down from the top to the bottom ends.

[0028] According to a further aspect of the invention there is provided connecting means for inter-connecting adjacent pressure ring segments of a pressure ring assembly suitable for use in an electric arc furnace, the connecting means being characterised therein that it comprises two leg sections connected to each other by means of an intermediate bridge section wherein the leg sections are at least partially tapered relative to each

other and relative to an elongate axis of the connecting means, the connecting means further being adapted to engage the pressure ring segments such that they are drawn towards each other during installation of the pressure ring assembly.

[0029] The connecting means may be an elongate connecting bracket adapted to engage the pressure ring segments. Particularly, the connecting means may be an elongate sliding bracket adapted to slide into or over complementarily tapered engagement formations defined in the pressure ring segments.

[0030] The bridge section may span substantially the length of the connecting means. Alternatively, the bridge section may comprise of a plurality of spaced apart cross braces extending between the leg sections of the connecting means.

[0031] According to one embodiment of the invention, the connecting means includes two distinct leg sections and a distinct intermediate bridge section. In an alternative embodiment of the invention the leg sections may be defined by end zones of an arcuate sheet of material. The connecting means may have a substantially C-shaped, U-shaped or V-shaped transverse cross-sectional profile.

[0032] According to a further aspect of the invention there is provided a pressure ring assembly suitable for use in an electric arc furnace, the pressure ring assembly comprising at least one pressure ring segment, at least one contact shoe located radially inwardly from the pressure ring segment, and a piston arrangement including a piston push plate located between the pressure ring segment and the contact shoe for forcing the contact shoe into electrical contact with an electrode, the piston arrangement including a pressurisation cavity being in flow communication with a high pressure fluid source, the piston arrangement including a seal in the pressurisation cavity for sealing the cavity, wherein the seal is characterised therein that it comprises a number of washer-like seal discs, arranged side-by-side and welded together to form a resilient concertina-like bellows.

[0033] In particular, the seal comprises a number of substantially parallel, thin, annular metal discs that are circumferentially welded to each other to form the concertina-like bellows. Alternatively, the seal may include a number of spacers arranged between the metal discs, in which case the metal discs are welded to the spacers.

[0034] The annular discs may be of a thickness of between 0.1mm and 2mm.

[0035] A further feature provides for the pressurisation cavity to be arranged in flow communication with a liquid supply channel and a liquid return channel. In one form of the invention the liquid supply channel and liquid return channel may be embedded in the pressure ring segment, and in combination with the pressurisation cavity may define a first flow channel for conveying fluid through the pressure ring segment and through the pressurisation cavity so as to actuate the piston arrangement while simultaneously cooling the pressure ring segment. In an

alternative form of the invention the pressure ring segment may include a second independent flow channel, embedded in the pressure ring segment for conveying fluid through the pressure ring segment for cooling it.

[0036] In a further alternative of the invention, the liquid supply channel and a liquid return channel may be arranged outside of the pressure ring segment.

[0037] The pressurisation cavity may be defined by a housing characterised therein that the housing is of a material having a thermal conductivity of at least 100 Watt per meter Kelvin.

[0038] The piston arrangement further may be characterised therein that it includes a secondary seal arranged between the piston push plate and the housing. In particular the secondary seal may be arranged in an annular gap formed between the piston push plate and the sleeve-like housing. More particularly, the piston push plate may include a circumferential groove for receiving the secondary seal. The secondary seal may be in the form of a metal ring.

[0039] According to a further aspect of the invention there is provided a pressure ring assembly suitable for use in an electric arc furnace, the pressure ring assembly comprising a pressure ring arranged around an electrode, and a contact shoe arranged between the pressure ring and the electrode such that an annular gap is formed between the pressure ring and the contact shoe, the pressure ring assembly being characterised therein that it includes a sealing arrangement between the pressure ring and the contact shoe, the sealing arrangement including a recess in one or both of the pressure ring and the contact shoe, and a seal trapped in the recess for sealing the annular gap.

[0040] The seal may be a resilient seal, and in a preferred form of the invention, the seal also may be biased for facilitating constant sealing of the annular gap during displacement of the contact shoe. The seal may be of an insulating material, and in particular may be made of ceramic or alternatively silicon carbide.

[0041] The seal may comprise of a plurality of seal segments arranged in end-to-end fashion in the recess so as to form a substantially continuous annular seal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] An embodiment of the invention is described by way of a non-limiting example, and with reference to the accompanying drawings in which:

- Figure 1 is a perspective view of the pressure ring assembly in accordance with the invention;
- Figure 2 is a plan view of the pressure ring assembly of figure 1;
- Figure 3 is a cross-sectional side view of the pressure ring assembly of figure 1;
- Figure 4 is a cross-sectional plan view of the pressure ring assembly of figure 1;
- Figure 5 is a cross-sectional plan view of a connect-

ing arrangement in accordance with the invention;

- Figure 6 is a cross-sectional side view of a sealing arrangement in accordance with the invention;
- Figure 7 is a cross-sectional view of the bellows used in the pressure ring assembly of figure 1;
- Figure 8 is a front view of one pressure ring segment in accordance with the invention;
- Figure 9 is two perspective views of the connecting means in accordance with the invention; and
- Figure 10 is a graphical representation of the relationship between creep rate and temperature for various materials.

SPECIFIC EMBODIMENT OF THE INVENTION

[0043] Referring to the drawings, a non-limiting embodiment of a pressure ring assembly in accordance with the invention is generally indicated by reference numeral 10. The pressure ring assembly 10 includes a pressure ring 20, comprising a plurality of interconnected pressure ring segments 22, a plurality of contact shoes 50 located adjacent an operatively inner face 36 of the pressure ring 20, as well as a plurality of piston arrangements 40. located between each contact shoe 50 and the pressure ring 20. In use the pressure ring 20 and contact shoes 50 encircle an electrode (not shown) used in the electric arc furnace (not shown).

[0044] The pressure ring 20 according to the particular embodiment is a circular ring when viewed in plan, and two adjacent pressure ring segments 22 of the pressure ring are shown in figures 1 and 2. Each pressure ring segment is arcuate when viewed in plan, and includes an outer face 35 facing away from the electrode and an inner face 36 facing the electrode (not shown). Each pressure ring segment has a top end 24 and a bottom end 25, the bottom end in this embodiment terminating in a substantially L-shaped section. A circumferential recess 33 is provided towards the bottom end 25 of the pressure ring segment 22, and in this particular configuration the recess 33 is located in a face of the L-shaped section that faces the contact shoe 50. A seal 54 is located in the groove, and is described in more detail herein below. A hanger bracket 23 extends from the top end 24, and is used to suspend the pressure ring segment 22, and thus the pressure ring 20, from a hanger bracket 51 connected to the contact shoe 50.

[0045] Each pressure ring segment 22 furthermore has opposing, parallel side ends 26, being substantially perpendicular relative to the top and bottom ends, 24 and 25. Engagement formations 27 are located proximate the side ends 26, and extends at least partially between the top end 24 and the bottom end 25 of the pressure ring segment 22. In this particular embodiment the engagement formations 27 are in the form of recesses located

in the inner face 36 of the pressure ring segment 22, but it will be appreciated that the engagement formations can be in the form of elongate protrusions rather than recesses, and that the engagement formations can be located in the outer face 35 instead of the inner face 36 of the pressure ring segment 22. The recesses 27 are tapered relative to the side ends 26, and more particularly are tapered away from the side ends 26 going down from the top end 24 to the bottom end 25. In the particular embodiment the recesses 27 are tapered along an entire length thereof, but it will be appreciated that only a part of each recess needs to be tapered, and that a remainder may for instance be parallel relative to the side ends 26.

[0046] As is best seen in figures 1 and 5, the recesses 27 are furthermore undercut towards side ends 26 of the pressure ring segments 22 so as to define lips 28 that aid in securely connecting adjacent pressure ring segments 22.

[0047] Adjacent pressure ring segments 22 are releasably connected by means of outwardly tapering or diverting connecting means 60. In this particular example the connecting means are in the form of elongate sliding brackets, shown in perspective in figure 9. Each sliding bracket 60 includes two elongate leg sections 61, which is connected to each other by means of an intermediate bridge section 62. The two elongate leg sections 61 are tapered relative to each other and relative to an elongate axis 64 of the sliding bracket 60, and more particularly the two leg sections 61 diverge so as to fit the complementary tapered recesses 27 in adjacent pressure ring segments 22. The bridge section 62 shown in this embodiment is in the form of a substantially solid sheet-like section extending between the leg sections 61 along substantially the whole length of the leg sections 61, but the bridge section may also comprise a plurality of spaced apart cross-braces (not shown). It will be appreciated that the leg sections and the bridge section may be integrally formed, for instance from a sheet of material being bent into a suitable shape, or cast from cast steel. The sliding bracket 60 also includes an aperture 63 for use during installation and removal of the sliding bracket 60. As can be seen from figure 5, the sliding bracket 60 is substantially C-shaped when seen in cross-sectional plan view. Similarly the bracket can also be U-shaped or V-shaped.

[0048] In use two pressure ring segments 22 are positioned adjacent one another so that the adjacent recesses 27 form two diverging channels or engagement formations. Proper alignment is facilitated by providing alignment apertures 29 and alignment balls 34 in the sides 26 of the pressure ring segments. A connecting device 60 is subsequently inserted from the top end 24 of the pressure ring segments 22 in order for the elongate leg sections 61 to enter the recesses 27 from above. As the connecting device 60 is forced downwardly, the leg sections 61 engage the recesses 27 and the lips 28, in so doing forcing the two pressure ring segments 22 towards one another due to the tapered configuration of the sliding bracket 60 and the recesses 27. It will be ap-

preciated that the recesses 27, and thus the leg sections 61 of the sliding bracket 60, need not be diverging or tapered along the entire length thereof. Sections of the clamping device 61 and recesses 27 may be substantially parallel, as long as at least some sections, whether upper or lower sections, are tapered.

[0049] A contact shoe 50 is located adjacent the inner face 36 of each pressure ring segment 22. In a complete pressure ring assembly 10 the contact shoes 50 are thus located radially inwardly from the pressure ring, so that the pressure ring 20 surrounds the contact shoes 50. The contact shoes 50 are displaceable relative to the pressure ring segments 22, so as to be able to engage an electrode (not shown) being located inside the pressure ring 20 as well as the contact shoes 50. When an electrode is engaged, a reaction force is exerted on the contact shoes towards the pressure ring segments 22, which in turn absorbs such reaction force. It should be noted that the weight of the contact shoe 50 is carried via a contact shoe hanger bracket 51, and not by the pressure ring segment 22.

[0050] A piston arrangement 40, as seen in figure 3, is provided in each pressure ring segment 22 in order to facilitate movement of a contact shoe 50 relative to a pressure ring segment 22. The piston arrangement 40 includes a pressurisation cavity 42 formed by a piston push plate 41, a sleeve-like housing 43 and the inner face 36 of the pressure ring segment 22. The piston push plate 41 is moveably connected relative to the pressure ring segment 22 and sleeve-like housing 43 by means of a seal 44 in the form of a bellows, which also serves to seal the pressurisation cavity 42. The bellows 44 is shown in more detail in figure 7, and comprises a number of washer-like metal discs 46, arranged side by side with spacers 49 provided there between. Outer edges of the discs 46 are welded to the spacers 49, and inner edges 47 are welded to one another to form a concertina-like bellows. This type of bellows is often referred to as leaf bellows. In use the bellows 44 is displaceable in the direction indicated by arrow A. The metal discs are typically of a thickness between 0.1 mm and 2mm.

[0051] A first end of the bellows 44 is welded to the piston push plate 41, and a second end of the bellows 44 is welded to an inner face of the sleeve-like housing 43. This configuration result in the piston push plate 41 being moveable relative to the bellow housing 43, but whilst still being sealed relative to the bellow housing 43. The pressurisation cavity 42 therefore remains continuously sealed along the entire stroke of the piston push plate 41. Movement of the piston push plate 41 relative to the pressure ring segment 22 is limited by means of a stroke limiter 45, which can be of various configurations, but in the particular configurations is in the form of a bolt that can be set in a required position.

[0052] The pressurisation cavity 42 is be pressurised so as to impart an outward force on the piston push plate 41. The resilience of the bellows 44 allows the piston push plate 41 to be displaced away from the pressure

ring segment 22, so as to in use force the contact shoes 50 into abutment with the electrode (not shown). It will be appreciated that the piston arrangement 40 can be in the form of a cartridge-type piston assembly, in which case the pressurisation cavity 42 will be defined by the piston push plate 41, sleeve-like housing 43 and an end plate extending from the sleeve-like housing 43. Such an assembly will be separate from the pressure ring segment, and will merely locate inside a recess provided in the pressure ring segment.

[0053] The pressurisation cavity 42 is pressurised by introducing high-pressure fluid (such as water) into the pressurisation cavity 42 via a first flow channel 31 embedded inside the pressure ring segment 22. In this particular embodiment each pressure ring segment 22 includes two internal flow channels that are configured in parallel. The second flow channel 32 is solely used as a cooling channel, wherein heat is removed from the pressure ring segment 22 by a cooling fluid flowing inside the cooling channel. Whilst the first flow channel 31 also contributes towards cooling, it also conveys liquid to and from the piston cavity 42. An increase in the feed pressure to the first flow channel 31 will thus result in an increase in pressure in the pressurisation cavity 42, and thus in resultant piston push plate 41 movement.

[0054] In use heat will be removed from the pressure ring segment by the fluid in the first flow channel 31 even if the second flow channel 32 is inoperative, and vice versa. This is beneficial in that the pressure ring segment can remain in operation even after the use of either the first 31 or second 32 flow channel has been terminated due to, for example, failing of the bellows 44, as sufficient heat transfer will be provided via the remaining flow channel until the system can be shut off for maintenance. This is a major improvement to other systems where heat transfer and piston displacement is facilitated by a single, shared channel. It will be appreciated that the first 31 and the second 32 flow channels may be located outside the pressure ring segment 22 when a cartridge-type piston assembly is used as described hereinbefore.

[0055] A secondary seal 48 is furthermore provided between the piston push plate 41 and the sleeve-like housing 43. The secondary seal 48 is located in a circumferential sealing groove located in the periphery of the piston push plate, and is typically in the form of a metal ring. This seal 48 prevents dust and dirt from entering the piston arrangement 40, and more particularly gaps between adjacent discs 46 of the bellows 44.

[0056] As mentioned above, a seal 54 is located in a recess 33 provided in the bottom end 25 of the pressure ring segment 22. A lower section 53 of the contact shoe 50 defines an opposing sealing face, so as to seal an annular gap between the contact shoes 50 and the pressure ring 20. The sealing arrangement is shown in more detail in figure 6. The seal may comprise a plurality of seal segments sections positioned adjacent one another to form a substantially continuous circumferential seal. It will be appreciated that various combination can be uti-

lised, such a providing the circumferential groove in the contact shoe as opposed to the pressure ring, or to provide circumferential recesses in both the pressure ring and the contact shoe. Various seals 54 can be utilised in this application. For instance a ceramic seal can be used in which case the seal can be biased towards a sealing position by providing a spring washer between the seal and the recess. In the alternative, a resilient seal may be used, in which case a spring washer or the like will not be required.

[0057] The pressure ring 20 is exposed to elevated temperatures because of its location in close proximity of the furnaces interior. In addition substantial outwardly directed reaction forces are exerted on the pressure ring due to the clamping action of the contact shoes 50 on the electrode. It is therefore important to manufacture the pressure ring 20, and more particularly the individual pressure ring segments 22, from a material firstly having good heat conductivity characteristics to ensure proper heat removal, and secondly having good mechanical strength properties at elevated temperatures. It is of particular importance that the material has a reasonably low creep rate under high-temperature, high-stress conditions.

[0058] The inventors surprisingly found that copper/chrome and copper/silver micro alloys proved to be particularly suitable for this application. Alloys comprising 0.15% percent (weight by weight) silver and 1.5% percent (weight by weight) chrome were tested, and improved performance was noted. For example, the improved performance of the copper and silver (denoted CuAg in the graph) is shown in figure 9, being a comparison between the creep per 1000 hours versus stress at elevated temperatures for different materials. It will be apparent from the graph that the copper/silver alloy can withstand higher stresses at the same creep rate experienced in traditionally used materials such as oxygen-free copper (CuOF) and high-conductivity copper (HC Cu). The addition of silver or chrome to copper somewhat reduces the heat conductivity of the material compared to pure copper, but the heat conductivity is still within acceptable margins, and more particularly is still up to 6.5 times that of Aluminium Bronze and carbon steel, and up to 20 times that of stainless steel, which were all previously used in this application.

[0059] It has also been found that correct material selection when designing the bellow housing 43 and piston push plate 41 contributes substantially towards extending the life and increasing the reliability of the pressure ring assembly. In this regard it was found that using a material with thermal conductivity in excess of 100 Watt per meter Kelvin, such as copper, substantially improved the cooling ability of the bellow housing and piston push rate, thus resulting in a longer life expectancy.

[0060] It will be appreciated that the above is only one embodiment of the invention, and that there may be many variations in detail without departing from the spirit and the scope of the invention as set out in the claims.

[0061] The following are the claims of the parent application as filed and are included as part of the description of the present application.

1. A pressure ring assembly [10] suitable for use in an electric arc furnace, the pressure ring assembly [10] comprising a pressure ring [20] characterised therein that it is made of a metal alloy wherein a first metal of the alloy is copper, and a second metal is selected from a group comprising of chrome and silver. 5
2. The pressure ring assembly [10] according to claim 1 characterised therein that the alloy comprises at least 97% copper, and when the second metal is chrome, then between 0.5% and 3.0% chrome, and particularly 1.5% chrome; and when the second metal is silver, then between 0.05% and 0.5% silver, and particularly 0.15% silver. 10
3. Use of a metal alloy wherein a first metal is copper, and a second metal is selected from a group comprising of chrome and silver in the manufacture of a pressure ring [20] suitable for use in an electric arc furnace. 15
4. A pressure ring assembly [10] suitable for use in an electric arc furnace, the pressure ring assembly [10] comprising at least two pressure ring segments [22] dimensioned to engage each other to form a pressure ring [20] around an electrode, each pressure ring segment [22] having a top end [24], a bottom end [25], two opposing side ends [26], an inner face [36] facing the electrode, and an opposite outer face [35]; the pressure ring assembly [10] being characterised therein that each pressure ring segment [22] includes two engagement formations [27] located proximate the opposing side ends [26] and extending at least partially between the top [24] and bottom ends [25], each engagement formation [27] further being characterised therein that it is defined within at least one face of the ring segment [22] and is at least partially tapered relative to the side ends [26], the engagement formations [27] being adapted to be engaged by connecting means [60] such that the pressure ring segments [22] are drawn towards each other during installation of the pressure ring assembly [10]. 20
5. The pressure ring assembly [10] according to claim 4 characterised therein that each engagement formation [27] is a substantially continuous elongate formation and is defined either by a recess embedded in or a protrusion protruding from a face of the pressure ring segment [22]. 25
6. The pressure ring assembly [10] according to claim 4 characterised therein that the engagement 30

formation [27] includes a lip [28] dimensioned to cooperate with a complementarily dimensioned lip engaging formation defined in the connecting means [60] so as to create a secure engagement between the engagement formation [27] and the connecting means [60].

7. The pressure ring assembly [10] according to claim 4 characterised therein that each engagement formation [27] comprises of two elongate recesses defined in the inner face of a ring segment [22] proximate the opposing side ends [26] and tapering downwardly between the top and bottom ends, and more particularly, tapering away from the side ends [26] going down from the top to the bottom ends.

8. Connecting means [60] for inter-connecting adjacent pressure ring segments [22] of a pressure ring assembly [10] suitable for use in an electric arc furnace, the connecting means [60] being characterised therein that it comprises two leg sections [61] connected to each other by means of an intermediate bridge section [62] wherein the leg sections [61] are at least partially tapered relative to each other and relative to an elongate axis [64] of the connecting means [60], the connecting means [60] further being adapted to engage the pressure ring segments [22] such that they are drawn towards each other during installation of the pressure ring assembly [10].

9. The connecting means [60] according to claim 8 characterised therein that it is an elongate connecting bracket adapted to engage the pressure ring segments [22], and more particularly the connecting means [60] is an elongate sliding bracket adapted to slide into or over complementarily tapered engagement formations [27] defined in the pressure ring segments [22].

10. The connecting means [60] according to claim 8 characterised therein that the bridge section [62] either spans substantially the length of the connecting means [60], or alternatively the bridge section [62] comprises of a plurality of spaced apart cross braces extending between the leg sections [61] of the connecting means [60].

11. The connecting means [60] according to claim 8 characterised therein that it includes two distinct leg sections [61] and a distinct intermediate bridge section [62].

12. The connecting means [60] according to claim 8 characterised therein that the leg sections [61] are defined by end zones of an arcuate sheet of material, the connecting means [60] having a substantially C-shaped, U-shaped or V-shaped transverse cross-sectional profile.

13. A pressure ring assembly [10] suitable for use in an electric arc furnace, the pressure ring assembly [10] comprising at least one pressure ring segment [22], at least one contact shoe [50] located radially inwardly from the pressure ring segment [22], and a piston arrangement [40] including a piston push plate [41] located between the pressure ring segment [22] and the contact shoe [50] for forcing the contact shoe [50] into electrical contact with an electrode, the piston arrangement [40] including a pressurisation cavity [42] being in flow communication with a high pressure fluid source, the piston arrangement [40] including a seal [44] in the pressurisation cavity [42] for sealing the cavity, wherein the seal [44] is characterised therein that it comprises a number of washer-like seal discs [46], arranged side-by-side and welded together to form a resilient concertina-like bellows.

14. The pressure ring assembly [10] according to claim 13 characterised therein that the seal [44] comprises a number of substantially parallel, thin, annular metal discs [46] that are circumferentially welded to each other to form the concertina-like bellows.

15. The pressure ring assembly [10] according to claim 13 characterised therein that the seal [44] includes a number of spacers [49] arranged between the metal discs [46], in which case the metal discs are welded to the spacers.

16. The pressure ring assembly [10] according to claims 14 or 15 characterised therein that the annular discs [46] have a thickness of between 0.1 mm and 2mm.

17. The pressure ring assembly [10] according to claim 13 characterised therein that the pressurisation cavity [42] is arranged in flow communication with a liquid supply channel and a liquid return channel wherein the liquid supply and return channels are embedded in the pressure ring segment [22] and in combination with the pressurisation cavity [42] define a first flow channel [31] for conveying fluid through the pressure ring [20] and through the pressurisation cavity [42] so as to actuate the piston arrangement [40] while simultaneously cooling the pressure ring segment [22].

18. The pressure ring assembly [10] according to claim 17 characterised therein that the pressure ring segment [22] includes a second independent flow channel [32], embedded in the pressure ring segment [22] for conveying fluid through the pressure ring segment [22] for cooling it.

19. The pressure ring assembly [10] according to claim 13 characterised therein that the pressurisa-

tion cavity [42] is arranged in flow communication with a liquid supply channel and a liquid return channel wherein the liquid supply and return channels are arranged outside of the pressure ring segment [22].

20. The pressure ring assembly [10] according to claim 13 characterised therein that the pressurisation cavity [42] is defined by a housing [43] made of a material having a thermal conductivity of at least 100 Watt per meter Kelvin.

21. The pressure ring assembly [10] according to claim 13 characterised therein that the piston arrangement [40] includes a secondary seal [48] arranged between the piston push plate [41] and the housing [43], and in particular in an annular gap formed between the piston push plate [41] and the sleeve-like housing [43], the piston push plate [41] including a circumferential groove for receiving the secondary seal [48], which may be in the form of a metal ring.

22. According to a further aspect of the invention there is provided a pressure ring assembly [10] suitable for use in an electric arc furnace, the pressure ring assembly [10] comprising a pressure ring [20] arranged around an electrode, and a contact shoe [50] arranged between the pressure ring [20] and the electrode such that an annular gap is formed between the pressure ring [20] and the contact shoe [50], the pressure ring assembly [10] being characterised therein that it includes a sealing arrangement between the pressure ring and the contact shoe [50], the sealing arrangement including a recess [33] in one or both of the pressure ring [20] and the contact shoe [50], and a seal [54] trapped in the recess [33] for sealing the annular gap.

23. The pressure ring assembly [10] according to claim 22 characterised therein that the seal [44] is a resilient seal, and in a preferred form of the invention, is also biased for facilitating constant sealing of the annular gap during displacement of the contact shoe [50].

24. The pressure ring assembly [10] according to claim 22 characterised therein that the seal [44] is of an insulating material, and in particular is made of ceramic or silicon carbide.

25. The pressure ring assembly [10] according to claim 22 characterised therein that the seal [44] comprises of a plurality of seal segments arranged in end-to-end fashion in the recess so as to form a substantially continuous annular seal [54].

26. According to the invention there is provided a pressure ring assembly [10] suitable for use in an

electric arc furnace, the pressure ring assembly [10] comprising at least two pressure ring segments [22] dimensioned to engage each other to form a pressure ring [20] around an electrode, each pressure ring segment [22] having a top end [24], a bottom end [25], two opposing side ends [26], an inner face [36] facing the electrode, and an opposite outer face [35], the pressure ring assembly [10] further comprising at least one contact shoe [50] arranged between the pressure ring [20] and the electrode such that an annular gap is formed between the pressure ring [20] and the contact shoe [50], and a piston arrangement [40] including a piston push plate [41] located between the pressure ring segment [22] and the contact shoe [50] for forcing the contact shoe [50] into electrical contact with the electrode, the piston arrangement [40] including a pressurisation cavity [42] being in flow communication with a high pressure fluid source, the pressure ring assembly [10] being characterised therein that it includes at least one of the following features, namely that the pressure ring [20] is made of a metal alloy wherein a first metal of the alloy is copper, and a second metal is selected from a group comprising of chrome and silver,

each pressure ring segment [22] includes two engagement formations [27] located proximate the opposing side ends [26] and extending at least partially between the top [24] and bottom ends [25], each engagement formation [27] further being characterised therein that it is defined within at least one face [35, 36] of the pressure ring segment [22] and is at least partially tapered relative to the side ends [26], the engagement formations [27] being adapted to be engaged by connecting means [60] such that the pressure ring segments [22] are drawn towards each other during installation of the pressure ring assembly [10]; it includes connecting means [60] for inter-connecting adjacent pressure ring segments [22], the connecting means [60] comprising two leg sections [61] connected to each other by means of an intermediate bridge section [62] wherein the leg sections [62] are at least partially tapered relative to each other and relative to an elongate axis [64] of the connecting means [60], the connecting means [60] further being adapted to engage the pressure ring segments [22] such that they are drawn towards each other during installation of the pressure ring assembly [10];

the piston arrangement [40] includes a seal [44] in the pressurisation cavity [42] for sealing the cavity, wherein the seal [44] is characterised therein that it comprises a number of washer-like seal discs [46], arranged side-by-side and welded together to form a resilient concertina-like bellows; and/or

it includes a sealing arrangement between the pressure ring and the contact shoe [50], the sealing arrangement including a recess [33] in one or both of

the pressure ring [20] and the contact shoe [50], and a seal [54] trapped in the recess [33] for sealing the annular gap.

27. A pressure ring assembly [10] substantially as herein illustrated and exemplified with reference to the accompanying drawings.

28. Connecting means [60] for inter-connecting adjacent pressure ring segments [22] of a pressure ring assembly [10] substantially as herein illustrated and exemplified with reference to the accompanying drawings.

Claims

1. A pressure ring assembly [10] suitable for use in an electric arc furnace, the pressure ring assembly [10] comprising a pressure ring [20] arranged around an electrode, and a contact shoe [50] located between the pressure ring [20] and the electrode such that an annular gap is formed between the pressure ring [20] and the contact shoe [50], the pressure ring assembly [10] **characterised** therein that it includes a sealing arrangement between the pressure ring [20] and the contact shoe [50], the sealing arrangement including a recess [33] in at least one of the pressure ring [20] and the contact shoe [50], with a seal [54] being locatable in the recess [33] for sealing the annular gap.
2. The pressure ring assembly [10] according to claim 1 wherein the recess is located in the pressure ring towards an operatively lower zone of the pressure ring.
3. The pressure ring assembly [10] according to claim 1 wherein the recess is located in the contact shoe towards an operatively lower zone of the contact shoe.
4. The pressure ring assembly [10] according to claim 1 wherein the seal [54] is located in the recess [33] for sealing the annular gap.
5. The pressure ring assembly [10] according to claim 4 wherein the seal is biased away from the recess [33] so as to facilitate constant sealing of the annular gap during displacement of the contact shoe [50].
6. The pressure ring assembly [10] according to claim 5 wherein the seal [44] is a resilient seal.
7. The pressure ring assembly [10] according to claim 5 wherein the seal is biased by way of a biasing means located between the seal [44] and the recess [33] in which it is located.

8. The pressure ring assembly [10] according to claim 7 wherein the biasing means is in the form of at least one spring member.

9. The pressure ring assembly [10] according to claim 4 wherein the seal [44] is made of an insulating material. 5

10. The pressure ring assembly [10] according to claim 9 wherein the seal [44] is made of ceramic or silicon carbide. 10

11. The pressure ring assembly [10] according to any one of the preceding claims **characterised** therein that the seal [44] comprises of a plurality of seal segments arranged in end-to-end configuration in the recess so as to form a substantially continuous annular seal [54]. 15

12. A pressure ring assembly [10] comprising at least two pressure ring segments [22] dimensioned to engage each other to form a pressure ring [20] around an electrode, each pressure ring segment [22] having a top end [24], a bottom end [25], two side ends [26], an inner face [36] facing the electrode, and an opposite outer face [35], the pressure ring assembly [10] further comprising at least one contact shoe [50] arranged between the pressure ring [20] and the electrode such that an annular gap is formed between the pressure ring [20] and the contact shoe [50], and a piston arrangement [40] including a piston push plate [41] located between the pressure ring segment [22] and the contact shoe [50] for forcing the contact shoe [50] into electrical contact with the electrode, 20
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the pressure ring assembly [10] **characterised** therein that it includes a sealing arrangement between the pressure ring and the contact shoe [50], the sealing arrangement including a recess [33] in at least one of the pressure ring [20] or the contact shoe [50], and a seal [54] being located in the recess [33] for sealing the annular gap. 40

13. The pressure ring assembly [10] according to claim 12 **characterised** therein that the seal [44] comprises of a plurality of seal segments arranged in end-to-end configuration in the recess so as to form a substantially continuous annular seal [54]. 45

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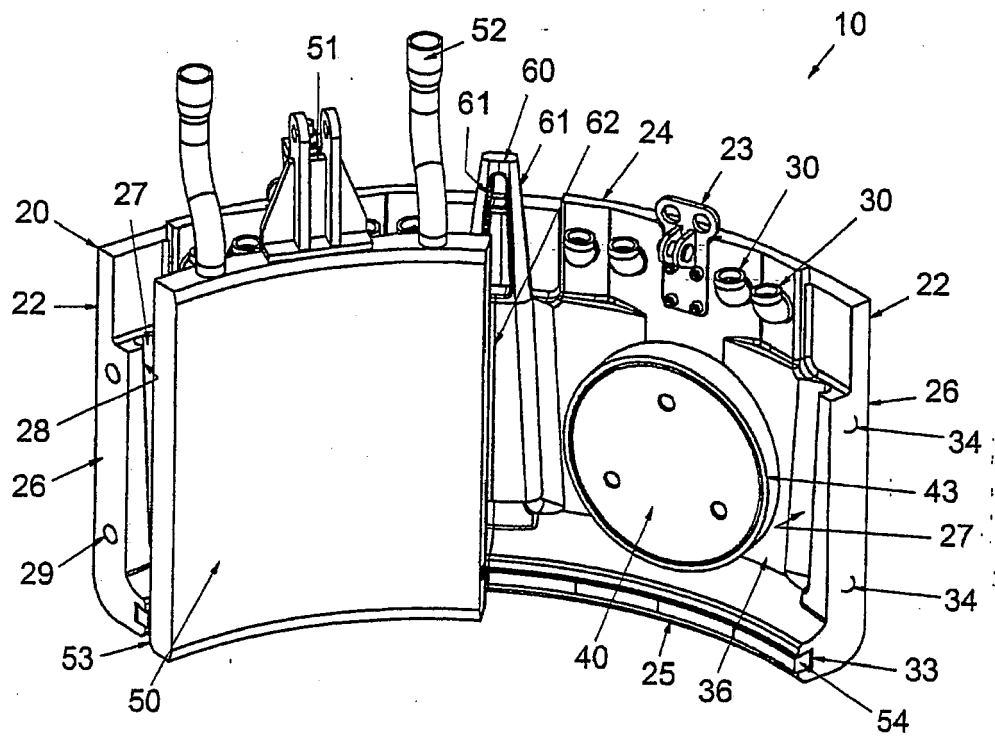


FIGURE 1

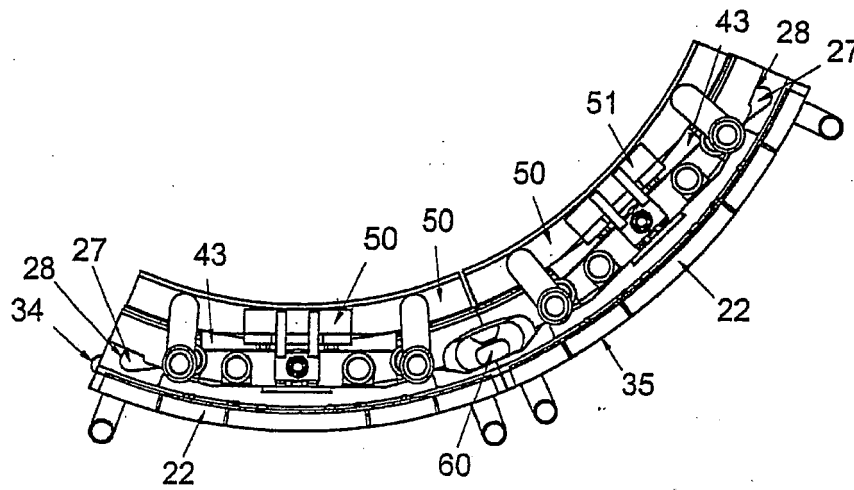


FIGURE 2

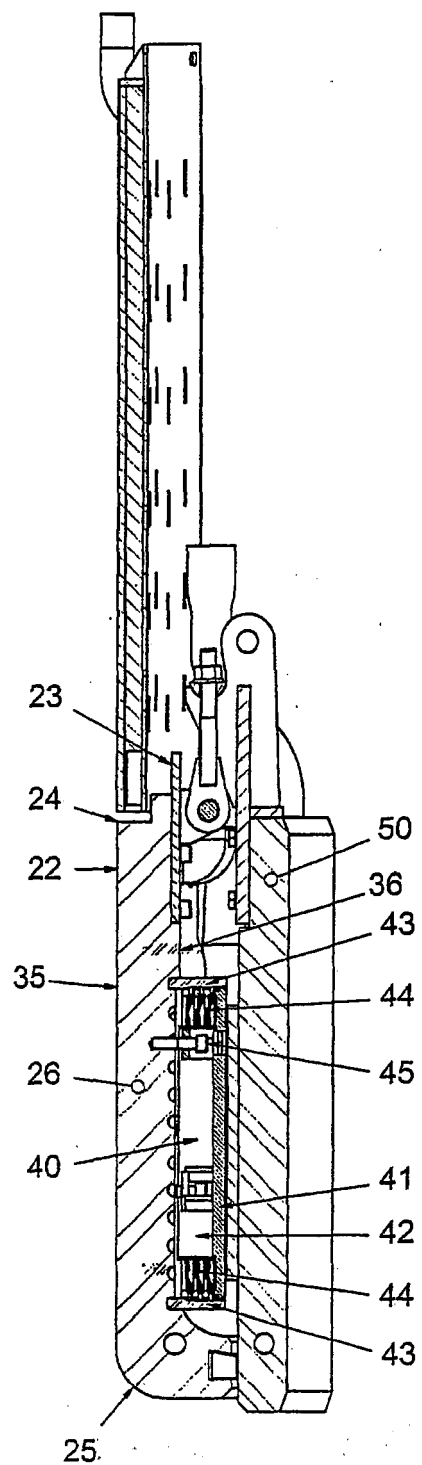


FIGURE 3

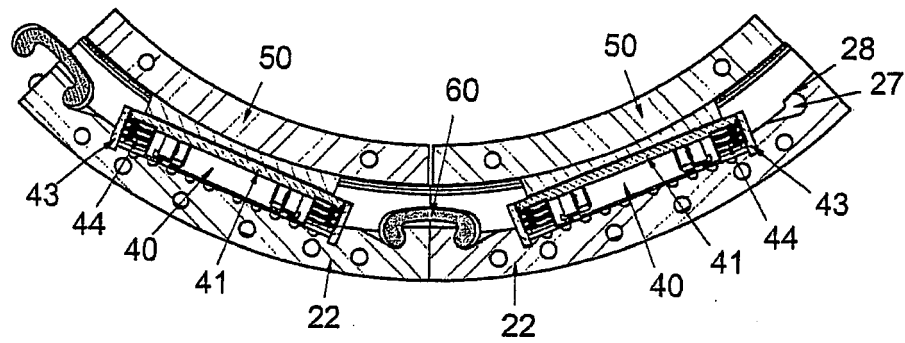


FIGURE 4

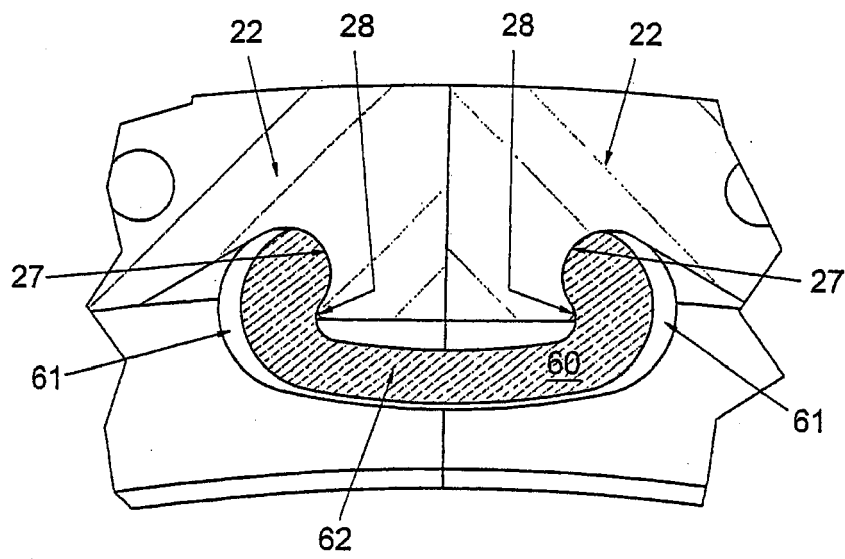


FIGURE 5

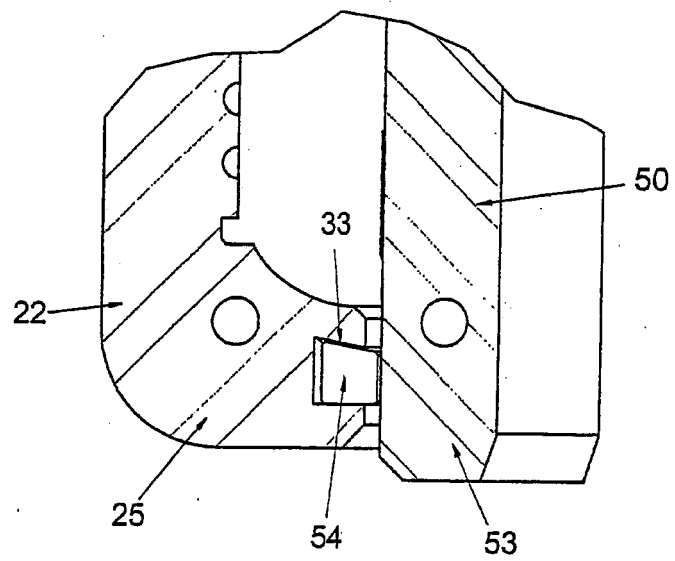


FIGURE 6

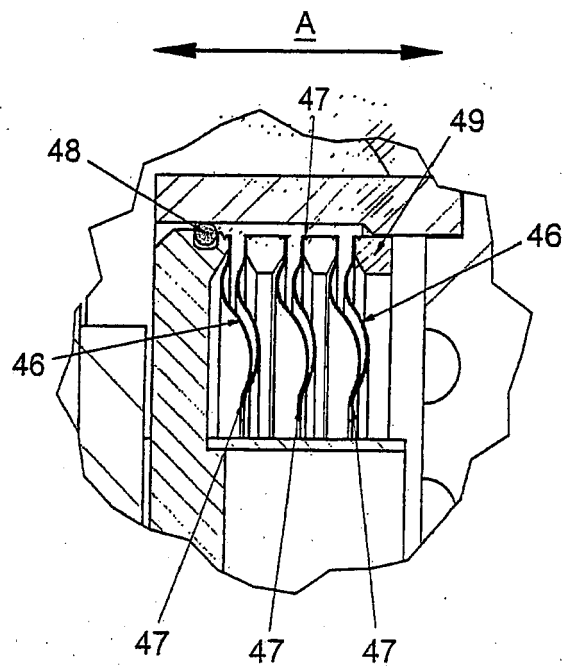


FIGURE 7

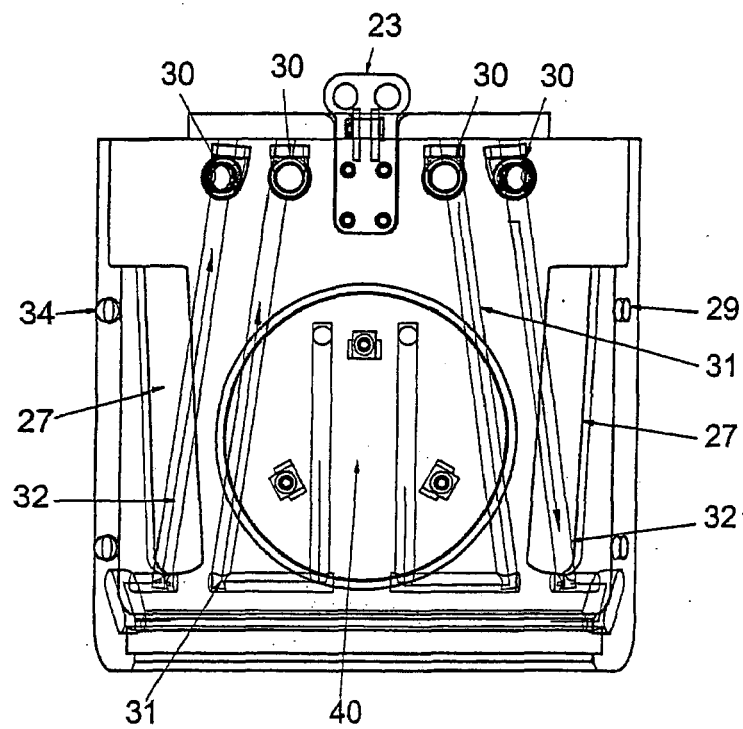


FIGURE 8

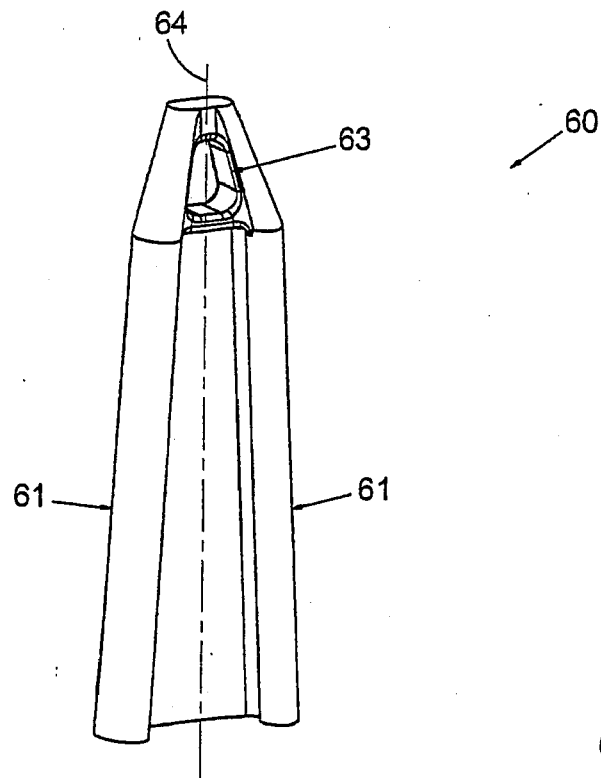


FIGURE 9a

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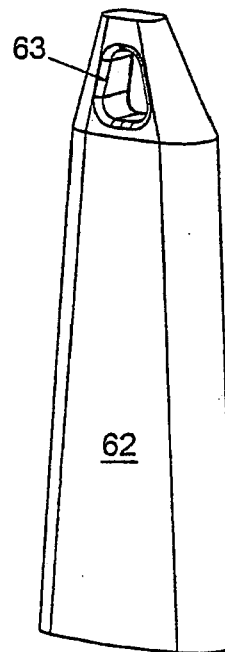


FIGURE 9b

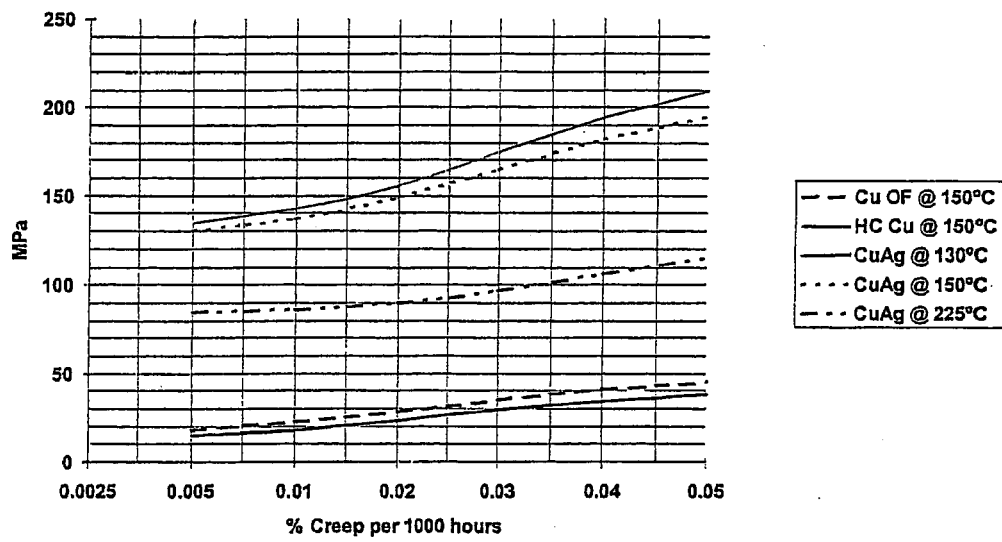


FIGURE 10