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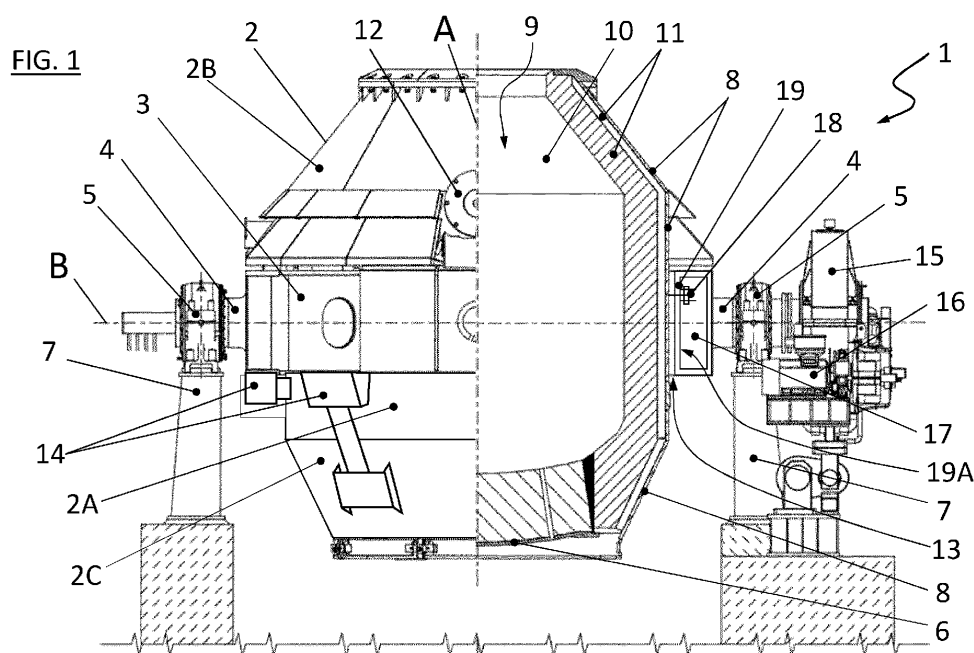
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(54) METALLURGICAL PROCESSING ASSEMBLY

(57) A metallurgical processing assembly, such as a steelmaking converter, comprising:

- a vessel;
- a rod moving jointly with the vessel, in particular with radial deformation of the vessel;
- a reference surface with a position independent from radial movement by the vessel;

- a distance measuring unit configured to measure displacement of the rod relative to the reference surface. In a specific embodiment, movement of the rod is augmented by a pantograph mechanism and transmitted to movement by a slider contact of a variable resistor, allowing remote measurement of the changed resistance.



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Description

[0001] The invention relates to a metallurgical processing assembly, such as a furnace or converter for melting, refining or otherwise metallurgically processing solid or molten metals, e.g., mixed with slag and/or additives, and to a method for measuring deformation, in particular radial deformation, e.g., by thermal expansion and mechanical loads, and optionally also for measuring local temperatures of a vessel of the processing assembly. Particular examples include converters for steelmaking, such as for basic oxygen steelmaking furnace (BOF) or argon oxide decarburization (AOD) processes, etc. Such converters typically comprise large vessels with an open top end, a metal outer shell and refractory linings protecting the outer shell from the process temperatures in the interior of the vessel during operation. The vessels typically have a central axis, a cylindrical middle section with one side coaxially joining a conical top section with an open end, and an opposite side coaxially joining a bottom section. The words "top section" and "bottom section" refer to a position of the vessel during processing of the charged content, i.e., with an essentially vertical central axis. The word "radial" refers to a direction substantially perpendicular to the central axis of the vessel.

[0002] The vessels are usually coaxially mounted within a trunnion ring. The trunnion ring can for example be water-cooled or air-cooled in order to transfer heat away from the vessel shell. The trunnion rings can be annular or U-shaped, as is typically the case for AOD systems, or have any other suitable configuration. A radial clearance is present between the vessel and trunnion ring. This clearance provides an air space allowing radial deformation of the vessel and creating an air draft or chimney effect locally cooling the vessel. During its economic lifetime, the vessel is exposed to various loads causing deformation. This includes thermal loads causing expansion, and mechanical loads causing creep and other deformations. Deformations in radial direction reduce the clearance between the vessel and the trunnion ring. If the clearance becomes too narrow, the vessel needs to be replaced.

[0003] The assembly of the vessel and the trunnion ring is rotatably supported by two oppositely arranged and mutually aligned trunnion pins allowing to tilt the vessel with the trunnion ring about a substantially horizontal axis, for example during tapping of processed liquid steel or during charging.

[0004] With prolonged use, the refractory linings gradually deteriorate and the thickness of the refractory linings becomes less. The outer steel shell of the vessel becomes less insulated and is exposed to higher heat loads, which accelerates the deformation of the vessel.

[0005] JP 2008/214717 teaches to measure heat at the outer shell of the vessel during operation using thermocouples, so as to assure timely replacement of the vessel. It also teaches to measure the clearance width between the vessel and the trunnion ring, using a laser

range-finder. The laser electronics are heat sensitive and must be protected or placed at a cooler location

[0006] It is an object of the invention to provide a more robust system for monitoring conditions of a metallurgical converter vessel without the need to use heat sensitive electronic sensors.

[0007] The object of the invention is achieved with a metallurgical processing assembly, such as a furnace or converter, comprising:

- a vessel;
- a rod moving jointly with the vessel, in particular with radial deformation of the vessel;
- a reference surface with a position independent from movement by the vessel caused by radial deformation of the vessel;
- a distance measuring unit configured to measure displacement of the rod relative to the reference surface, in particular radial displacement relative to a longitudinal axis of the vessel.

[0008] Radial deformation of the vessel by thermal expansion and/or by mechanical loads and reduction of the gap width of the clearance between the vessel and the trunnion ring can directly be derived from the measured displacement of the rod relative to the reference surface. Monitoring the distance between the rod and the reference surface can be carried out at safe distance from the hot vessel shell.

[0009] The rod may for example extend radially relative to a central longitudinal axis of the vessel, e.g., through a matching opening in the reference surface. The rod can be a fixed protrusion of the outer shell of the vessel or a separate arm or pin clamped against the outer shell of the vessel.

[0010] The reference surface can for example be a wall of the trunnion ring, for example in the interior of the trunnion ring on the wall bordering the clearance between the trunnion ring and the vessel.

[0011] The interior of a trunnion ring can be very hot, for example in the order of about 200°C. To facilitate measurement at a position which is safe for an operator and for heat sensitive electronics, the assembly may for example comprise a transducer for converting the measured displacement of the rod into a value which is measurable remote from the trunnion ring. This value can for example be an electric characteristic, such as the electrical resistance in an electric circuit. A very robust transducer can for example be formed by a variable resistor, such as a rheostat or potentiometer, in particular a wire wound resistor, with a resistor coil and a slider contact, such as annular sleeve or wiper, movable along the resistor coil. Moving the slider contact along the resistor coil will change the number of turns of the resistor coil within the circuit, and as a result it changes the electrical resistance of the variable resistor. The resistor is part of an electric circuit with cables extending from the resistor to a low temperature position outside the trunnion ring.

Change of the electric resistance of the resistor can then be measured safely by equipment at the low temperature position.

[0012] A transmission can be used for transferring movement of the rod to the slider contact. The transmission translates radial movement of the rod caused by deformation of the vessel shell, into movement of the slider contact along the resistor coil and hence will change the resistance of the variable resistor. Displacement of the rod is directly proportional to the electrical resistance, so there is a linear relation between deformation of the vessel and change of the electrical resistance in the variable resistor.

[0013] Measuring accuracy can be improved if the transmission comprises an amplifier mechanism, such as a four bar linkage, for example a pantograph or parallelogram linkage with a ground link and a coupler link of even length.

[0014] In a specific embodiment, the ground link can be fixed to the reference surface and extend parallel to the rod, whereas the coupler link can be pivotally joined to the rod. A lower and an upper linking bar of even length can be used to couple the ground link to the coupler link forming a parallelogram. The upper link can have an extension with a free end coupled to the wiper or sleeve of the variable resistor. The length of the extension determines the degree of amplification.

[0015] The rod can be a projection or pin, for example extending radially from the vessel shell. In a specific embodiment, the rod is part of a thermocouple, e.g., a housing or protective tube of a thermocouple contacting the vessel shell. Biasing elements, such as springs can be used to maintain thermally conductive contact between the thermocouple and the shell of the vessel. This can for example be achieved by means of a base plate fixed to the rod, the reference surface being between the base plate and the vessel, while bias elements bias the base plate with the rod towards the vessel shell. The bias elements can for example comprise one or more compression spring pushing the base plate apart from a support with a fixed distance from the reference surface.

[0016] Optionally, a series of thermocouples can be used, distributed over at least a part of the vessel shell. In addition, infrared cameras can be used. For example, a series of thermocouples can be used to measure the temperature at the top and middle sections of the vessel, while infrared cameras are used to measure temperatures at the bottom section of the vessel.

[0017] Steel making converters usually comprise an annular or U-shaped trunnion ring wholly or partly surrounding a cylindrical middle section of the vessel. In such a case, the reference surface can be part of the trunnion ring. The trunnion ring can be provided with one or more of such arrangements having a reference surface, a rod and a distance measuring unit as described above, for example two, three or more of such arrangements around the vessel, so thermal deformation of the vessel can be measured from different positions.

[0018] The metallurgical process assembly of the present invention is particularly suitable for use with a BOF, AOD or similar steel making converter, or for similar metallurgical processes, the vessel having an open top end, a steel outer shell and refractory linings at an interior wall of the outer shell.

[0019] The converter assembly as disclosed can be used to provide a reliable and robust method of measuring expansion of a vessel of a metallurgical converter by measuring the distance between a selected point of a rod or projection extending from the vessel, and the reference surface having a position independent from deformation of the vessel.

[0020] The invention is further explained with reference to the accompanying drawings showing an exemplary embodiment.

Figure 1: shows an exemplary embodiment of a converter, left half in front view, right half in longitudinal cross section;

Figure 2: shows in detail the arrangement for measuring deformation of the vessel of the converter.

[0021] Figure 1 shows a metallurgical converter 1, in this specific example a steel making converter for use with a BOF process. The steel making converter 1 comprises a vessel 2, a trunnion ring 3 around the vessel 2 and a pair of trunnion pins 4, supported by bearings 5 resting on pedestals 7.

[0022] The vessel 2 has a central longitudinal axis A, a cylindrical middle section 2A with a top side coaxially joining a conical top section 2B, and a bottom side coaxially joining a conical bottom section 2C with a dish shaped detachable bottom or crown 6. Other vessel configurations can also be used. The vessel 2 has a steel shell 8 and an open top end 9. The shell 8 encloses an interior 10 accessible via the open top end 9, and has an inner surface protected by a refractory lining 11. The upper part of the vessel 2 is provided with a tap opening 12.

[0023] In the shown exemplary embodiment, the trunnion ring 3 is a hollow ring around the middle section of the vessel 2. Between the vessel 2 and the trunnion ring 3 is a gap or clearance 13. A suspension system 14 of a commonly known type is arranged between the trunnion ring 3 and the vessel 2 for supporting the vessel 2 in the process position as shown in Figure 1, as well as in any tilted position.

[0024] The assembly of the vessel 2, the suspension system 14, the trunnion ring 3 and other fixed parts is supported by the trunnion pins 4 which are at diametrically opposite sides of the trunnion ring 3 and are aligned to define a tilting axis B. One or both of the trunnion pins 4 is or are operatively connected to a gear box 15 driven by one or more motors 16 for tilting the vessel 2 for charging via the open top end 9 or for tapping via the tap opening 12 or via the open top end 9 or for any other activities requiring tilting of the vessel 2.

[0025] To start the metallurgical process, the vessel 2

is tilted and charged with steel scrap and liquid metal, in particular molten iron, and optionally one or more further liquid or solid constituents. The vessel 2 is then set up-right and a water-cooled oxygen lance (not shown) blows high-purity oxygen onto the charge. Alternatively, or additionally, high-purity oxygen can be blow into the charge via the bottom or the lower part of the vessel 2. The high-purity oxygen ignites the carbon content in the charge. Although the refractory lining 11 protects the steel shell 8 of the vessel 2 against the very high process temperatures, the shell 8 of the vessel 2 can still reach temperatures of about 400°C or even more. Over time the refractory lining 11 will gradually degrade and the shell 8 of the vessel 2 will be subjected to even higher heat loads. This eventually results in permanent deformation and expansion of the vessel 2 in the long run. At a certain point, the deformation is such that the vessel 2 needs to be replaced.

[0026] The trunnion ring 3 is hollow and encloses an interior space 17. A measuring unit 18 for measuring and monitoring the width of the clearance gap 13 between the trunnion ring 3 and the shell 8 of the vessel 2 is arranged within the interior 17 of the trunnion ring 3. Alternatively, or additionally, one or more of such measuring units 18 can be arranged at the top side and/or bottom side of the trunnion ring 3. Although Figure 1 shows just a single measuring unit 18, a series of such measuring units 18 can be used distributed over the trunnion ring 3.

[0027] Figure 2 shows in more detail an exemplary embodiment of such a measuring unit 18 at the clearance gap 13 between the shell 8 of the vessel 2 and an inner wall 19 of the trunnion ring 3. The inner wall 19 has an interior side face 19A forming a reference surface for the measuring unit 18. In alternative embodiments, another wall or part of the trunnion ring can be used as a reference surface. A thermocouple 20 protrudes through an opening in the inner wall 19 of the trunnion ring 3. The thermocouple 20 extends in a radial direction relative to the longitudinal axis A of the vessel 2. The thermocouple 20 abuts the shell 8 of the vessel 2 to measure the local temperature of the shell 8. Any radial movement of the shell 8, e.g., caused by thermal expansion or mechanical loads, is transferred to movement of the thermocouple 20 in radial direction relative to the longitudinal axis A of the vessel 2.

[0028] A base plate 21 is fixed to the top end of the thermocouple 20. The base plate 21 moves with the thermocouple 20 and the shell 8 of the vessel 2. The thermocouple 20 is arranged between a pair of shafts 22 fixed to the inner wall 19 of the trunnion ring 3 and protruding through openings in the base plate 21. The top ends of these shafts 22 carry a pressure plate 23. A prestressed compression spring 24 is placed around the respective shaft 22 forcing the respective pressure plate 23 and the base plate 21 apart. This forces the thermocouple 20 firmly against the shell 8 of the vessel 2 and ensures a solid contact required for accurate measurement of the temperature of the shell 8. Due to this clamp-

ing, the thermocouple 20 moves jointly with any radial deformation of the vessel 2, in particular with thermal expansion of the vessel 2.

[0029] The thermocouple 20 can be guided in a protective housing, in particular a pipe section 20A, which is also fixed to the base plate 21 and which moves jointly with the thermocouple 20.

[0030] Radial deformation of the vessel 2, e.g., caused by thermal expansion or mechanical loads, is measured by measuring the distance between the base plate 21 and the reference surface 19A. In this specific embodiment, the measuring unit 18 is in the interior 17 of the trunnion ring 3. In operation, the temperature within the interior 17 of the trunnion ring 3 can be up to about 200°C or even higher, which is too high for a human observer or for heat sensitive sensor electronics. A variable resistor 25 extends from the reference surface 19A in a direction parallel to the thermocouple 20. The variable resistor 25 comprises a wire wound resistor coil 26 and a slider contact or sleeve 27 movable along the resistor coil 26. The lower end of the wire wound resistor coil 26 is a fixed contact 28, which is fixed to, but electrically isolated from, the inner wall 19 of the trunnion ring 3. The free top end of the resistor coil 26, the fixed contact 28 and the slider contact 27 are connected to heat resistant cables 30 forming an electric circuit extending to a cooler place outside the trunnion ring with safe temperatures for a human operator or heat sensitive electronics. Optionally, more than three cables can be used, for instance with a Wheatstone bridge. Moving the slider contact 27 along the resistor coil 26 will change the number of turns of the coil 26 within in the circuit, and as a result it changes the electrical resistance of the variable resistor 25. Such a variable resistor 25 is a very simple, robust and heat resistant electric component.

[0031] A transmission 29 transfers movement of the thermocouple 20 to the slider contact 27. In this specific embodiment, the transmission 29 is a pantograph or parallelogram linkage with a ground link 29A and a coupler link 29B of even length between the respective pivotal joints 29C. A fastener 29D fixates the ground link 29A to the reference surface 19A. The ground link 29A and the coupler link 29B are substantially parallel. The coupler link 29B is pivotally joined to the base plate 21 of the thermocouple 20 by a pivotal axis 29E. A lower linking bar 29F and an upper linking bar 29G of even length between the pivotal joints 29C and 29E couple the ground link 29A to the coupler link 29B forming a parallelogram. The upper link 29G has an extension 29H with a free end coupled to the slider contact 27 of the variable resistor 25. The slider contact 27 is electrically isolated from the upper link 29G.

[0032] In operation, thermal and mechanical loads will cause deformation of the vessel 2. In Figure 2, the position of the shell 8 of the vessel 2 and the base plate 21 before radial deformation, is shown in dotted lines, while their position after radial deformation is shown in continuous lines. The radial deformation d is the distance be-

tween a dotted line and the corresponding continuous line. The reference surface 19A of the trunnion ring 3 does not move with the shell 8 of the vessel 2, and is shown in continuous lines only.

[0033] The parallelogram linkage 29 converts radial movement of the thermocouple 20 caused by thermal expansion or other radial deformation of the shell 8 of the vessel 2, into movement of the slider contact 27 along the resistor coil 26, which changes the resistance of the variable resistor 25 and the electric circuit extending to the cooler position, where the change is measured. The parallelogram linkage or pantograph 29 amplifies the movement of the base plate 21 so the movement can be measured more accurately.

[0034] The disclosure is not restricted to the above described embodiment which can be varied within the scope of the claims. For example, the reference surface can be separate from the trunnion ring, or the rod can be a pin or projection other than a thermocouple.

Claims

1. A metallurgical processing assembly comprising:

- a vessel;
- a rod moving jointly with the vessel, in particular with radial deformation of the vessel;
- a reference surface with a position independent from radial movement by the vessel;
- a distance measuring unit configured to measure displacement of the rod relative to the reference surface.

2. The assembly of claim 1, wherein the reference surface is a surface of a wall of the trunnion ring, for example a surface of the wall bordering the clearance between the trunnion ring and the vessel, the surface being in the interior of the trunnion ring.

3. The assembly of claim 1 or 2, further comprising a transducer for converting the measured displacement into a remotely measurable value, e.g., an electric characteristic.

4. The assembly of claim 3, the transducer comprising:

- a resistor, e.g., a rheostat or potentiometer, with resistor body and a slider contact moveable along the resistor body;
- and a transmission transferring movement of the rod to the slider contact.

5. The assembly of claim 4, wherein the transmission comprises an amplifier mechanism, such as a four bar linkage or pantograph.

6. The assembly according to any one of the preceding

claims, wherein the rod is part of a thermocouple, e.g., a housing or protective tube of a thermocouple.

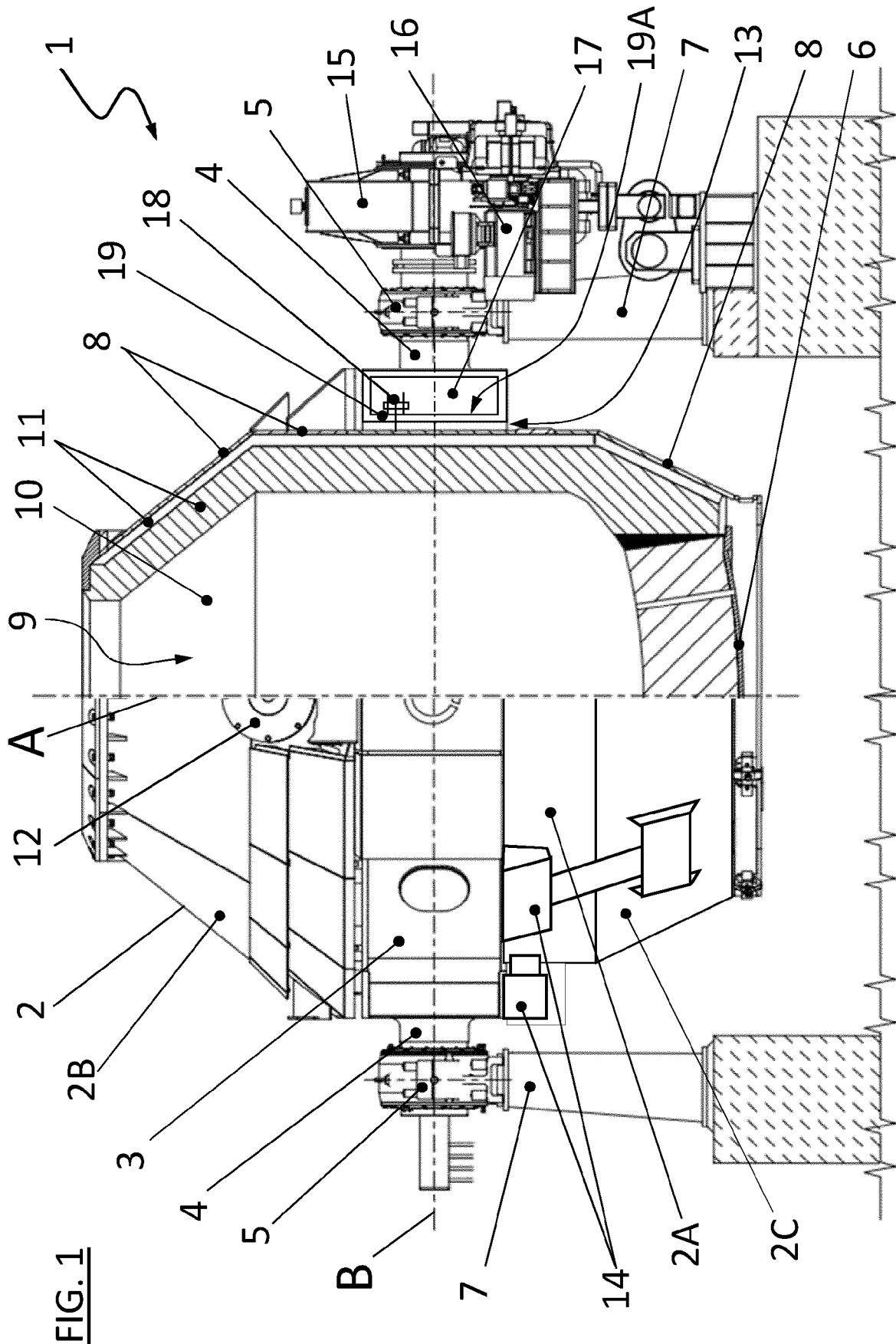
7. The assembly of claim 6, wherein a base plate is fixed to the rod, the reference surface being between the base plate and the vessel, and wherein the assembly comprises bias elements biasing the base plate downward.

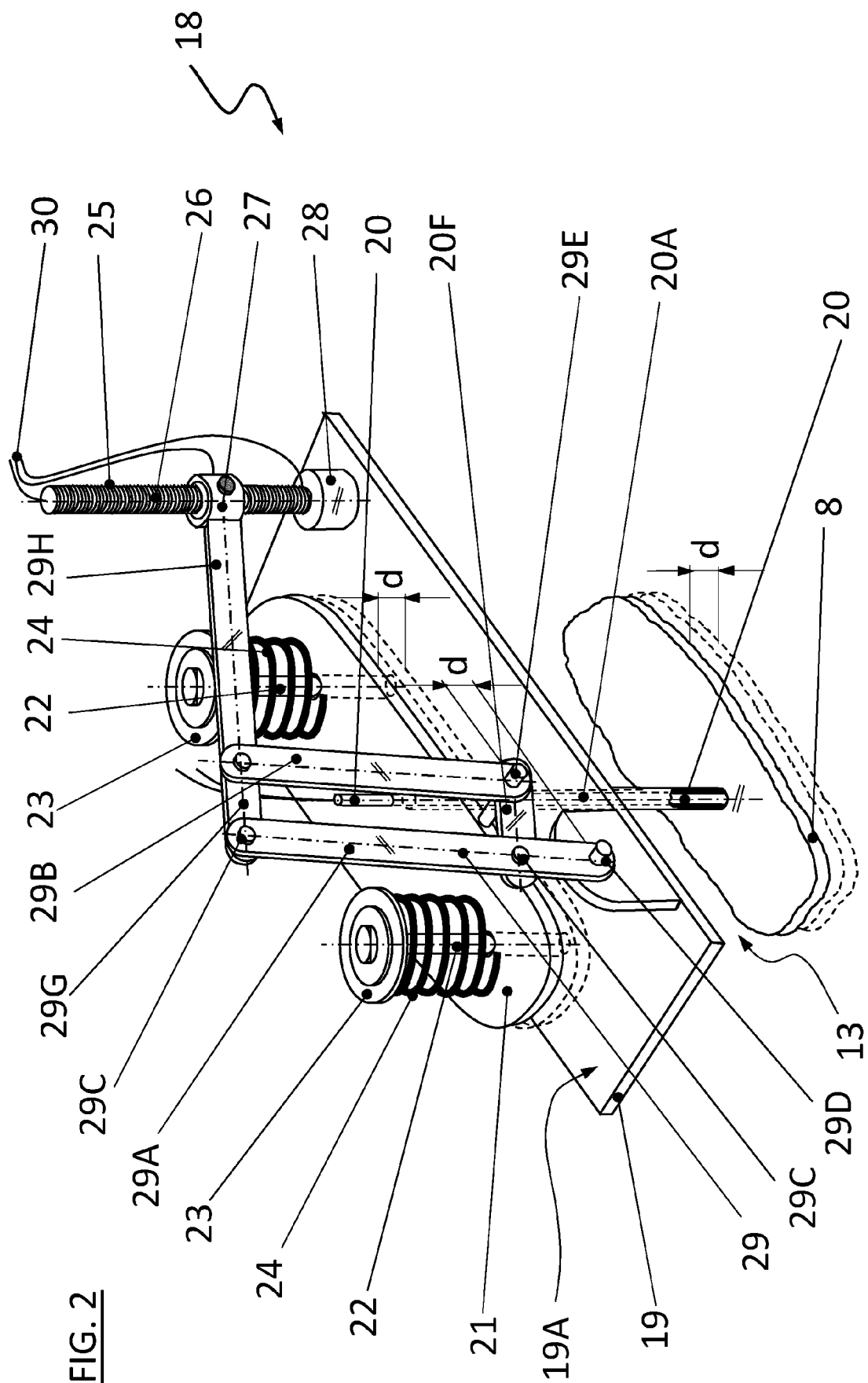
8. The assembly of claim 7, wherein the bias elements comprise one or more compression spring pushing the base plate apart from a support with a fixed distance from the reference surface.

9. The assembly according to any one of the preceding claims, wherein the assembly comprises a trunnion ring coaxially surrounding the vessel, and wherein the reference surface is part of the trunnion ring.

10. The assembly according to any one of the preceding claims, wherein the assembly is a converter, in particular a steel making converter, the vessel having an open top end, a steel outer shell and refractory linings at an interior surface of the outer shell.

11. Method of measuring radial deformation of a vessel of a metallurgical processing assembly by measuring the distance between a selected point of a rod or projection extending from the vessel, and a reference surface having a position independent from deformation of the vessel.







EUROPEAN SEARCH REPORT

Application Number

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Place of search Munich		Date of completion of the search 22 June 2022	Examiner Gavriliu, Alexandru
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