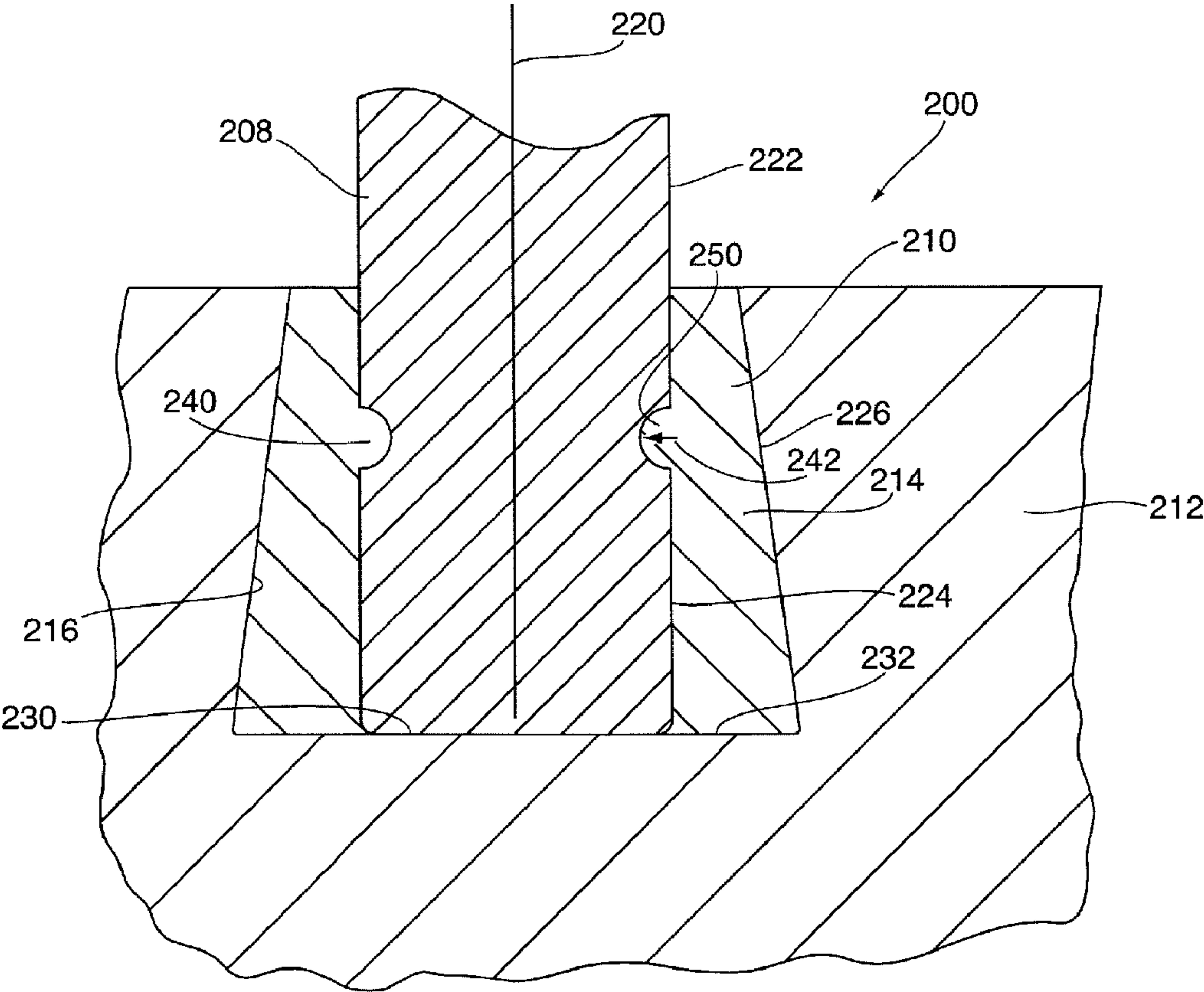




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(54) **Titre : ENSEMBLE D'ANODE ET PROCEDE DE FABRICATION D'ENSEMBLE D'ANODE**
(54) **Title: ANODE ASSEMBLY AND METHOD FOR MANUFACTURING ANODE ASSEMBLY**

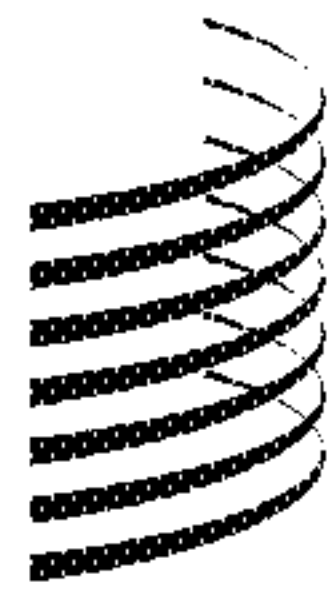


(57) **Abrégé/Abstract:**
An aluminum electrolysis cell anode assembly has an anode, a stub and a thimble. The stub is inserted into a stub hole of the anode. The thimble is formed between the stub and the anode within the stub hole. A lateral wall of the stub has a discontinuity,

(57) Abrégé(suite)/Abstract(continued):

which may be a recess, a protrusion or a combination thereof. An inner surface of the thimble engages the discontinuity of the stub. The engagement restricts axial movement of the thimble relative to the stub. Under thermal expansion of the anode assembly, the base of the stub is urged towards the stub hole bottom and stub-to-anode resistance is improved. This further improves efficiency of an aluminum electrolysis process.

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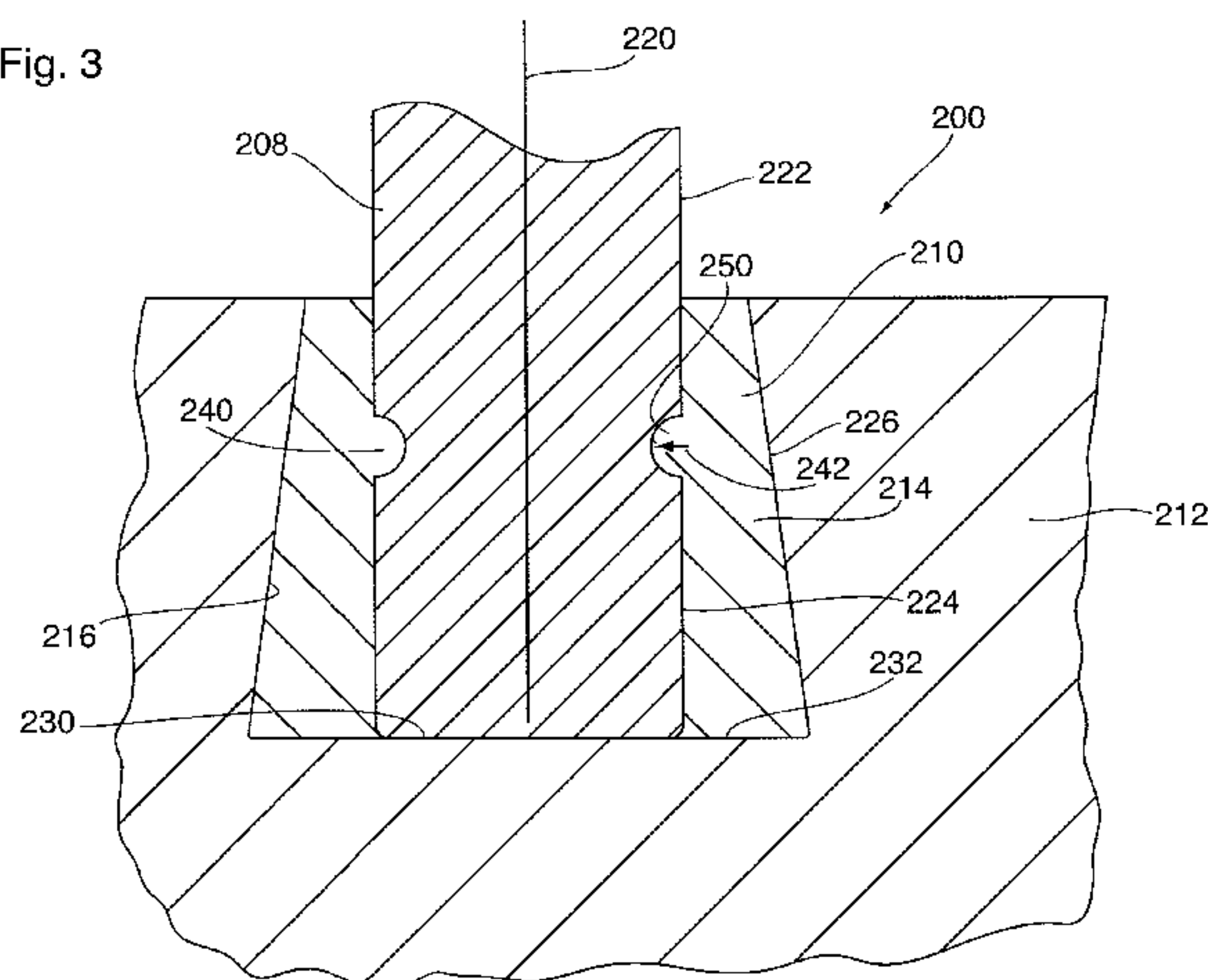
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Fig. 3



(57) Abstract: An aluminum electrolysis cell anode assembly has an anode, a stub and a thimble. The stub is inserted into a stub hole of the anode. The thimble is formed between the stub and the anode within the stub hole. A lateral wall of the stub has a discontinuity, which may be a recess, a protrusion or a combination thereof. An inner surface of the thimble engages the discontinuity of the stub. The engagement restricts axial movement of the thimble relative to the stub. Under thermal expansion of the anode assembly, the base of the stub is urged towards the stub hole bottom and stub-to-anode resistance is improved. This further improves efficiency of an aluminum electrolysis process.

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ANODE ASSEMBLY AND METHOD FOR MANUFACTURING ANODE ASSEMBLY

FIELD

[0002] The present disclosure generally relates to the field of electrolytic
10 production of aluminum. More specifically, the embodiments of the present disclosure
relate to a low-voltage anode assembly of an aluminum electrolysis cell and methods for
manufacturing the low-voltage anode assembly.

INTRODUCTION

[0003] Aluminum is typically produced according to the Hall-Héroult process in
15 which alumina is dissolved in molten cryolite and electrolyzed with an intense direct
current. The cryolite bath is contained in electrolytic cells lined with carbon cathodes
while carbon anodes hang from rods connected to an electrical bus bar. Under the
influence of the electric current, the alumina is reduced with oxygen being deposited on
the anodes and forming mostly carbon dioxide while the molten aluminum is deposited
20 on the cell bottom and periodically tapped.

[0004] U.S. patent publication no. 2010/0096258 describes an anode assembly
for aluminum electrolysis cells includes carbon anodes with stub holes and an anode
hanger having stubs, in which the anodes are fixed to the anode hanger by cast iron
and the stub holes are fully or partially lined with an expanded graphite lining. The
25 anode assembly provides a reduced voltage drop across an interface between the cast
iron and the carbon anode and thus increases cell productivity significantly. Mechanical
stresses in the stubhole area are reduced. A collar formed from the lining prevents
spilling of cast iron over the anode surface and a protective shot plug or a protective

collar optionally prevent direct contact of hot electrolyte bath with the stub and the cast iron. A method of manufacturing anode assemblies and an aluminum electrolysis cell, are also provided.

SUMMARY

5 [0005] According to one exemplary aspect, there is provided an aluminum electrolysis cell anode assembly having an anode, an electrically conductive stub and a thimble. The anode defines a stub hole having a lateral wall and a bottom. The electrically conductive stub is at least partially inserted into the stub hole. The stub defines a longitudinal axis and has a longitudinal lateral wall and a base for contacting
10 the stub hole bottom. The stub lateral wall has at least one discontinuity. The thimble is formed within the stub hole and has an inner surface. A portion of the inner surface of the thimble engages the discontinuity of the stub and restricts axial movement of the thimble relative to the stub.

[0006] According to one exemplary aspect, there is provided a method of
15 manufacturing an anode assembly of an aluminum electrolysis cell. Accordingly, an electrically conductive stub is provided. The electrically conductive stub defines a longitudinal axis, the stub having a base and a longitudinal lateral wall. At least one discontinuity in the lateral wall of the stub is formed. The stub is inserted into a stub hole of an anode of the aluminum electrolysis cell. A thimble is cast between the lateral wall
20 of the stub and the stub hole, a portion of the inner surface of the thimble engaging the discontinuity of the stub.

DRAWINGS

[0007] The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the present specification and are not intended to
25 limit the scope of what is taught in any way. These and other features of exemplary embodiments will become more apparent from the following description in which reference is made to the appended drawings wherein:

[0008] Figure 1 is a perspective view of a prior art aluminum electrolysis cell anode assembly, with a portion of the anode cut away;

[0009] Figure 2 is a sectional view of a portion of the stub and anode of a prior art aluminum electrolysis cell anode assembly;

[0010] Figure 3 is an elevated cross sectional view of an anode assembly having a stub with a configuration as shown in Figure 4A, wherein the stub of Figure 3 is
5 sectioned along line 3-3' of Figure 4A;

[0011] Figures 4A-4F are plan views of a stub of the anode assembly according to various exemplary embodiments;

[0012] Figures 5A-5C are plan views of a stub of the anode assembly according to various exemplary embodiments;

10 [0013] Figures 6A-6C are plan views of a stub of the anode assembly according to various exemplary embodiments;

[0014] Figure 7 is an elevated cross sectional view of an anode assembly having a stub with a configuration as shown in Figure 5A, wherein the stub of Figure 3 is sectioned along line 7-7' of Figure 5A;

15 [0015] Figure 8 is an elevated cross sectional view of an anode assembly according to various exemplary embodiments;

[0016] Figure 9 is an elevated cross-sectional view of an anode assembly according to various exemplary embodiments;

[0017] Figure 10 is an elevated cross-sectional view of an anode assembly
20 according to various exemplary embodiments;

[0018] Figure 11 is an elevated cross-sectional view of an anode assembly according to various exemplary embodiments;

[0019] Figure 12 is an elevated cross-sectional view of an anode assembly according to various exemplary embodiments; and

25 [0020] Figure 13 is an elevated cross-sectional view of an anode assembly according to various exemplary embodiments.

DESCRIPTION OF VARIOUS EMBODIMENTS

[0021] It will be appreciated that numerous specific details are set forth in order to provide a thorough understanding of the exemplary embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the embodiments described herein. Furthermore, this description is not to be considered as limiting the scope of the embodiments described herein in any ways, but rather as merely describing the implementation of the various embodiments described herein.

[0022] Referring now to Figure 1, therein illustrated is a perspective view of an anode assembly 100 commonly used in the art. The anode assembly has a rod 102 for coupling to a bus bar (not shown) that delivers direct current at high amperage. For example, the direct current provided can be in the range of 50 kA to 600 kA or more. In some applications, the direct current can be greater than 600kA. An end of the rod 102 is coupled to a yoke 104, which has one or more laterally extending arms 106. Each of the arms 106 is further coupled to one of one or more stubs 108. A stub 108 is at least partially inserted into a stub hole 110 of an anode 112 of the aluminum electrolysis cell to couple the stub hole 110 to the anode 112. Each of the rod 102, yoke 104 and stubs 108 are formed of an electrically conductive material to conduct electricity from the busbar to the anode 112.

[0023] Reference is now made to Figures 1 and 2, wherein Figure 2 illustrates a sectional view of a portion of the region where one stub 108 is inserted into a stub hole 110 of the anode 112. A thimble 114 is formed between a lateral wall of the stub 108 and a lateral wall 116 of the stub hole 110. The thimble 114 provides a mechanical coupling between the stub 108 and the anode 112 while also providing an electrical path therebetween. The thimble 114 prevents the anode 112 from falling away from the stub 108, for example under the force of gravity.

[0024] The thimble 114 is formed by casting the thimble material at a temperature above the melting point of the material. For example, where the thimble 114 is formed of

cast iron, the casting temperature is in the range of 1200-1400°C. Before submerging into the bath of molten cryolite, the thimble material may be cooled to allow for solidification of the material that was cast to form the thimble 114. For example, the thimble material may be cooled at room temperature. It will be appreciated that when the thimble material is cooled, the thimble will undergo negative thermal expansion. As a result of this negative thermal expansion, one or more air gaps 120 may form between the stub 108 and the lateral wall 116 of the stub hole 110. Moreover, as a result of the negative thermal expansion, the engagement of the stub 108 with the thimble 114 can become looser such that under the force of gravity a base of the stub 108 moves away from the bottom of the stub hole 110. This movement generally decreases the quality of the contact between the base of the stub 108 and the bottom of the stub hole 110. For example, the contact pressure and/or the area of contact between the base of the stub 108 and the bottom of the stub hole 110 can decrease. In some cases, the air gap 120 may form between the base of the stub 108 and the bottom of the stub hole 110.

[0025] The decrease of quality of the contact increases the effective resistance between the stub 108 and the anode 112. This increased effective resistance contributes to a greater voltage drop due to the stub-to-anode coupling. The stub-to-anode resistance represents a loss that contributes to an increase of the cost of aluminum production. Increasing the quality of the contact to decrease the stub-to-anode resistance would therefore lead to a more efficient aluminum production process.

[0026] One attempt in the art to improve the quality of contact between the stub 108 and the anode 112 is to vary the configuration of the lateral wall 116 of the stub hole 110 in order to increase the surface area of the lateral wall 116. According to one configuration, the stub hole 110 has a plurality of longitudinal recesses 111 (shown in Figure 1) that extend from the top surface of the stub hole 110 to the bottom of the stub hole 110. Accordingly, a thimble 114 cast between the stub 108 and the anode 112 has a plurality of flutes 118 corresponding to the recesses 111, and these are also shown in Figure 1. The flutes 118 increase the surface area of an outer surface of the thimble 114 contacting the lateral wall 116 of the stub hole 108, with the intended result that the quality of the stub-to-anode contact is improved. However, the increased surface area

of the outer surface results in a reduced contact pressure. This may further result in a greater mean contact resistance and may increase the stub-to-anode resistance.

[0027] Referring now to Figure 3, therein illustrated is an elevated cross sectional view of a portion of an anode assembly 200 according to one exemplary embodiment. A portion of a stub 208 is inserted into a stub hole 210 of an anode 212. The stub hole 210 is defined by lateral wall 216. In this embodiment, the stub hole 210 has a frusto-conical shape defined by inclined lateral wall 216, with lateral wall 216 being outwardly inclined toward the bottom 232 (lower surface) of the stub hole 210.

[0028] The stub 208 defines a central longitudinal axis 220, a longitudinal lateral wall 222 and a base 230 at its lower end. As herein used, the terms “longitudinally” or “axially” interchangeably refer to a direction substantially parallel to the longitudinal axis 220. The stub 208 is initially inserted into the stub hole 210 of the anode 212 such that the base 230 of the stub 208 contacts the bottom 232 of the stub hole 210. The lateral wall 222 of the stub 208 includes at least one discontinuity 240. When the stub 208 is inserted into the stub hole 210, the discontinuity 240 is located on the lateral wall 222 of the stub 208 at a position intermediate the top surface of the stub hole 210 and the stub hole bottom 232.

[0029] A thimble 214 is formed between the stub 208 and the anode 212. An inner surface 224 of the thimble 214 at least partially contacts the lateral wall 222 of stub 208. An outer surface 226 of the thimble 214 contacts the lateral wall 216 of the stub hole 210.

[0030] The engagement of the outer surface 226 of the thimble 214 with the lateral walls 216 of the stub hole 210 can restrict the movement of the thimble 214 relative to the anode 212. As described above, under negative thermal expansion of the thimble 214, the thimble 214 has a tendency to slip out of the stub hole 210 due to force of gravity and decreased contact pressure between the outer surface 226 of the thimble and the lateral wall 216 of the stub hole 210. The engagement of the outer surface 226 of the thimble 214 with the lateral wall 216 restricts the slipping of the thimble 214.

[0031] A portion of the inner surface 224 of the thimble 214 engages the discontinuity 240 of the stub 208. The thimble 214 has a thimble discontinuity 250 having a shape corresponding to the discontinuity 240 of the stub discontinuity 240. The engagement of the stub discontinuity 240 with the thimble discontinuity 250 thus forms a shear key connection.

[0032] The engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 restricts the movement of the thimble 214 relative to the stub 208. Consequently, movement of the stub 208 relative to the anode 212 is also restricted. It will be appreciated that engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 restricts the slipping of the stub 208.

[0033] According to various exemplary embodiments, when the anode assembly 200 undergoes positive thermal expansion, the engagement of the lateral wall 222 and discontinuity 240 of the stub 208 with the inner surface 224 of the thimble 214 exerts a mechanical force on the thimble 214 in the radial direction. This force is transmitted by the thimble 214 to the anode stub hole lateral wall 216. The stub 208 also expands in the vertical direction. The mechanical force on the stub 208 has a non-zero component in the longitudinal direction defined by longitudinal axis 220. Under positive thermal expansion of the anode 212, a mechanical force towards the stub hole bottom 232 is exerted on the stub 208. Under positive thermal expansion of the anode 212, the engagement of the outer surface 226 of the thimble 214 with lateral wall 216 of the anode 212 urges the stub base 230 towards the stub hole bottom 232. Where a gap had formed between the stub base 230 and the stub hole bottom 232 due to negative thermal expansion, the urging of the stub base 230 towards the stub hole bottom 232 reduces the size of the gap or closes the gap. Where the gap is closed, physical contact between the stub base 230 and the stub hole bottom 232 is re-established and the quality of the contact between the stub 208 and the stub hole bottom 232 is improved. In both the cases of reducing the size of the gap and closing the gap, the result is a decrease in the stub-to-anode electrical resistance. Where the stub base 230 is already in contact with the stub hole bottom 232, the urging of the stub base 230 towards the stub hole bottom 232 increases the contact pressure between the stub base 230 and

the stub hole bottom 232, which also results in improved quality of contact between the stub base 230 and the stub hole bottom 232 and a decrease in the stub-to-anode electrical resistance.

[0034] According to various exemplary embodiments, when the thimble 214
5 undergoes positive thermal expansion, the engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 of the stub 208 exerts a mechanical force on the stub 208. The mechanical force on the stub 208 has a non-zero component in the longitudinal direction defined by longitudinal axis 220. The engagement of the lateral wall 216 with the outer surface 226 of the thimble 214 can act in combination with the
10 engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 of the stub 208. As a result, under positive thermal expansion of the thimble 214 or the anode assembly 200, a mechanical force towards the stub hole bottom 232 is exerted on the stub 208. Furthermore, under positive thermal expansion of the thimble 214 or anode assembly 200, the engagement of the inner surface 224 of the thimble 214 with the
15 discontinuity 240 of the stub 208 urges the stub base 230 towards the stub hole bottom 232. Where a gap had formed between the stub base 230 and the stub hole bottom 232 due to negative thermal expansion, the urging of the stub base 230 towards the stub hole bottom 232 reduces the size of the gap or closes the gap. Where the gap is closed, physical contact between the stub base 230 and the stub hole bottom 232 is re-
20 established and the quality of the contact between the stub 208 and the stub hole bottom 232 is improved. In both the cases of reducing the size of the gap and closing the gap, the result is a decrease in the stub-to-anode electrical resistance. Where the stub base 230 is already in contact with the stub hole bottom 232, the urging of the stub base 230 towards the stub hole bottom 232 increases the contact pressure between the
25 stub base 230 and the stub hole bottom 232, which also results in improved quality of contact between the stub base 230 and the stub hole bottom 232 and a decrease in the stub-to-anode electrical resistance.

[0035] During the electrolysis process for producing aluminum, the anode assembly 200 is submerged in an electrolytic bath having a temperature in the range of
30 about 900°C to 1100°C. Since this operating range of temperatures can be significantly

higher than the temperature at which the thimble 214 is cooled after being cast, the thimble 214 undergoes positive thermal expansion after the anode assembly 200 is submerged in the bath. Under this positive thermal expansion, the engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 of the stub 208 increases the mechanical force exerted on the stub 208 towards the stub hole bottom 232. The exerted mechanical force can be further due to the engagement of the outer surface 226 of the thimble 214 with the lateral wall 216 of the stub hole. The engagement of thimble 214 with the stub 208 can urge the stub base 230 towards stub hole bottom 232. Therefore, after submerging the anode assembly 200 into the bath during the electrolysis process for producing aluminum, the stub-to-anode electrical resistance is decreased, thereby leading to a more efficient process.

[0036] According to various exemplary embodiments illustrated in Figures 3 and 4A to 4E, each discontinuity 240 of the lateral wall 222 of the stub 208 is a recess extending from the lateral wall 222 of the stub 208 into the body of the stub 208. The recessed discontinuity 240 may extend, for example, transversely from the lateral wall 222 of the stub 208 along a direction substantially orthogonal to the longitudinal axis 220 of the stub 208. The depth of the recessed discontinuity 240 may be defined by a vector 242 having a component oriented in a plane substantially orthogonal to the longitudinal axis 220 of the stub 208. The length of the recessed discontinuity 240 extends along a perimeter of the lateral wall 222 of the stub 208 in a plane substantially orthogonal to the longitudinal axis of the stub 208. For example, the component of a vector defining the length of the recessed discontinuity 240 in a direction orthogonal to the longitudinal axis 220 may be larger than the component of the length in a direction parallel to the longitudinal axis 220.

[0037] When casting the thimble 214, thimble material flows into the recessed discontinuity 240 of the lateral wall 222 of the stub 208. When the thimble material is cooled to form a solid, the thimble material that flowed into the discontinuity 240 forms the engagement with the discontinuity 240. For example, the thimble discontinuity 250 engaging the stub discontinuity 240 is a protrusion extending from the inner surface 224 of the thimble 214 into the lateral wall 222 of the stub 208. The engagement of the stub

discontinuity 240 with the thimble discontinuity 250 thus forms a shear key connection, wherein the stub discontinuity is concave and the thimble discontinuity 250 is convex.

[0038] The lower surface of the recessed discontinuity 240 may be pressed against the lower surface of the thimble discontinuity 250, which restricts further axial movement of the stub 208 relative to the thimble 214. Due to engagement of the outer surface 226 of thimble 214 with the lateral wall 216 of the stub hole 210, movement of the stub 208 relative to the anode 212 can also be restricted. Restricting movement of the stub 208 relative to the thimble 214 contributes to the maintaining of a good contact between the stub base 230 and stub hole bottom 232, thereby also maintaining a low stub-to-anode electrical resistance.

[0039] Referring now to Figures 4A-4F, therein illustrated are plan views of various exemplary embodiments of the stub 208 having at least one recessed discontinuity 240. While each of the stubs 208 are illustrated as having a circular cross-section in a plane orthogonal to the longitudinal axis 220, it will be understood that the stub 208 can have a cross-section having various alternate shapes, such as a rectangle, pentagon, or hexagon. The embodiments shown in Figures 4A-4F can be adapted to the stub 208 having an alternate cross-section.

[0040] Referring specifically to Figure 4A, therein illustrated is an exemplary embodiment of the stub 208 having at least one recessed discontinuity 240 comprising a continuous annular groove extending circumferentially about the lateral wall 222 of the stub 208. Alternatively, the stub 208 can have a plurality of recessed discontinuities 240, each discontinuity defining an arc of the circumference of the lateral wall 222. For example, the recessed discontinuity 240 shown in Figure 4A can be formed using at least one machining tool to make one or more cuts on the lateral wall 222 of the stub 208.

[0041] Referring to Figure 4B, therein illustrated is another exemplary embodiment of the stub 208 having at least two recessed discontinuities 240. The at least two recessed discontinuities 240 each define a segment 244 in the cross-section of the stub 208. The at least two recessed discontinuities 240 are substantially parallel.

At least one of the segments 244 defined by one of the recessed discontinuities 240 further defines an arc 246. The recessed discontinuities 240 shown in Figure 4B can be formed using at least one machining tool that makes a tangential cut on the other surface of the stub 208.

5 [0042] Referring to Figure 4C, therein illustrated is another exemplary embodiment of the stub having at least one recessed discontinuity 240 defining a curved depth 252. The recessed discontinuity 240 shown in Figure 4C can be formed using at least one machining tool that machines at least one circular cut on the lateral wall 222 of the stub 208, wherein each circular cut comprises an arcuate slot formed in
10 the stub 208, having a maximum depth 252 measured radially inwardly from the lateral wall 222 to the central longitudinal axis 220.

[0043] Referring to Figure 4D, therein illustrated is another exemplary embodiment of the stub 208 having a plurality of recessed discontinuities 240. Each of the plurality of recessed discontinuities 240 defines a segment 254 in the cross-section
15 of the stub 240. The segments 254 defined by the recessed discontinuities are connecting such that an arc defined by the segments 254 covers 360° of the circumference of the stub 208. The recessed discontinuities 240 shown in Figure 4D can be formed using at least one machining tool that machines a tangential cut on the lateral wall 222 of the stub 208.

20 [0044] Referring to Figure 4E, therein illustrated is another exemplary embodiment of the stub 208 having four recessed discontinuities 240. The four recessed discontinuities 240 each define a segment 256 in the cross-section of the stub 208. Each of a first pair of opposing recessed discontinuities of the plurality of recessed discontinuities 240 are substantially parallel. Each of a second pair of opposing
25 recessed discontinuities of the plurality of recessed discontinuities 240 are substantially parallel while being orthogonal to the first pair of opposing recessed discontinuities 240. The recessed discontinuities 240 shown in Figure 4E can be formed using at least one machining tool that machines a tangential cut on the outer surface of the stub 208.

[0045] Referring to Figure 4F, therein illustrated is another exemplary embodiment of the stub 208 having at least one recessed discontinuity 240 extending into the body of the stub 208. The recessed discontinuity 240 extends radially towards the longitudinal axis 220. The at least one recessed discontinuity 240 extends in a plane
5 orthogonal to the longitudinal axis 220. A vector defining the extension of the at least one recessed discontinuity 240 has a component in the plane orthogonal to the longitudinal axis 220 that is greater than a component parallel to the longitudinal axis 220. The at least one recessed discontinuity 240 of Figure 4F can be formed by drilling from the lateral wall 222 of the stub 208 into the body of the stub 208.

10 [0046] According to various exemplary embodiments illustrated in Figures 5A to 5C and Figure 7, the at least one discontinuity 240 of the lateral wall 222 of the stub 208 is a protrusion, which is identified herein by reference numeral 240'. For example, the protruding discontinuity 240' extends transversely from the lateral wall 222 of the stub 208 along a plane substantially orthogonal to the longitudinal axis 220 of the stub 208. A
15 length 248 (Fig. 7) of the protruding discontinuity 240' extends along a perimeter of the lateral wall 222 of the stub 208 in a plane substantially orthogonal to the longitudinal axis 220 of the stub 208. The component of the length 248 of the protruding discontinuity 240' in a direction orthogonal to the longitudinal axis 220 may be larger than the component of the length 248 in a direction parallel to the longitudinal
20 axis 220.

[0047] When casting the thimble 214, thimble material flows about the protruding discontinuity 240' of the lateral wall 222 of the stub 208. When the thimble material is cooled to form a solid, the thimble material that flowed about the discontinuity 240' forms the engagement with the discontinuity 240'. The thimble discontinuity 250
25 engaging the stub discontinuity 240' is a recess extending into the inner surface 224 of the thimble 214. The engagement of the stub discontinuity 240' with the thimble discontinuity 250 forms a shear key connection, wherein the stub discontinuity 240' is convex and the thimble discontinuity 250 is concave.

[0048] An upper surface of the protruding discontinuity 240' is pressed against an
30 upper surface of the thimble discontinuity 250, which restricts further axial movement of

the stub 208 relative to the thimble 214. Due to engagement of the outer surface 226 of thimble 214 with the lateral wall 216 of the stub hole 210, movement of the stub 208 relative to the anode 212 can also be restricted. Restricting movement of the stub 208 relative to the thimble 214 contributes to the maintaining of a good contact between the stub base 230 and stub hole bottom 232, thereby also maintaining a low stub-to-anode electrical resistance.

[0049] Referring now to Figures 5A to 5C, therein illustrated are plan views of various exemplary embodiments of the stub 208 having at least one protruding discontinuity 240'. While each of the stubs 208 are illustrated as having a circular cross-section in a plane orthogonal to the longitudinal axis 220, it will be understood that the stub 208 can have a cross-section having various alternate shapes, such as a rectangle, pentagon, or hexagon. The embodiments shown in Figures 5A to 5C can be adapted to the stub 208 having an alternate cross-section.

[0050] Referring to Figures 5A and 7, therein illustrated is an exemplary embodiment of the stub 208 having a protruding discontinuity 240' in the form of an annular protrusion extending circumferentially about the lateral wall 222 of the stub 208. Alternatively, the stub 208 can have a plurality of protruding discontinuities 240', each discontinuity 240' defining an arc of the circumference of the lateral wall 222. For example, the protruding discontinuity 240' shown in Figures 5A and 7 can be formed by molding the stub 208 using a mold having at least one recess corresponding to the protruding discontinuity 240' to be formed.

[0051] Referring to Figure 5B, therein illustrated is another exemplary embodiment of the stub 208 having a plurality of protruding discontinuities 240' each extending over a portion of the circumference of the lateral wall 222 of the stub 208. For example, the protruding discontinuities 240' may be equally radially spaced apart. For example, the protruding discontinuities 240' shown in Figure 5B can be formed by molding the stub 208 using a mold having a plurality of recesses corresponding to the protruding discontinuities 240' to be formed.

[0052] Referring to Figure 5C, therein illustrated is another exemplary embodiment of the stub 208 having at least one attached protruding discontinuity 240'. The stub 208 has at least one recess extending into the body of the stub 208. The recess may extend radially towards the longitudinal axis 220, similar to the embodiment
5 illustrated in Figure 4F. The at least one recess of Figure 5C may be formed by drilling in from the lateral wall 222 of the stub 208 towards the longitudinal axis 220. The protruding discontinuity 240' is attached to the stub 208 by inserting a portion of the protruding discontinuity 240' into the recess. Advantageously, the protruding discontinuity 240' is formed with an electrically conductive material. The portion of the
10 protruding discontinuity 240' extending from the lateral wall 222 of the stub 208 may have a larger diameter than the portion of protruding discontinuity 240' inserted into the recess.

[0053] According to various exemplary embodiments of the stub 208 having at least one protruding discontinuity 240', the discontinuity 240' can be formed by
15 attaching one or more protruding members onto the lateral wall 222 of the stub 208. For example, the members can be welded onto the lateral wall 222.

[0054] According to various exemplary embodiments of the stub 208 having at least one protruding discontinuity 240, each discontinuity can be formed by build-up of protruding members onto the lateral wall 222 of the stub 208. For example, the
20 members can be formed by building up welding material onto the lateral wall 222.

[0055] Referring now to Figures 6A-6C, therein illustrated are plan views of various exemplary embodiments of the stub 208 having at least one discontinuity 240 that is a recessed discontinuity and at least one discontinuity 240' that is a protruding discontinuity. Each recessed discontinuity 240 can be formed using at least one
25 machining tool, for example, to make a circular cut on the lateral wall 222 of the stub 208. Each protruding discontinuity 240' can be formed by molding the stub 208 using a mold having at least one recess corresponding to the protruding discontinuity 240' to be formed. Alternatively, each recessed discontinuity 240 and each protruding discontinuity 240' can be simultaneously formed by molding the stub 208 using a mold having at
30 least one recess and at least one protrusion corresponding to the recessed and

protruding discontinuities 240, 240' to be formed. Alternatively, each protruding discontinuity 240' can be formed by attaching a member onto the lateral wall 222 of the stub 208, for example by welding. Alternatively each protruding discontinuity 240' can be formed by build-up of material. For example, each protruding discontinuity 240' can be formed by building up welding material onto the lateral wall 222. While each of the stubs 208 are illustrated as having a circular cross-section in a plane orthogonal to the longitudinal axis 220, it will be understood that the stub 208 can have a cross-section having various alternate shapes, such as a rectangle, pentagon, or hexagon. The embodiments shown in Figures 6A to 6C can be adapted to the stub 208 having an alternate cross-section.

[0056] Referring to Figure 6A, therein illustrated is another exemplary embodiment of the stub 208 having at least one recessed discontinuity 240 and at least one protruding discontinuity 240'. The at least one recessed discontinuity 240 defines a curved depth 258. The at least one recessed discontinuity 240 extends lengthwise in a plane orthogonal to the longitudinal axis 220. A vector defining the lengthwise extension of the at least one recessed discontinuity 240 has a component in the plane orthogonal to the longitudinal axis 220 that may be greater than a component parallel to the longitudinal axis 220. The at least one protruding discontinuity 240' defines a spherical or semi-cylindrical outer surface.

[0057] Referring to Figure 6B, therein illustrated is another exemplary embodiment of the stub 208 having at least one recessed discontinuity 240 and at least one protruding discontinuity 240'. The at least one recessed discontinuity 240 defines a segment 266 in the cross-section of the stub 240. For example, the at least one recessed discontinuities 240 extends lengthwise in a plane orthogonal to the longitudinal axis 220. For example, a vector defining the lengthwise extension of the at least one recessed discontinuity 240 has a component in the plane orthogonal to the longitudinal axis 220 that may be greater than a component parallel to the longitudinal axis 220. The at least one protruding discontinuity 240' defines a spherical or semi-cylindrical outer surface.

[0058] Referring to Figure 6C, therein illustrated is another exemplary embodiment of the stub 208 having at least one recessed discontinuity 240 and at least one protruding discontinuity 240'. The at least one recessed discontinuity 240 defines a segment 266 in the cross-section of the stub 240. The at least one recessed discontinuity 240 extends lengthwise in a plane orthogonal to the longitudinal axis 220. A vector defining the lengthwise extension of the at least one recessed discontinuity 240 has a component in the plane orthogonal to the longitudinal axis 220 that may be greater than a component parallel to the longitudinal axis 220. The stub 208 has at least one recess extending into the body of the stub 208. The recess extends radially towards the longitudinal axis 220, similar to the embodiment illustrated in Figure 4F. The at least one recess of Figure 5C may be formed by drilling in from the lateral wall 222 of the stub 208 towards the longitudinal axis 220. The protruding discontinuity 240' is attached to the stub 208 by inserting a portion of protruding discontinuity 240' into the recess. The protruding discontinuity 240' is advantageously formed with an electrically conductive material. The portion of the protruding discontinuity 240' extending from the lateral wall 222 of the stub 208 may have a larger diameter than the portion of protruding discontinuity 240' inserted into the recess.

[0059] Referring now to Figure 8, therein illustrated is an elevated cross-sectional view of a portion of an anode assembly 200 according to one exemplary embodiment. A portion of a stub 208 is shown received in a stub hole 210 of an anode 212. The lateral wall 222 of the stub 208 includes a plurality of discontinuities 240 being spaced apart in the longitudinal direction defined by longitudinal axis 220. For example, one or more of the discontinuities 240 can be a recess extending from the lateral wall 222 of the stub 208 into the body of the stub 208. One or more of the discontinuities 240 can be a protrusion extending from the lateral wall 222 of the stub 208. Alternatively, the plurality of axially spaced apart discontinuities 240 can be a combination of recessed discontinuities 240 and protruding discontinuities 240'. In the illustrated embodiment, three spaced-apart recessed discontinuities 240 are provided.

[0060] Continuing with Figure 8, a thimble 214 is formed between the stub 208 and the anode 212. An inner surface 224 of the thimble 214 at least partially contacts

the lateral wall 222 of the stub 208. An outer surface 226 of the thimble 214 contacts a lateral wall 216 of the stub hole 210.

[0061] A plurality of portions of the inner surface 224 of the thimble 214 each engages one of the discontinuities 240 of the stub 208. For example, the thimble 214 has a plurality of thimble discontinuities 250 having a shape corresponding to a corresponding discontinuity 240 of the stub 208. For example, where one of the stub discontinuities 240 is recessed, the corresponding thimble discontinuity 250 is a protrusion extending into the lateral wall 222 of the stub 208. Conversely, where one of the stub discontinuities 240' is protruding, the corresponding thimble discontinuity 250 is a recess extending from the inner surface 224 of the thimble 214.

[0062] The engagement of the inner surface 224 of the thimble 214 with the plurality of discontinuities 240 restricts the movement of the thimble 214 relative to the stub 208. Due to engagement of the outer surface 226 of thimble 214 with the lateral wall 216 of the stub hole 210, movement of the stub 208 relative to the anode 212 can also be restricted. As described above, under negative thermal expansion of the thimble 214, the stub 208 has a tendency to slip out of the stub hole 210 due to force of gravity and decreased contact pressure between the thimble lateral surface 226 and the anode stub hole lateral wall 216. It will be appreciated that engagement of the inner surface 224 of the thimble 214 with the discontinuities 240 restricts the slipping of the stub 208.

[0063] According to various exemplary embodiments, when the anode assembly 200 undergoes positive thermal expansion, the engagement of the inner surface 224 of the thimble 214 with the plurality of discontinuities 240 of the stub 208 exerts a mechanical force on stub 208. The mechanical force on the stub 208 has a non-zero component in the longitudinal direction defined by the longitudinal axis 220. The engagement of the lateral wall 216 with the outer surface 226 of the thimble 214 can act in combination with the engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 of the stub 208. As a result, under positive thermal expansion of the thimble 214 or the anode assembly 200, a mechanical force towards the stub hole bottom 232 is exerted on the stub 208. Furthermore, under positive thermal expansion of the thimble 214 or anode assembly 200, the engagement of the inner surface 224 of

the thimble 214 with the discontinuities 240 of the stub 208 urges the stub base 230 towards stub hole bottom 232. Where a gap had formed between the stub base 230 and the stub hole bottom 232 due to negative thermal expansion, the urging of the stub base 230 towards the stub hole bottom 232 reduces the size of the gap or closes the gap.

5 Where the gap is closed, physical contact between the stub base 230 and the stub hole bottom 232 is re-established and the quality of the contact between the stub 208 and the stub hole bottom 232 is improved. In both the cases of reducing the size of the gap and closing the gap, the result is a decrease in the stub-to-anode electrical resistance. Where the stub base 230 is already in contact with the stub hole bottom 232, the urging
10 of the stub base 230 towards the stub hole bottom 232 increases the contact pressure between the stub base 230 and the stub hole bottom 232, which also results in improved quality of contact between the stub base 230 and the stub hole bottom 232 and a decrease in the stub-to-anode electrical resistance.

[0064] During the electrolysis process for producing aluminum, the anode
15 assembly 200 is submerged in a cryolite electrolyte bath having a temperature in the range of about 900°C to 1100°C. Since this operating range of temperatures is significantly higher than the temperature at which the thimble 214 is cooled after being cast, the thimble 214 undergoes positive thermal expansion after the anode assembly 200 is submerged in the bath. Under this positive thermal expansion, the engagement
20 of the inner surface of the thimble 214 with the discontinuities 240 of the stub 208 increases the mechanical pressure on the stub 208 towards the stub hole 210. The exerted mechanical force can be further due to the engagement of the outer surface 226 of the thimble 214 with the lateral wall 216 of the stub hole. The engagement of the thimble 214 with the stub 208 can also urge the stub base 230 towards stub hole bottom
25 232. Therefore, after submerging the anode assembly 200 into the bath during the electrolysis process for producing aluminum, the stub-to-anode electrical resistance is decreased, thereby leading to a more efficient process.

[0065] Referring now to Figure 9, therein illustrated is an elevated cross-sectional view of a portion of an anode assembly 200 according to one exemplary embodiment. A
30 portion of a stub 208 is shown received in a stub hole 210 of an anode 212. The stub

208 defines a longitudinal axis 220, a longitudinal lateral wall 222 and a base 230. The lateral wall 222 of the stub includes at least one discontinuity 240 having characteristics similar to the discontinuity described in relation to Figures 3-8. A protruding member 260 extends axially from the stub base 230. The protruding member 260 has a width that covers a portion of the surface area of the stub base 230. The protruding member 260 can be integrally formed with the stub 208. The end of the protruding member 260 may be pointed. Alternatively, the end of the protruding member 260 may be rounded.

[0066] The protruding member 260 can be formed when forming the stub 208. For example, the stub 208 having the protruding member 260 can be formed when casting the stub material in an appropriately shaped mold. Alternatively, the protruding member 260 can be formed by machining the base 230 of a stub 208. For example, the machining of the stub 208 is suitable for retrofitting existing stubs 208.

[0067] When inserted into the stub hole 210 of an anode 212, the stub 208 is only in direct contact with the anode 212 through the protruding member 260. When the thimble 214 is formed between the stub 208 and anode 212, in addition to an inner surface 224 of the thimble 214 at least partially contacting the lateral wall 222 of stub 208 and an outer surface 226 of the thimble 214 contacting a lateral wall 216 of the stub hole 210, a base portion 262 of the thimble 214 is formed between the stub base 230 and the stub hole bottom 232. In addition to contacting the anode 212 through the protruding member 260, the stub base 230 contacts the stub hole bottom 232 via the base portion 262 of the thimble 214.

[0068] In an ideal situation, the stub 208 is fully axially aligned with the stub hole 210. However, in operation, the stub 208 can become misaligned within the stub hole 210, for example, due to manufacturing tolerances, thermal forces and mechanical forces on the anode assembly 200. In some cases when the stub 208 is not fully aligned, the stub 208 is not centered within the stub hole 210 or the stub 208 is inserted at an incline such that the longitudinal axis 220 is not orthogonal to a plane defined by the stub hole bottom 232. Where the stub 208 is inclined, as shown in Figure 9, the longitudinal axis 220 forms a non-zero angle θ with a vertical axis 270 defining an axis orthogonal to the plane defined by the stub hole bottom 232. It will be appreciated that

according to some types of stubs, the misaligned insertion of the stub can significantly disrupt the stub-to-anode connection and therefore disrupt the stub-to-anode electrical resistance.

[0069] The protruding member 260 provides a consistent electrical contact
5 between the stub 208 and the anode 212. When the stub 208 becomes misaligned within the stub hole 210, the protruding member 260 maintains the direct contact between the stub 208 and the anode 212. Where the end of the protruding member 260 is pointed or rounded, the area of the contact between the protruding member 260 and the stub hole bottom 230 remains consistent over a range of angles θ of incline of the
10 stub 208, thereby providing a consistent electrical contact between the stub 208 and the anode 212. Additionally, over the range of angles θ of incline of the stub 208, the base portion 262 of the thimble 214 provides a contact between the stub base 230 and the stub hole bottom 232.

[0070] According to various exemplary embodiments where the protruding
15 member 260 is pointed, the axial force exerted on the stub 208 can cause the protruding member 260 to penetrate the stub hole bottom 232. The penetration further improves the contact between the stub hole 208 and the stub hole bottom 232 via the base portion 262 of the thimble. As a result, stub-to-anode electrical resistance is improved.

[0071] Referring now to Figure 10, therein illustrated is an elevated cross-sectional view of a portion of an anode assembly 200 according to another exemplary embodiment. A portion of a stub 208 is shown received in a stub hole 210 of an anode 212. The stub 208 defines a longitudinal axis 220, a longitudinal lateral wall 222 and a base 230. The lateral wall 222 of the stub 208 includes at least one discontinuity 240
25 having characteristics similar to the discontinuities described in relation to Figures 3-9. The base 230 of the stub 208 is formed to have a convexly curved surface. For example, the base 230 can have a substantially curved surface. The stub hole bottom 232 can have a concavely curved surface. The radius of curvature of the stub hole bottom 232 can be greater than that of the stub base 230, as shown in Figure 10.

[0072] The stub 208 having the convexly curved base 230 can be formed when casting the stub material in an appropriately shaped mold. Alternatively, stub 208 having the convexly curved base 230 can be formed by machining the base 230 of a stub 208. For example, the machining of the stub 208 is suitable for retrofitting existing stubs 208.

5 [0073] Due to the curved surface of the stub base 230 and the curved surface of the stub hole bottom 232, only a portion of the stub base 230 is in direct contact with the stub hole bottom 232. When the thimble 214 is formed between the stub 208 and the anode 212, in addition to an inner surface 224 of the thimble 214 at least partially contacting the lateral wall 222 of the stub 208 and an outer surface 226 of the thimble
10 214 contacting a lateral wall 216 of the stub hole 210, a base portion 262 of the thimble is formed between the stub base 230 and the stub hole bottom 232. In addition to the portion of the stub base 230 directly contacting the stub hole bottom 232, the stub base 230 also contacts the stub hole bottom 232 via the base portion 262 of the thimble 214.

[0074] The convexly curved surface of the stub base 230 provides a consistent
15 electrical contact between the stub 208 and the anode 212. When the stub 208 becomes misaligned within the stub hole 210, the convexly curved stub base 230 maintains direct contact between the stub 208 and the anode 212. Due to the convexly curved stub base 230, the area of contact between the stub bottom surface 230 and the stub hole bottom 232 remains consistent over a range of angles θ of incline of the stub
20 208, thereby providing a consistent electrical contact between the stub 208 and the anode 212. According to exemplary embodiments where the stub hole bottom 232 is concavely curved, the correspondingly curved surfaces of the stub base 230 and the stub hole bottom 232 further improve the consistency of area of the contact between the protruding member 260 and the stub hole bottom 230 over a range of angles θ of incline
25 of the stub 208, thereby providing a further improved consistent electrical contact between the stub 208 and the anode 212.

[0075] Referring now to Figure 11, therein illustrated is an elevated cross-sectional view of a portion of an anode assembly 200 according to another exemplary embodiment. A portion of a stub 208 is shown received in a stub hole 210 of an anode
30 212. The stub 208 defines a longitudinal axis 220, a longitudinal lateral wall 222 and a

base 230. The lateral wall 222 of the stub includes at least one discontinuity 240 having characteristics similar to the discontinuities described in relation to Figures 3-10. The base 230 of the stub 208 is formed to have a convexly curved surface and a protruding member 260 extending axially from the stub base 230. According to various exemplary embodiments, the stub hole bottom 232 can have a concavely curved surface. The radius of curvature of the stub hole bottom 232 is greater than that of the stub base 230, as shown in Figure 11. A base of protruding member 260 joined to the stub base 230 has a width that covers a sub-portion of the surface area of the stub base 230. The protruding member 260 is integrally formed with the stub 208. The end of the protruding member 260 may be pointed. Alternatively, the end of the protruding member 260 may be rounded.

[0076] When inserted into the stub hole 210 of an anode 212, the stub 208 is only in direct contact with the anode 212 through the protruding member 260. When the thimble 214 is formed between the stub 208 and anode 212, in addition to an inner surface 224 of the thimble 214 at least partially contacting the lateral wall 222 of stub 208 and an outer surface 226 of the thimble 214 contacting a lateral wall 228 of the stub hole 210, a base portion 262 of the thimble 214 is formed between the stub base 230 and the stub hole bottom 232. In addition to contacting the anode 212 through the protruding member 260, the stub base 230 contacts the stub hole bottom 232 via the base portion 262 of the thimble 214.

[0077] The protruding member 260 provides a consistent electrical contact between the stub 208 and the anode 212. When the stub 208 becomes misaligned within the stub hole 210, the protruding member 260 maintains the direct contact between the stub 208 and the anode 212. Where the end of the protruding member 260 is pointed or rounded, the area of the contact between the protruding member 260 and the stub hole bottom 230 remains consistent over a range of angles θ of incline of the stub 208, thereby providing a consistent electrical contact between the stub 208 and the anode 212.

[0078] According to various exemplary embodiments where the protruding member 260 is pointed, the axial force exerted on the stub 208 due to positive thermal

expansion of the thimble 214 or anode assembly 200 can cause the protruding member 260 to penetrate the stub hole bottom 232. The penetration further improves the contact between the stub hole 208 and the stub hole bottom 232 via the base portion 262 of the thimble. As a result, the stub-to-anode electrical resistance is improved.

5 [0079] According to various exemplary embodiments, the stub base 230 may be textured to provide increased electrical contact with the bottom of the stub hole. For example, the surface of the stub base 230 can be knurled, as indicated by reference numeral 254 in Figure 11.

[0080] Referring now to Figure 12, therein illustrated is an elevated cross-sectional view of a portion of an anode assembly 200 according to another exemplary embodiment. A portion of a stub 208 is inserted into a stub hole 210 of an anode 212. The stub hole 210 is defined by lateral walls 216. For example, the stub hole 210 can have a frusto-conical shape defined by inclined lateral walls 216. A thimble 214 is formed between the stub 208 and the anode 212. An inner surface 224 of the thimble 214 at least partially contacts the lateral wall 222 of stub 208. An outer surface 226 of the thimble 214 contacts a lateral wall 216 of the stub hole 210.

[0081] The lateral wall 216 of the stub hole 210 has at least one anode discontinuity 280 on its surface. The anode discontinuity 280 is located on the surface of the lateral wall 216 of the stub hole 210 at a position intermediate the top surface of the stub hole 210 and the stub hole bottom 232. A portion of the outer surface 226 of the thimble 214 engages the anode discontinuity 280.

[0082] A portion of a stub 208 is inserted into the stub hole 210 of the anode 212. The stub 208 defines a longitudinal axis 220, a longitudinal lateral wall 222 and a base 230. The stub 208 is inserted into the stub hole 210 of the anode 212 such that the base 230 of the stub 208 contacts the bottom 232 of the stub hole 210. The lateral wall 222 of the stub 208 can be inclined, for example, at an angle substantially parallel to the inclined lateral walls 216 of the stub hole 210. According to various exemplary embodiments, in addition to the anode discontinuity 280, the lateral wall 222 of the stub 208 includes at least one discontinuity 240 having characteristics similar to the

discontinuities described in relation to Figures 3-11. When the stub 208 is inserted into the stub hole 210, the discontinuity 240 is located on the lateral wall 222 of the stub 208 at a position intermediate a top surface of the stub hole 210 and a stub hole bottom 232. At least one discontinuity 240 of the stub 208 opposes one of the at least one anode
5 discontinuity 280 of the lateral wall 216 of the anode 212.

[0083] The engagement of the outer surface 226 of the thimble 214 with the anode discontinuity 280 restricts the movement of the thimble 214 relative to the anode 212. Due to engagement of the lateral wall 222 of the stub 208 with the inner surface 224 of the thimble 214, movement of the stub 208 relative to the thimble 214 can also
10 be restricted. Consequently, movement of the stub 208 relative to the anode 212 is also restricted. The engagement of the outer surface 226 of the thimble 214 with the anode discontinuity 280 restricts the slipping of the thimble 214 that may occur under negative thermal expansion of the thimble 214.

[0084] According to various exemplary embodiments, as shown in Figure 12,
15 when the assembly 200 undergoes positive thermal expansion, the engagement of the outer surface 226 of the thimble 214 with the anode discontinuity 280 of the stub 208 creates a mechanical force on the thimble 214. The mechanical force on the stub 208 has a non-zero component in the longitudinal direction defined by longitudinal axis 220. The engagement of the lateral wall 216 with the outer surface 226 of the thimble 214
20 can act in combination with the engagement of the inner surface 224 of the thimble 214 with the discontinuity 240 of the stub 208, where one is provided. As a result, under positive thermal expansion of the thimble 214 or the anode assembly 200, a mechanical force towards the stub hole bottom 232 is exerted on the stub 208. Under positive thermal expansion, the engagement of the outer surface 226 of the thimble 214 with the
25 anode discontinuity 280 of the anode 212 urges the stub base 230 towards stub hole bottom 232. Where a gap had formed between the stub base 230 and the stub hole bottom 232 due to negative thermal expansion, the urging of the stub base 230 towards the stub hole bottom 232 reduces the size of the gap or closes the gap. Where the gap is closed, physical contact between the stub base 230 and the stub hole bottom 232 is
30 re-established and the quality of the contact between the stub 208 and the stub hole

bottom 232 is improved. In both the cases of reducing the size of the gap and closing the gap, the result is a decrease in the stub-to-anode electrical resistance. Where the stub base 230 is already in contact with the stub hole bottom 232, the urging of the stub base 230 towards the stub hole bottom 232 increases the contact pressure between the stub base 230 and the stub hole bottom 232, which also results in improved quality of contact between the stub base 230 and the stub hole bottom 232 and a decrease in the stub-to-anode electrical resistance.

[0085] During the electrolysis process for producing aluminum, the anode assembly 200 is submerged in a cryolite electrolytic bath having a temperature in the range of about 900°C to 1100°C. Since this operating range of temperatures is significantly higher than the temperature at which the thimble 214 is cooled after being cast, the thimble 214 undergoes positive thermal expansion after the anode assembly 200 is submerged in the bath. Under this positive thermal expansion, the engagement of the outer surface 226 of the thimble 214 with the anode discontinuity 280 and the engagement of the lateral wall 222 of the stub 208 with the inner surface 222 of the thimble 214 increase the mechanical pressure on the stub 208 towards the stub hole bottom 232. The engagement can also urge the stub base 230 towards stub hole bottom 232. Therefore, after submerging the anode assembly 200 into the bath during the electrolysis process for producing aluminum, the stub-to-anode electrical resistance is decreased, thereby leading to a more efficient process.

[0086] According to various exemplary embodiments, the at least one anode discontinuity 280 of the lateral wall 216 of the anode 212 is a recess extending from the lateral wall 216 of the anode 212 and radially outwardly into the body of the anode 212. For example, the recessed anode discontinuity 280 may extend transversely from the lateral wall 216 of the anode along a direction substantially orthogonal to the longitudinal axis 220. For example, the depth of the recessed anode discontinuity 280 is defined by a vector 282 having a component oriented in a plane substantially orthogonal to the longitudinal axis 220. The length of the recessed anode discontinuity 280 extends along a surface of the lateral wall 216 of the stub hole 210 in a plane substantially orthogonal to the longitudinal axis 220. The component of the length of the recessed

anode discontinuity 280 in a direction orthogonal to the longitudinal axis 220 may substantially larger than the component of the length in a direction parallel to the longitudinal axis 220.

[0087] When casting the thimble 214, thimble material flows into the recessed
5 anode discontinuity 280 of the lateral wall 216 of the stub hole 210. When the thimble material is cooled to form a solid, the thimble material that flowed into the anode discontinuity 280 forms the engagement with the anode discontinuity 280. The thimble material flowing into the anode discontinuity 280 forms a thimble discontinuity 290. The thimble discontinuity 290 engaging the anode discontinuity 280 is a protrusion extending
10 from the outer surface 226 of the thimble 214 into the lateral wall 216 of the anode 212. For example, the engagement of the anode discontinuity 280 with the thimble discontinuity 290 forms a shear key connection, wherein the anode discontinuity 280 is concave and the thimble discontinuity 290 is convex.

[0088] An upper surface of the recessed anode discontinuity 280 is pressed
15 against a surface of the thimble discontinuity 290, which restricts further axial movement of the anode 212 relative to the thimble 214. The engagement of the lateral wall 222 of the stub 208 with the inner surface 224 of the thimble 214 further restricts movement of the stub 208 relative to the thimble 214. As a result, movement of the stub 208 relative to the anode 212 is restricted. Restricting movement of the stub 208 relative to the
20 anode 212 contributes to the maintaining of a good contact between the stub base 230 and stub hole bottom 232, thereby also maintaining a low stub-to-anode electrical resistance.

[0089] According to other various exemplary embodiments, for example as shown in Figure 13, the at least one anode discontinuity of the lateral wall 216 of the
25 anode 212 is a protrusion, and is labeled 280'. The protruding anode discontinuity 280' may extend transversely from the lateral wall 216 of the anode 212 along a plane substantially orthogonal to the longitudinal axis 220 and, for example, may extend radially inwardly from the lateral wall 216. The length of the protruding anode discontinuity 280 extends along a perimeter of the lateral wall 216 of the anode 212 in a
30 plane substantially orthogonal to the longitudinal axis 220. The component of the length

of the protruding anode discontinuity 280' in a direction orthogonal to the longitudinal axis 220 may be larger than the component of the length in a direction parallel to the longitudinal axis 220.

[0090] When casting the thimble 214, thimble material flows about the protruding anode discontinuity 280' of the lateral wall 216 of the anode 212. When the thimble material is cooled to form a solid, the thimble material that flowed about the anode discontinuity 280' forms the engagement with the discontinuity 280'. The thimble material flowing into the anode discontinuity 280' forms a recessed thimble discontinuity, which is labelled 290' in Figure 13. For example, the thimble discontinuity 290' engaging the anode discontinuity 280' is a recess extending radially inwardly into the outer surface 226 of the thimble 214. For example, the engagement of the anode discontinuity 280' with the thimble discontinuity 290' forms a shear key connection, wherein the anode discontinuity 280' is convex and the thimble discontinuity 290' is concave.

[0091] According to one exemplary method of manufacturing an anode assembly of an aluminum electrolysis cell, the electrically conductive stub 208 defining the longitudinal axis 220 is first provided. The stub 208 has the base 230 and longitudinal lateral wall 222. The electrically conductive stub 208 is formed by casting stub material in a mold. For example, the stub material may be steel. The electrically conductive stub 208 may also be a stub that is already in use in an aluminum electrolysis cell and is to be retrofitted.

[0092] At least one discontinuity 240 is formed on the lateral wall 222 of the stub 208. For example, the discontinuity 240 may be formed when casting the stub material in the mold. Accordingly, the mold is appropriately shaped to have at least one corresponding discontinuity to shape the discontinuity 240 in the stub 208. The mold can be shaped to form a recessed discontinuity, a protruding discontinuity, or a combination thereof. Alternatively, the at least one discontinuity 240 can be formed by cutting a recess on the lateral wall 222 of the stub 208. For example, when retrofitting a stub 208, the at least one discontinuity can be formed by machining the lateral wall 222 of the stub 208.

[0093] According to various exemplary embodiments, where the stub base has a protruding member 260, the protruding member 260 can also be formed when forming the at least one discontinuity 240. For example, the protruding member 260 can be formed when casting the stub material in an appropriately shaped mold.

5 [0094] According to various exemplary embodiments, where the stub base 230 is convexly curved, the stub base 230 can also be formed when forming the at least one discontinuity 240. For example, the convexly curved stub base 230 can be formed when casting the stub material in an appropriately shaped mold. Alternatively, the convexly curved stub base 230 can be formed by machining the stub 208. For example, the
10 machining of the stub 208 is suitable for retrofitting existing stubs 208. After forming the at least one discontinuity 240 in the lateral wall 216 of the stub 208, where one is provided, the stub 208 is inserted into the stub hole 210 of the anode 212 of the aluminum electrolysis cell anode assembly 200. The stub 208 is inserted near a center of the stub hole 210 to leave a gap between a lateral wall 216 of the stub hole 210 and
15 the lateral wall 222 of the stub 208. The stub 208 is also inserted such that the stub base 230 contacts the stub hole bottom 232.

[0095] A thimble 214 is then formed between the lateral wall 222 of the stub 208 and a stub hole 210 of the anode 212, for example, by casting thimble material into the gap between the lateral wall 216 of the stub hole 210 and the lateral wall 222 of the stub
20 208. After the thimble 214 is formed, a portion of the inner surface of the thimble 214 engages the discontinuity 240 of the stub 208.

[0096] According to various exemplary embodiments, the stub hole 210 can be formed by using an appropriately shaped mould in an anode forming machine. Alternatively, or additionally, the stub hole 210 can be formed by machining the anode
25 212 prior to casting the thimble material.

[0097] According to various exemplary embodiments of the method of manufacturing an anode assembly, the method further includes forming at least one discontinuity 280 in the lateral wall 216 of the stub hole 210. The anode discontinuity 280 has the characteristics herein described with reference to Figures 12 and 13. The at

least one anode discontinuity 280 can be formed by cutting a recess on the lateral wall 216 of the stub hole 210.

[0098] While the above description provides examples of the embodiments, it will be appreciated that some features and/or functions of the described embodiments are susceptible to modification without departing from the spirit and principles of operation of the described embodiments. Accordingly, what has been described above has been intended to be illustrative and non-limiting and it will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto.

CLAIMS:

1. An aluminum electrolysis cell anode assembly comprising:
 - an anode defining a stub hole having a lateral wall and a bottom;
 - an electrically conductive stub being at least partially inserted into the stub
- 5 hole, the stub defining a longitudinal axis and having a longitudinal lateral wall and a base for contacting the stub hole bottom, the stub lateral wall having at least one discontinuity;
 - a thimble formed within the stub hole, the thimble having an inner surface, a portion of the inner surface engaging the discontinuity of the stub, said engagement restricting axial movement of the thimble relative to the stub.
- 10 2. The assembly of claim 1, wherein the thimble further comprises an outer surface, a portion of the outer surface of the thimble engaging the stub hole lateral wall, said engagement restricting axial movement of the anode relative to the stub.
3. The assembly of claim 2, wherein when the anode undergoes thermal expansion, said engagement of the outer surface of the thimble with the stub hole lateral wall urges the
- 15 stub base towards the stub hole bottom.
4. The assembly of any one of claims 1 to 3, wherein when the thimble undergoes thermal expansion, said engagement of the inner surface of the thimble with the discontinuity of the stub urges the stub base towards the stub hole bottom.
5. The assembly of claim 4, wherein urging the stub base towards the stub hole bottom
- 20 increases a contact pressure between the stub base and the stub hole bottom.
6. The assembly of any one of claims 4 or 5, wherein urging the stub base towards the bottom of the stub hole decreases a stub-to-anode resistance.
7. The assembly of any one of claims 1 to 6, wherein the discontinuity is a recess in the lateral wall of the stub.
- 25 8. The assembly of claim 7, wherein the recess extends about the perimeter of lateral wall of the stub.

9. The assembly of claim 7, wherein the recess defines a segment in a plane orthogonal to the longitudinal axis.

10. The assembly of claim 7, wherein the recess extends radially relative to the longitudinal axis.

5 11. The assembly of claim 7, wherein the recess is formed by machining a tangential cut on the lateral wall of the stub.

12. The assembly of claim 7, wherein the recess is formed by machining a circular cut on the lateral wall of the stub.

10 13. The assembly of claim 7, wherein the recess is formed by drilling the lateral wall of the stub.

14. The assembly of any one of claims 1 to 6, wherein the discontinuity is a protrusion in the lateral wall of the stub.

15. The assembly of any one of claims 1 to 6, further comprising a plurality of discontinuities positioned longitudinally on the lateral wall of the stub.

15 16. The assembly of any one of claims 1 to 15, further comprising at least one protruding member extending longitudinally from the stub base, the stub contacting the stub hole bottom through the protruding member.

20 17. The assembly of any one of claims 1 to 15, wherein the stub base is convexly shaped to contact a concavely shaped stub hole bottom, wherein the stub hole bottom has a larger radius of curvature than the stub base.

18. The assembly of any one of claims 1 to 15, wherein the stub base is textured to provide increased electrical contact with the bottom of the stub hole.

25 19. The assembly of any one of claims 1 to 18, wherein the stub hole lateral wall comprises a discontinuity, a portion of the outer surface of the thimble engaging the discontinuity of the stub hole lateral wall, said engagement restricting axial movement of the anode relative to the stub.

20. A method of manufacturing an anode assembly of an aluminum electrolysis cell, the method comprising:

providing an electrically conductive stub defining a longitudinal axis, the stub having a base and a longitudinal lateral wall;

5 forming at least one discontinuity in the lateral wall of the stub;

inserting the stub into a stub hole of an anode of the aluminum electrolysis cell;

casting a thimble between the lateral wall of the stub and the stub hole, a portion of the inner surface of the thimble engaging the discontinuity of the stub.

10 21. The method of claim 20, wherein the discontinuity is a recess in the lateral wall of the stub.

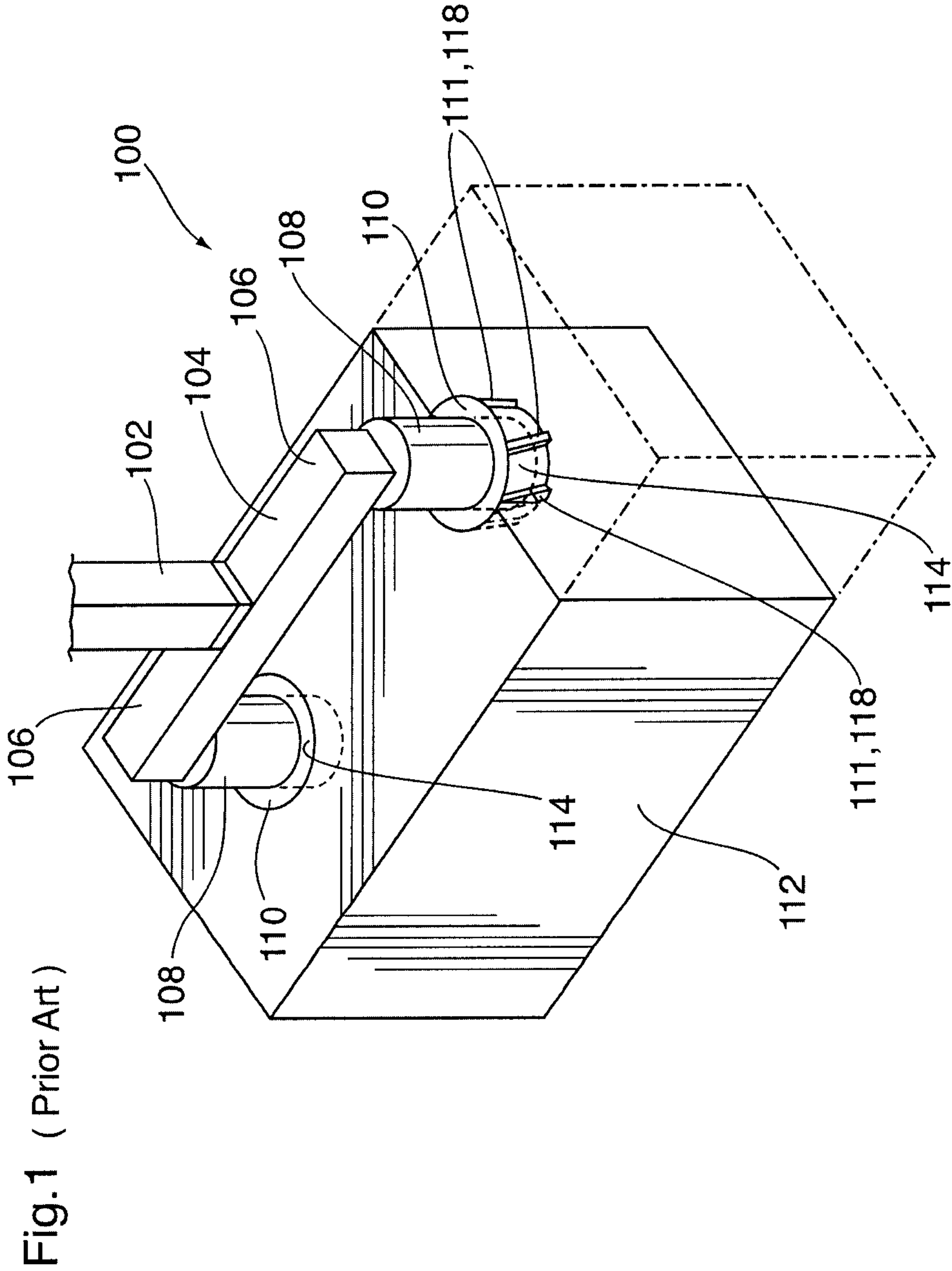
22. The method of claim 21, wherein the recess is formed by machining a cut on the lateral wall of the stub.

23. The method of any one of claims 20 to 22, further comprising:

15 forming at least one discontinuity in a lateral wall of the stub hole.

24. The method of any one of claims 20 to 23, wherein the stub comprises at least one protrusion extending longitudinally from the stub base, and wherein after casting the thimble, a portion of thimble contacts the stub base and the stub base partially contacts the stub hole bottom through the portion of the thimble.

20 25. The method of any one of claims 20 to 24, wherein the stub base is convexly shaped and wherein after inserting the stub into the stub hole, the stub base contacts a correspondingly concavely shaped bottom of the stub hole.



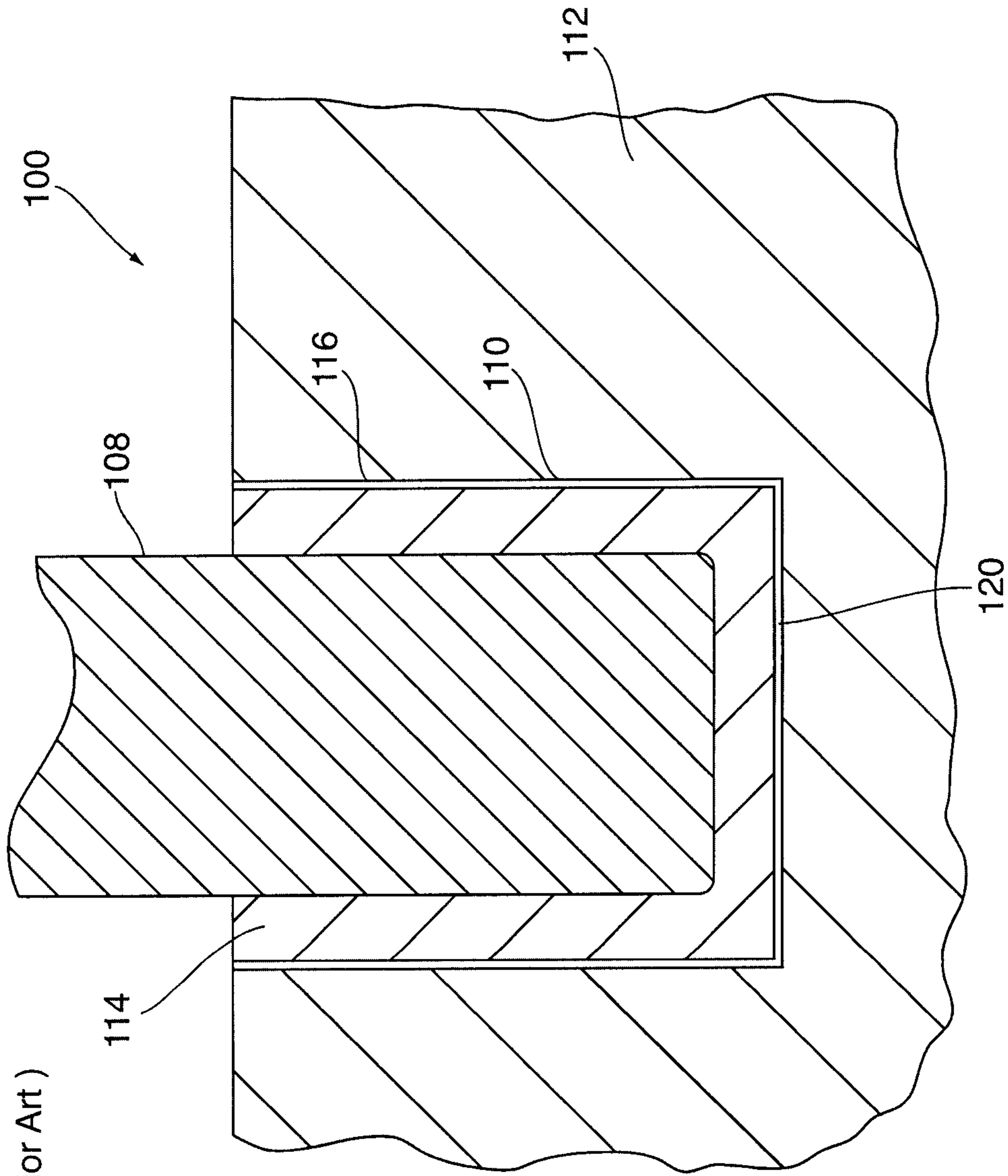


Fig. 2 (Prior Art)

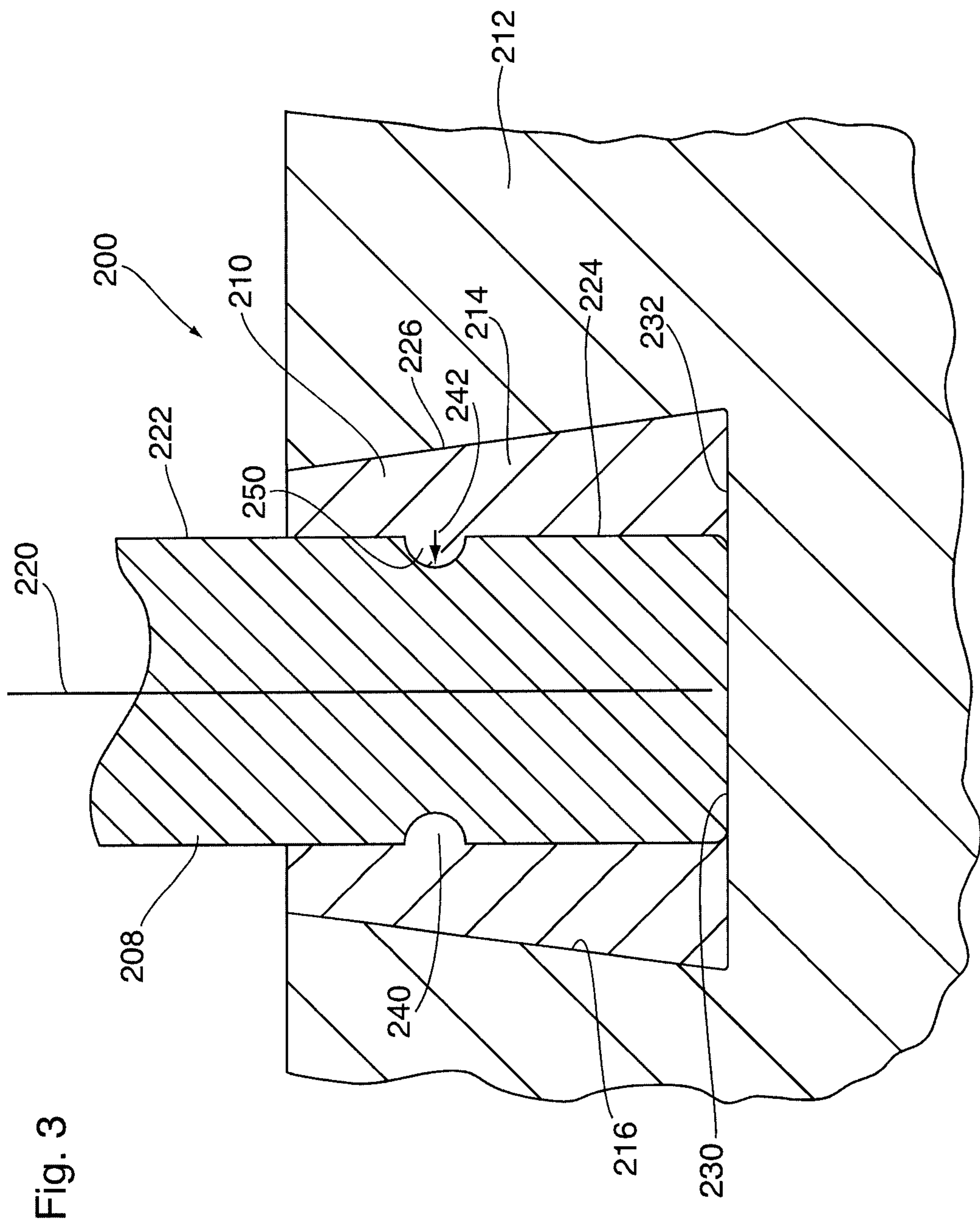
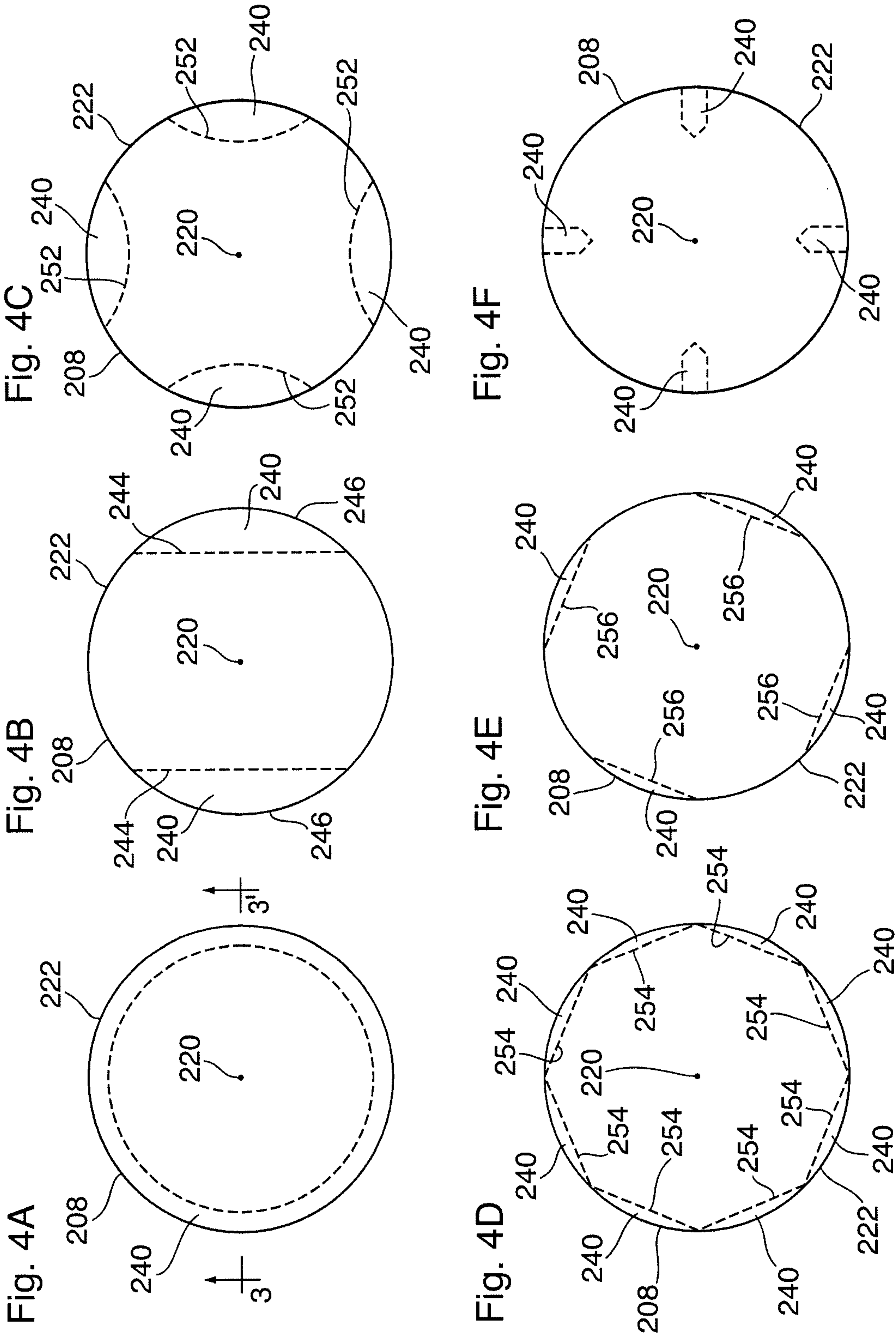
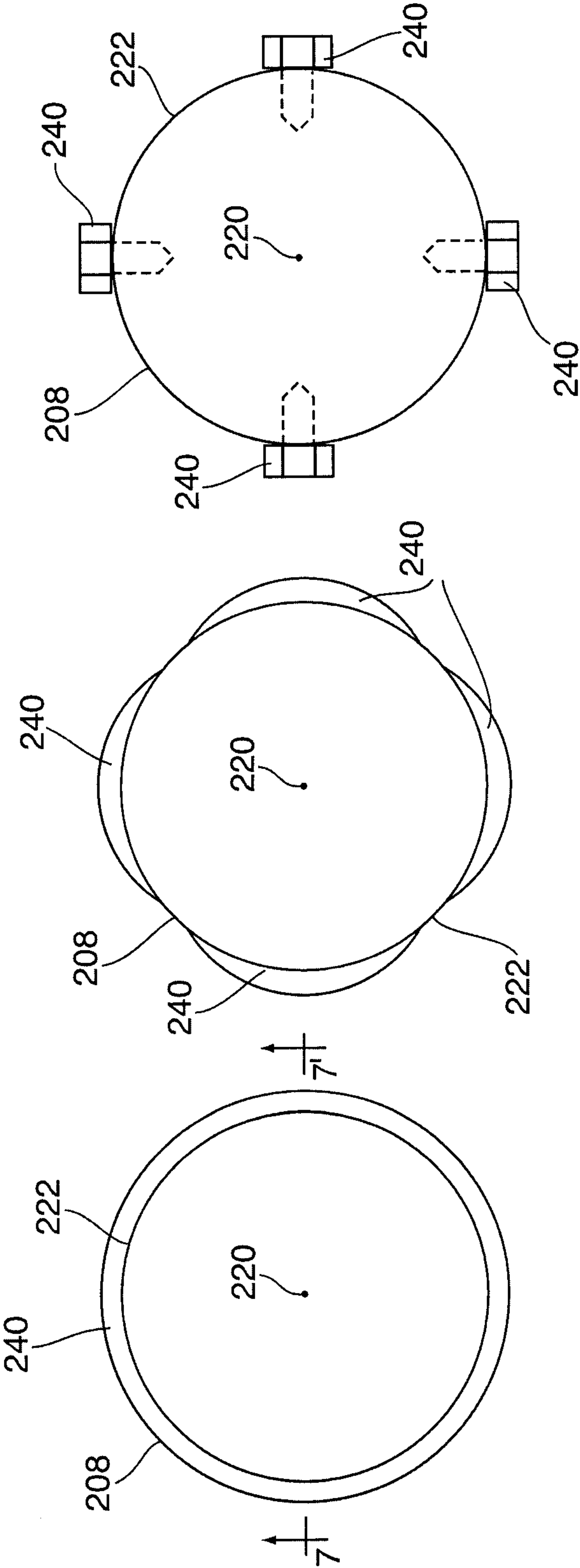


Fig. 3





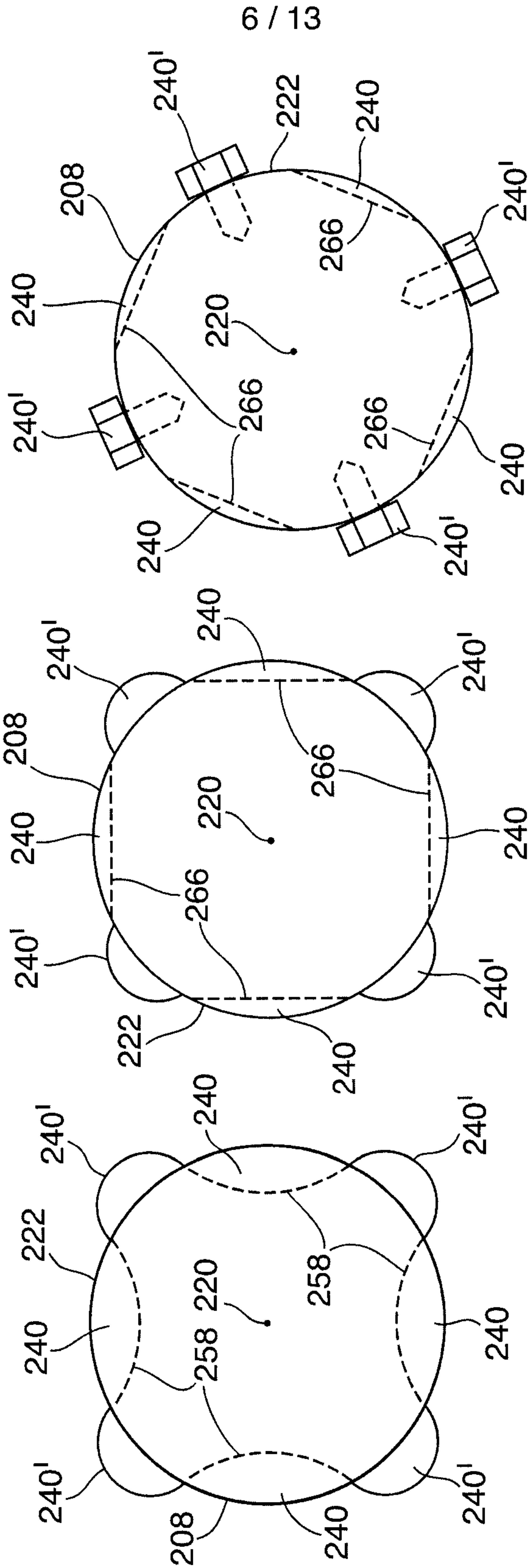


Fig. 6C

Fig. 6B

Fig. 6A

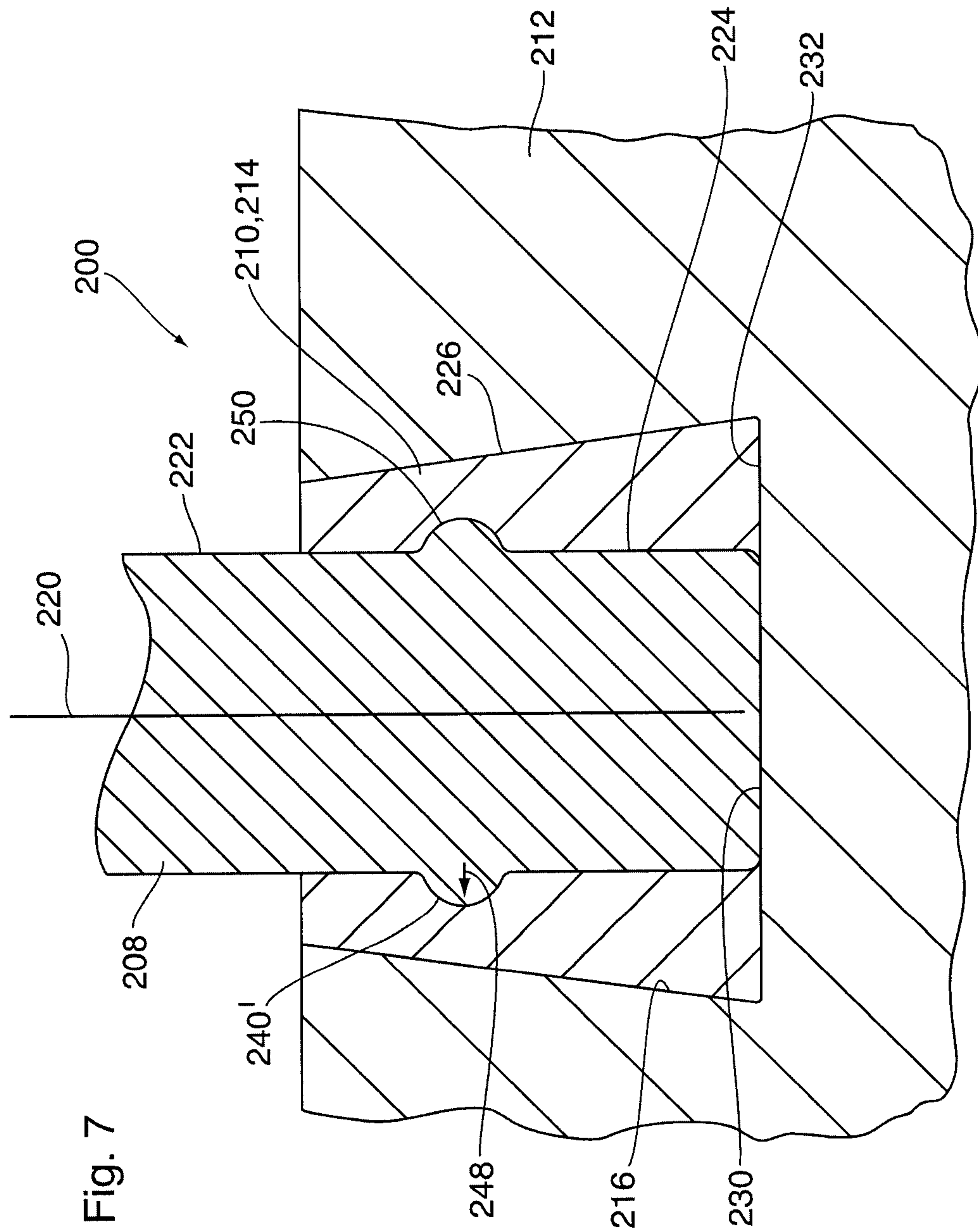


Fig. 7

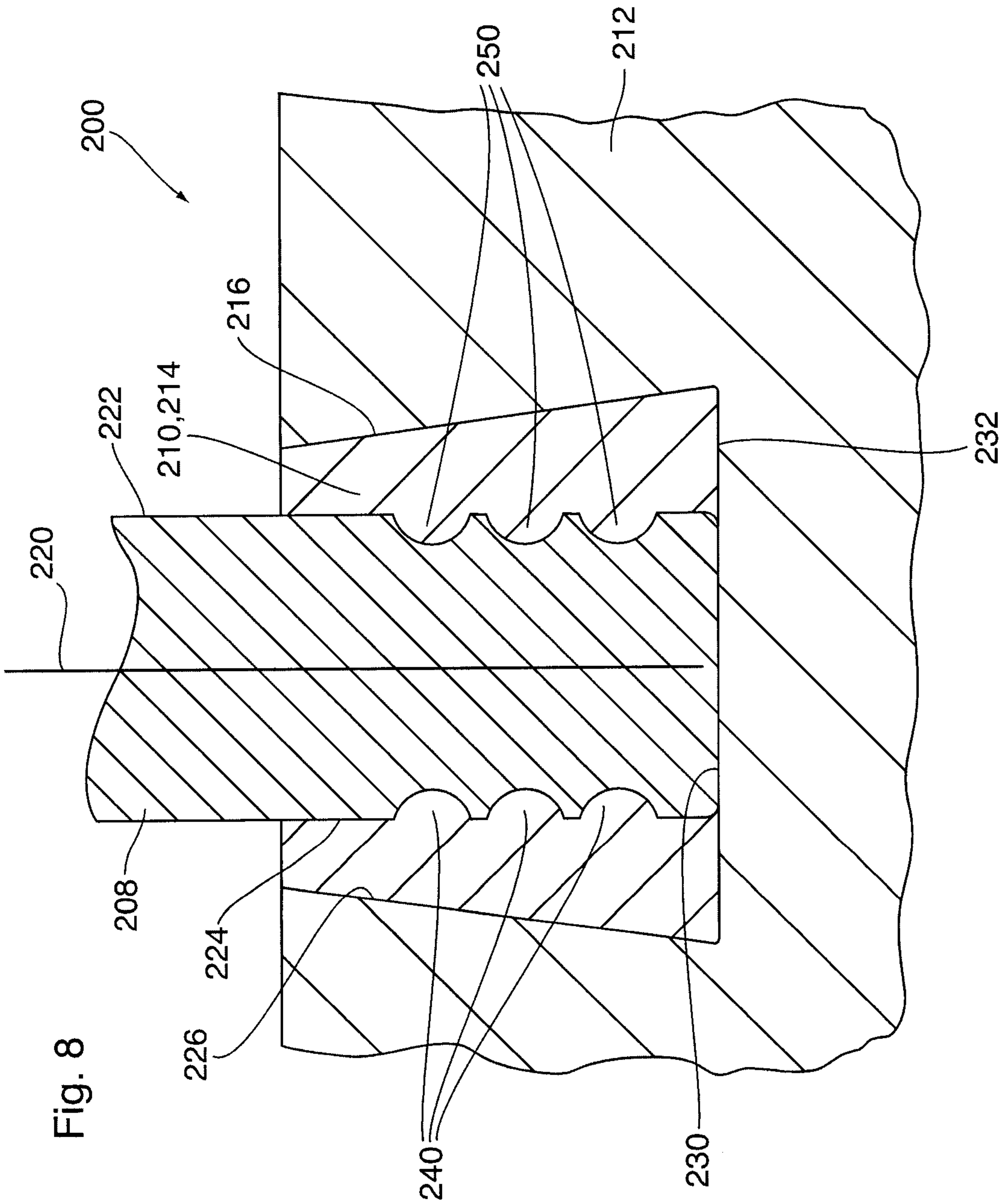
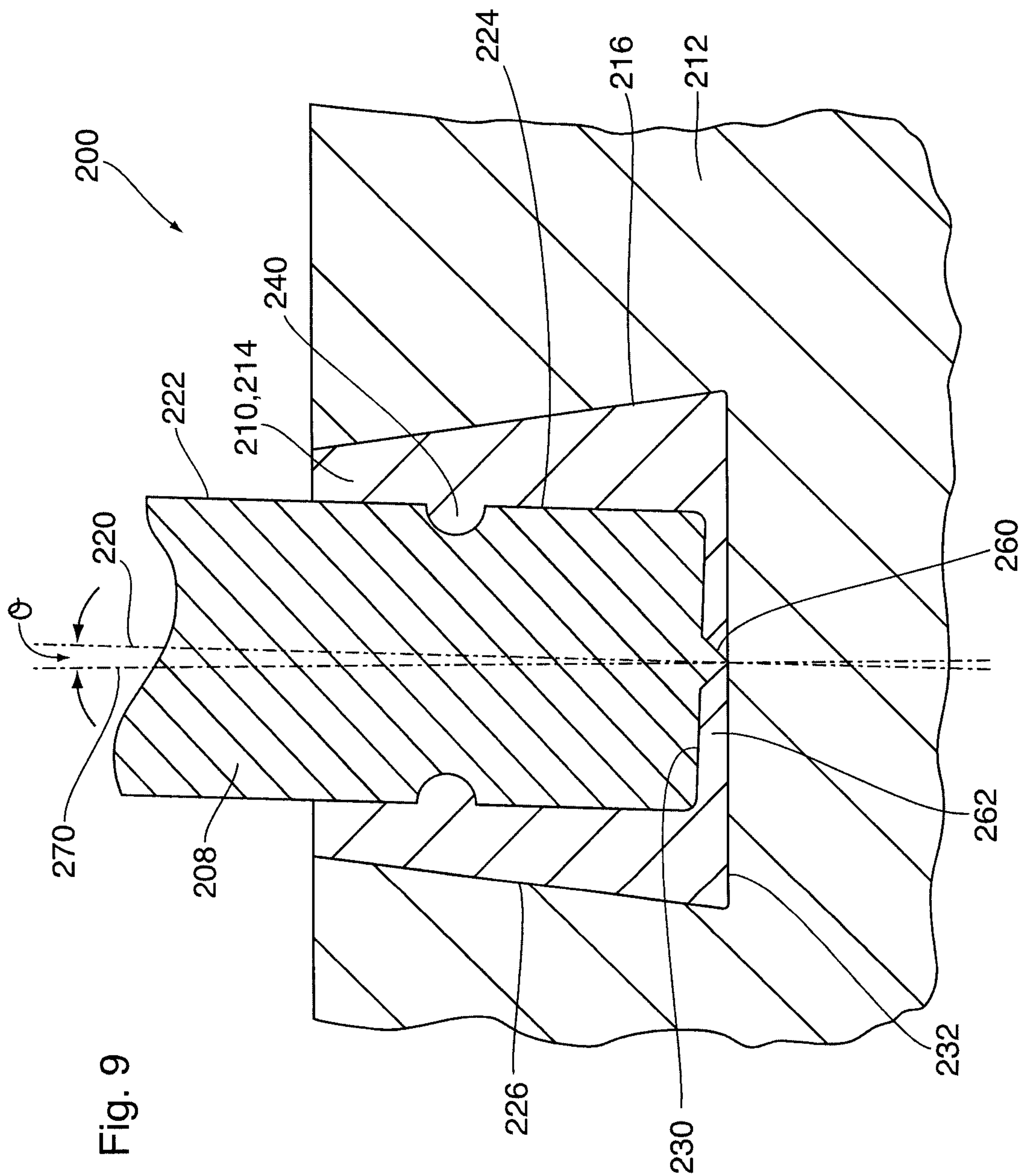
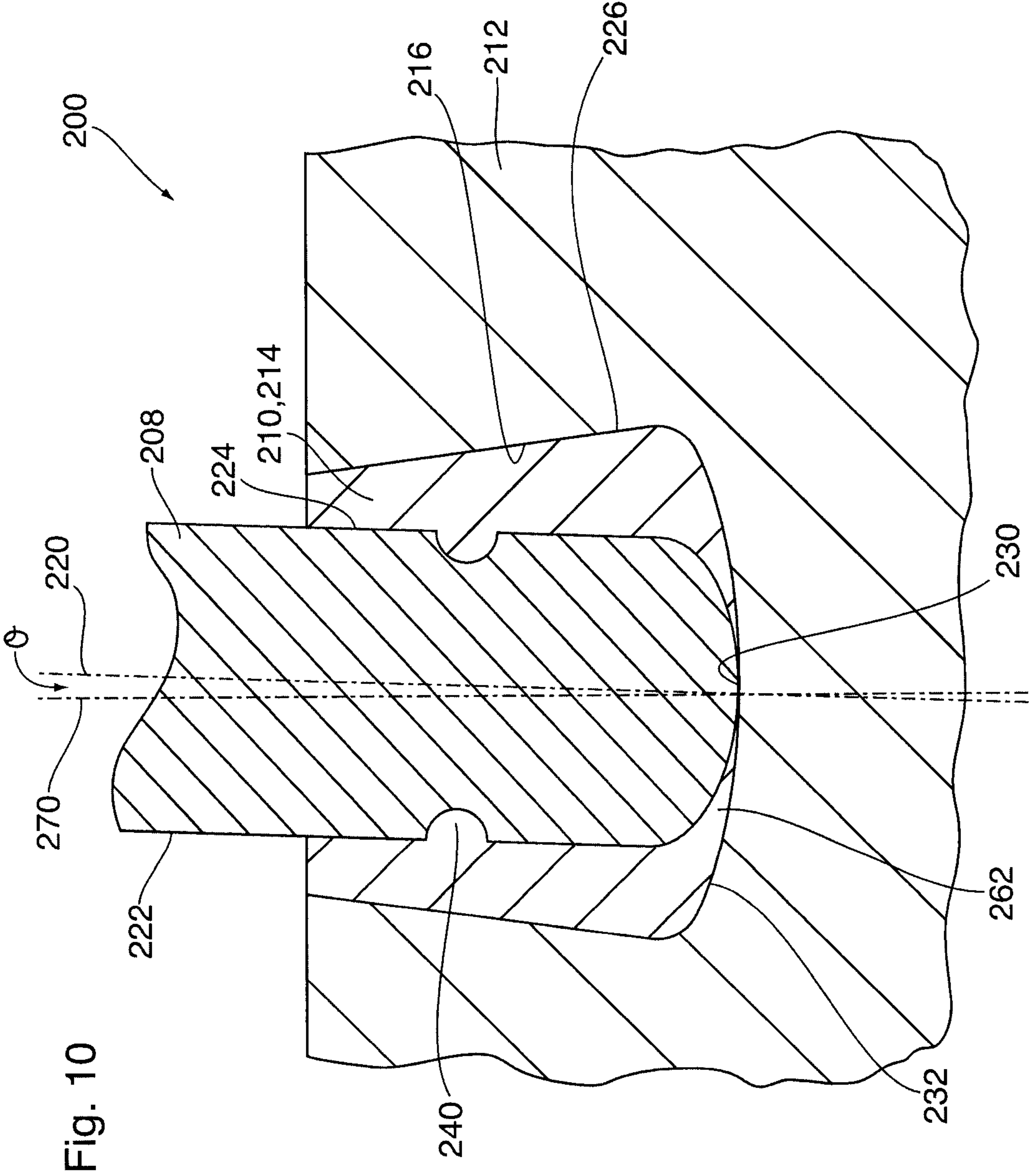


Fig. 8





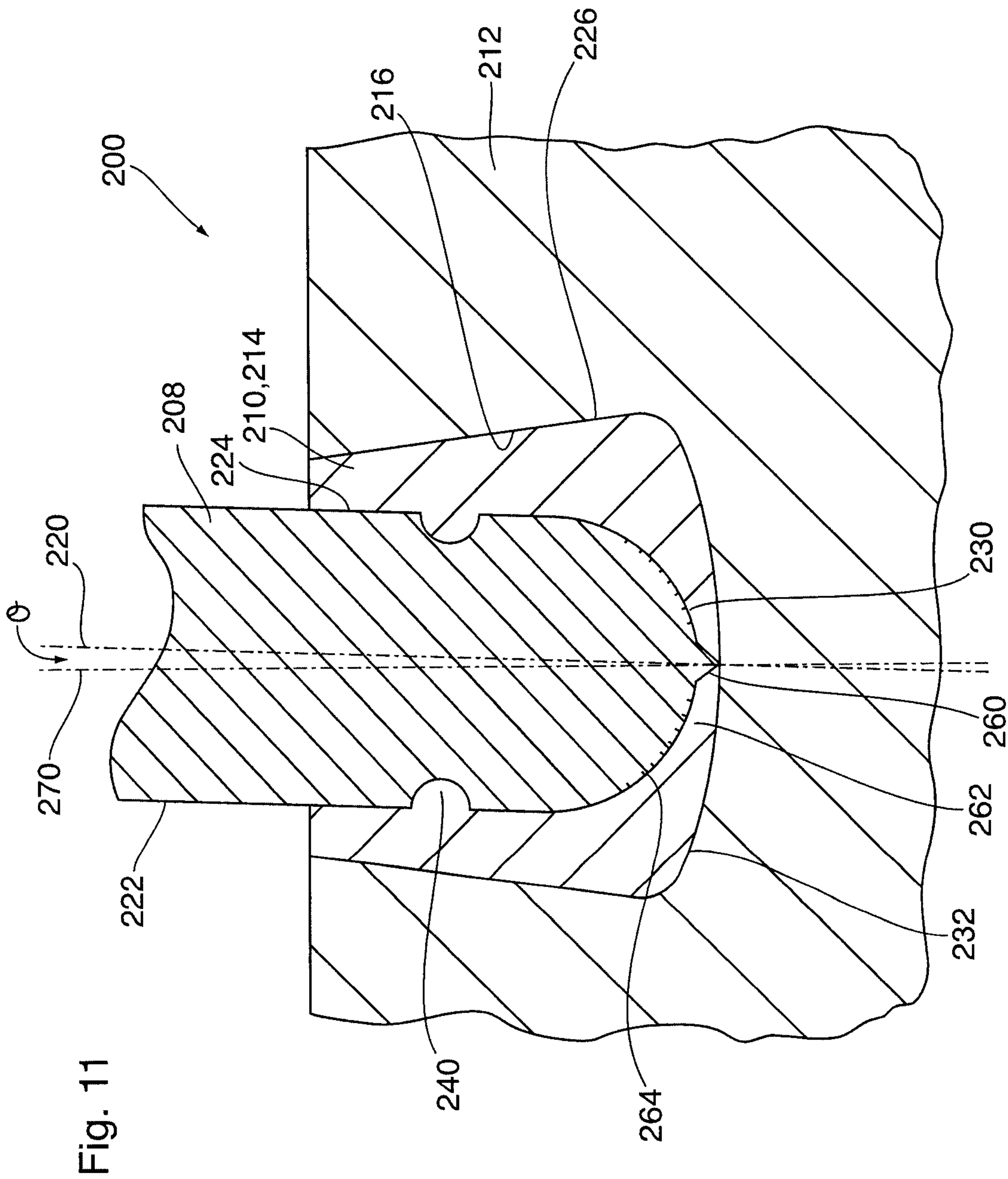


Fig. 11

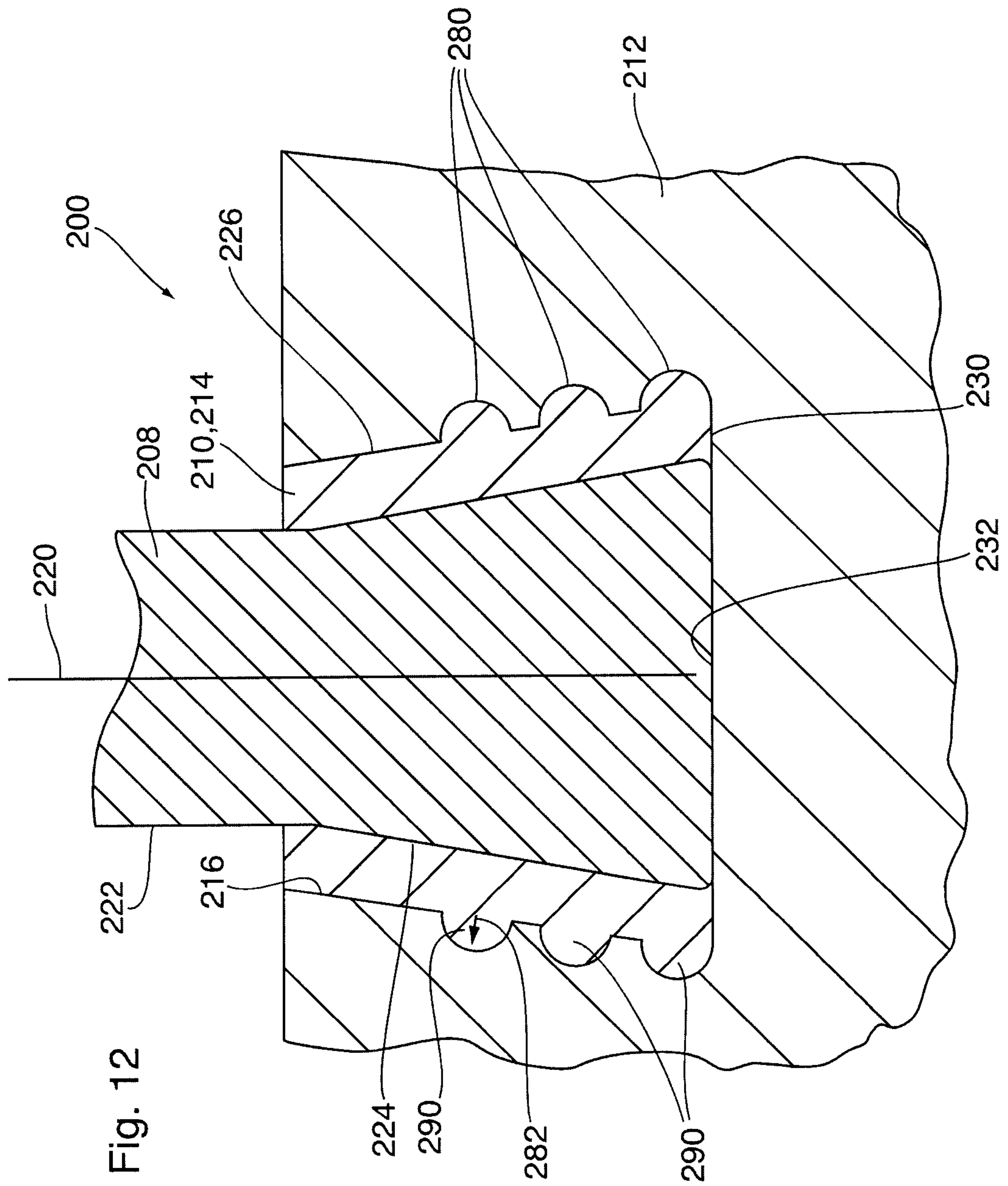


Fig. 12

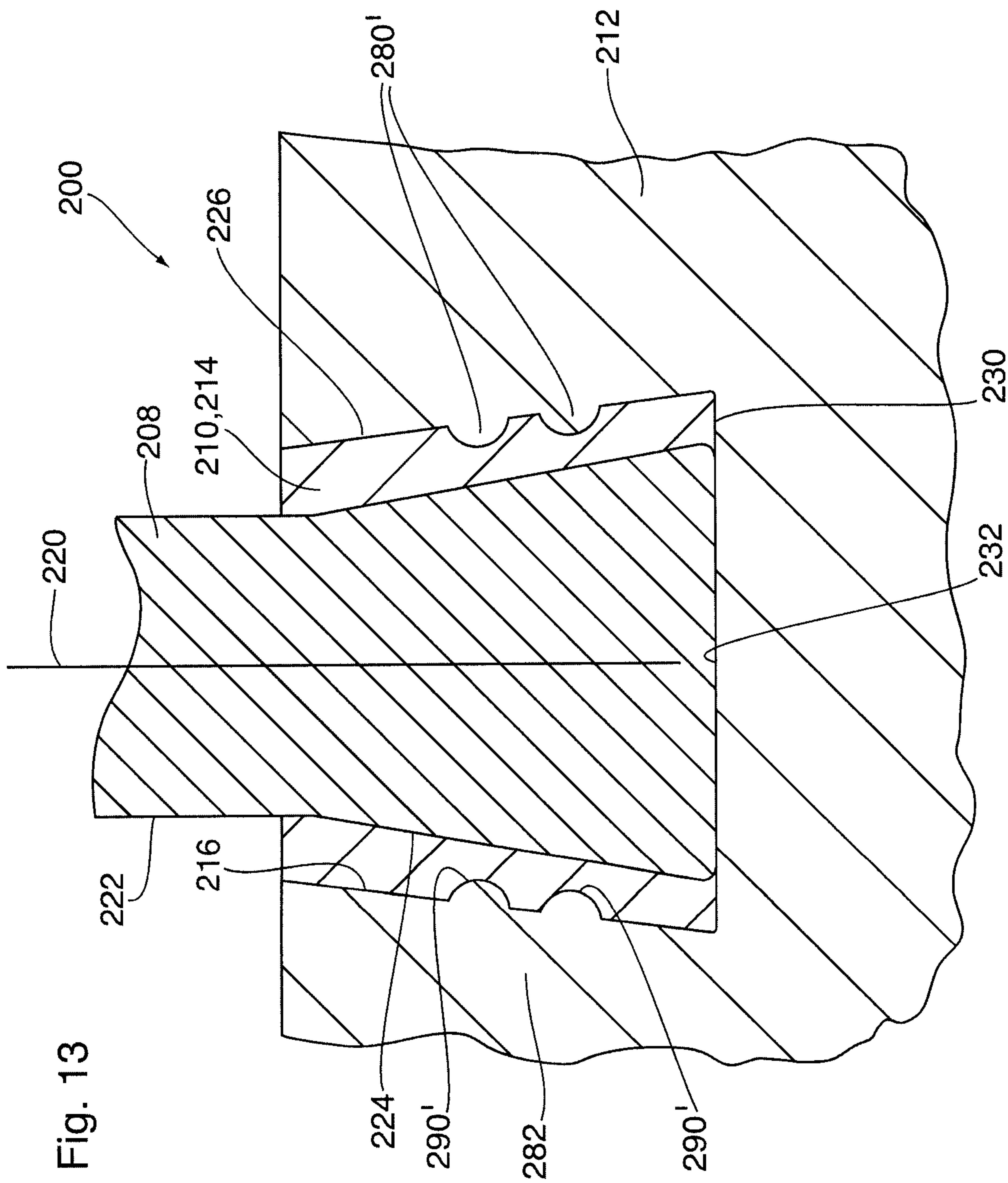


Fig. 3

