(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 779 121 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.02.2021 Bulletin 2021/07

(51) Int Cl.:
E21B 43/08 *(2006.01)*

(21) Application number: **19191660.0**

(22) Date of filing: **14.08.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **SEPARATING DEVICE AND USE OF A SEPARATING DEVICE**

(57) The present disclosure relates to a separating device for removing solid particles from fluids, and to the use of said separating device for removing solid particles from fluids.

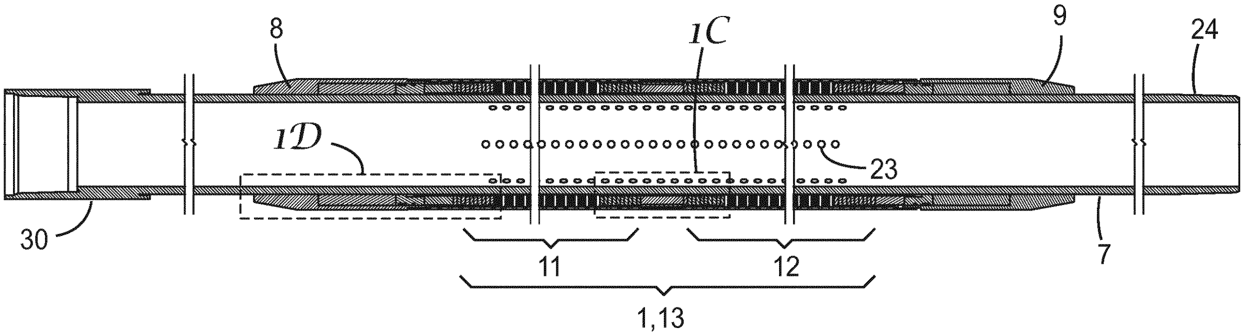

FIG. 1B

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Description

Technical Field

[0001] The present disclosure relates to a separating device for the removal of solid particles from a fluid.

Background

[0002] Such separating devices are required in many oil and gas extraction wells. Mineral oil and natural gas are stored in naturally occurring underground reservoirs, the oil or gas being distributed in more or less porous and permeable mineral layers. The aim of every oil or gas drill hole is to reach the reservoir and exploit it in such a way that, as far as possible, only saleable products such as oil and gas are extracted, while undesired by-products are minimized or even avoided completely. The undesired by-products in oil and gas extraction include solid particles such as sands and other mineral particles that are entrained from the reservoir up to the borehole by the liquid or gas flow.

[0003] Since the mineral sands are often abrasive, the influx of such solids into the production tubing and pump cause considerable undesired abrasive and erosive wear on all of the technical internals of the borehole. It is therefore endeavoured to free the production flow of undesired sands directly after it leaves the reservoir, that is to say while it is still in the borehole, by filter systems.

[0004] Problems of abrasion and erosion in the removal of solid particles from liquid and gas flows are not confined to the oil and gas industry, but may also occur in the extraction of water. Water may be extracted for the purpose of obtaining drinking water or else for the obtainment of geothermal energy. The porous, often loosely layered reservoirs of water have the tendency to introduce a considerable amount of abrasive particles into the material that is extracted. In these applications too, there is the need for abrasion- and erosion-resistant filters. Also in the extraction of ore and many other minerals, there are problems of abrasion and erosion in the removal of solid particles from liquid and gas flows.

[0005] In oil and gas extraction, the separation of undesired particles is usually achieved today by using filters that are produced by spirally winding and welding steel forming wires onto a perforated basepipe. Such filters are referred to as "wire wrap filters". Another commonly used type of construction for filters in oil and gas extraction is that of wrapping a perforated basepipe with metal screening meshes. These filters are referred to as "metal mesh screens". Both methods provide filters with effective screen apertures of 75 μm to 350 μm. Depending on the type of construction and the planned intended use of both these types of filter, the filtering elements are additionally protected from mechanical damage during transport and introduction into the borehole by an externally fitted, coarse-mesh cage. The disadvantage of these types of filter is that, under the effect of the abrasive particles flowing at high speed, metal structures are subject to rapid abrasive wear, which quickly leads to destruction of the filigree screen structures. Such high-speed abrasive flows often occur in oil and/or gas extraction wells, which leads to considerable technical and financial maintenance expenditure involved in changing the filters. There are even extraction wells which, for reasons of these flows, cannot be controlled by the conventional filtering technique, and therefore cannot be commercially exploited. Conventional metallic filters are subject to abrasive and erosive wear, since steels, even if they are hardened, are softer than the particles in the extraction wells, which sometimes contain quartz.

[0006] In order to counter the abrasive flows of sand with abrasion-resistant screen structures, US 8,893,781 B2, US 8,833,447 B2, US 8,662,167 B2 and WO 2016/018821 A1 propose filter structures in which the filter gaps, that is to say the functional openings of the filter, are created by stacking specially formed densely sintered annular discs of a brittle-hard material, preferably of a ceramic material. In this case, spacers are arranged on the upper side of annular discs, distributed over the circumference of the discs.

[0007] In the separating device of WO 2016/018821 A1, a perforated pipe is located inside the stack of annular discs, onto which pipe the brittle-hard annular discs are stacked. At the upper and lower end of the separating device, there are end caps made of steel which are firmly connected to the perforated pipe. Usually, separating devices such as disclosed in WO 2016/018821 A1 consist of an arrangement of separate modules, each module comprising a stack of brittle-hard annular discs. The modules are connected via intermediate elements made of steel. The intermediate elements are firmly connected with the perforated pipe. The intermediate elements are housing a compensator system which is usually made from steel, e.g. provided as springs, and which is required to compensate the thermal mismatch of perforated pipe and the stack of annular discs. Under operating conditions, the intermediate parts and also the compensator system are exposed to erosive and corrosive environment which is a risk for damage. The intermediate element and also the compensator system made from steel may erode and may get damaged to an extent where it loses its function, resulting in loss of sand control, and production has to be stopped.

[0008] Therefore, there is still a need to provide an improved separating device for the removal of solid particles from fluids, in particular from oil, gas and water. Particularly, there is a need to provide a separating device having an improved erosion and corrosion resistance.

[0009] As used herein, "a", "an", "the", "at least one" and "one or more" are used interchangeably. The term "comprise" shall include also the terms "consist essentially of" and "consists of".

Summary

[0010] In a first aspect, the present disclosure relates to a separating device for removing solid particles from fluids, comprising
a stack of at least three annular discs defining a central annular region along a central axis, each annular disc having an upper side and an underside, wherein the upper side of each annular disc each has two or more spacers, and wherein the spacers of the upper side of each annular disc contact the underside of the adjacent annular disc, and wherein the annular discs are stacked in such a way that a separating gap for the removal of solid particles is present in each case between adjacent annular discs, and wherein the central annular region comprises a first section and a second section,
a supporting structure for axial bracing of the central annular region, wherein the supporting structure is located inside the central annular region,
a tubular shroud for protection of the central annular region from mechanical damage, and
an intermediate element which is placed between the first section and the second section of the central annular region, wherein the intermediate element supports the shroud,
and wherein each annular disc comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ,
and wherein the intermediate element comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0011] In another aspect, the present disclosure also relates to a separating device for removing solid particles from fluids, comprising
a stack of at least three annular discs defining a central annular region along a central axis, each annular disc having an upper side and an underside, wherein the upper side and the underside of every second annular disc in the stack each has two or more spacers, and wherein the upper side and the underside of the respectively adjacent annular discs do not comprise any spacers, and wherein the spacers of the upper side of every second annular disc in the stack contact the underside of the adjacent annular disc, and wherein the spacers of the underside of every second annular disc in the stack contact the upper side of the adjacent annular disc, and wherein the annular discs are stacked in such a way that a separating gap for the removal of solid particles is present in each case between adjacent annular discs, and wherein the central annular region comprises a first section and a second section,
a supporting structure for axial bracing of the central annular region, wherein the supporting structure is located inside the central annular region,
a tubular shroud for protection of the central annular region from mechanical damage, and
an intermediate element which is placed between the first section and the second section of the central annular region, wherein the intermediate element supports the shroud,
and wherein each annular disc comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ,
and wherein the intermediate element comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0012] In yet a further aspect, the present disclosure relates to the use of a separating device as disclosed herein for removing solid particles from fluids
in a process for extracting fluids from extraction wells, or
in water or in storage installations for fluids, or
in a process for extracting ores and minerals.

[0013] The separating device as disclosed herein has an improved erosion resistance. The separating device as disclosed herein also has an improved corrosion resistance to the media to be extracted and the media used for maintenance such as acids. More specifically, the intermediate element of the separating device as disclosed herein has an improved erosion resistance and an improved corrosion resistance to the media to be extracted and the media used for maintenance such as acids.

[0014] The intermediate element of the separating device as disclosed herein is shorter than the intermediate element of the prior art. Depending on the diameter of the stack of annular discs, the length of the intermediate element is only from 25 to 50% of the length of an intermediate element of the prior art. Therefore, the filter area can be increased by adding more annular discs on the same length of a perforated pipe.

[0015] The separating device as disclosed herein can be used for harsh environments, that is for reservoirs to be exploited with streaks having high inflow and high erosional impact.

[0016] The intermediate element of the separating device as disclosed herein does not house a compensator system for compensating the thermal mismatch of perforated pipe and central annular region.

Brief description of the drawings

[0017] The present disclosure is explained in more detail on the basis of the drawings, in which

Figure 1A schematically shows the overall view of a separating device as disclosed herein;

Figure 1B shows a cross-sectional view of a separating device as disclosed herein;

Figures 1C and 1D show details of the cross-sectional view of Figure 1B;

Figures 2A - 2E show various details of the intermediate element of a separating device as disclosed herein;

Figures 3A - 3L show various details of the stack of annular discs of a separating device as disclosed herein; and

Figures 4A - 4L show various details of the stack of annular discs of a separating device as disclosed herein.

Detailed Description

[0018] Preferred embodiments and details of the separating device of the present disclosure are explained in more detail below with reference to the drawings.

[0019] Figure 1A shows the overall view of a separating device according to the present disclosure. Figure 1B shows a cross-sectional view of a separating device according to the present disclosure. The separating device according to the present disclosure comprises a stack of at least three annular discs defining a central annular region 1, 13 along a central axis. The separating device comprises a supporting structure for axial bracing of the central annular region. The supporting structure is located inside the central annular region 1, 13. The supporting structure may comprise a perforated pipe 7, on which the annular discs are stacked. The perforated pipe 7 with perforations 23 is located inside the stack 1, 13 of annular discs and is also referred to hereinafter as the base pipe. In other embodiments which are not shown in the drawings, the supporting structure of the separating device comprises one or more rods arranged within the central annular region. Usually provided at both ends of the perforated pipe 7 are threads 24, by way of which the separating device can be connected to further components, either to further separating devices or to further components of the extraction equipment. For connection to further components, a coupling 30 with inner threads on both sides may be screwed onto the thread 24.

[0020] If the supporting structure of the separating device comprises a perforated pipe, the supporting structure further comprises an end cap 8 at the upper end of the central annular region and an end cap 9 at the lower end of the central annular region 1, 13, the end caps being firmly connected to the base pipe 7.

[0021] The separating device further comprises a tubular shroud 22 (see Figure 1A) for protection of the central annular region 1, 13 from mechanical damage. The shroud 22 can be freely passed through by a flow. The shroud 22 protects the central annular region from mechanical damage during handling and fitting into the borehole.

[0022] For better understanding, and since the separating device according to the present disclosure is generally introduced into an extraction borehole in vertical alignment, the terms "upper" and "lower" are used here, but the separating device may also be positioned in horizontal orientation in the extraction borehole (in which case, upper typically would refer to the most upstream portion and lower would refer to the most downstream portion of the separating device, when in service).

[0023] The separating device according to the present disclosure comprises a stack of at least three annular discs defining a central annular region 1, 13 (see Figures 1B, 3H, 4H) along a central axis. The annular discs 2, 14, 15 (see Figures 3A - 3F and 4A - 4J) have an upper side 3, 16, 18 and an underside 4, 17, 19 (see Figures 3B, 4B, 4I - 4J).

[0024] In some embodiments, the upper side 3 of each annular disc 2 of the central annular region 1 each has two or more spacers 5 (see Figure 3A), and the underside 4 of each annular disc does not comprise any spacers (see Figure 3B). The spacers 5 of the upper side 3 of each annular disc 2 contact the underside 4 of the adjacent annular disc. The annular discs 2 are stacked in such a way that a separating gap 6 for the removal of solid particles is present in each case between adjacent annular discs (see Figures 3H - 3J).

[0025] The contact area 25 of the spacers 5 may be planar, so that the spacers 5 have a planar contact area with the adjacent annular disc (see Figures 3C and 3E). The planar contact area 25 is in contact with the adjacent underside 4 of the adjacent annular disc.

[0026] The upper side 3 of each annular disc 2 may have only two spacers 5. Typically, the upper side 3 of each annular disc 2 has three or more spacers 5 which are distributed over the circumference of the upper side 3 of the annular discs 2.

[0027] The underside 4 of each annular disc 2 may be formed at right angles to the central axis.

[0028] Each annular disc 2 comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0029] In some further embodiments, the upper side 16 and the underside 17 of every second annular disc 14 of the central annular region 13 each has two or more spacers 5 (see Figures 4A - 4F). The upper side 18 and the underside 19 of the respectively adjacent annular discs 15 do not comprise any spacers (see Figures 4H - 4J). The spacers 5 of the upper side 16 of every second annular disc 14 in the stack contact the underside 19 of the adjacent annular disc 15, and the spacers 5 of the underside 17 of every second annular disc 14 in the stack contact the upper side 18 of the adjacent annular disc 15. The annular discs are stacked in such a way that a separating gap 6 for the removal of solid particles is present in each case between adjacent annular discs (see Figures 4H - 4J).

[0030] The upper side 16 and the underside 17 of each annular disc 14 each may have only two spacers 5. Typically, the upper side 16 and the underside 17 of each annular disc 14 each has three or more spacers 5 which are distributed over the circumference of the upper side 16 and the underside 17 of the annular discs 14.

[0031] The contact area 25 of the spacers 5 may be planar, so that the spacers 5 have a planar contact area with the adjacent annular disc (see Figures 4C, 4E). The planar contact area 25 of the spacers 5 of the upper side 16 of an annular disc 14 is in contact with the underside 19 of the adjacent annular disc 15, and the planar contact area 25 of the spacers 5 of the underside 17 of an annular disc 14 is in contact with the upper side 18 of the adjacent annular disc 15.

[0032] Every upper side 18 of an annular disc 15 which does not comprise any spacers may be formed at right angles to the central axis, and every underside 19 of an annular disc 15 which does not comprise any spacers may be formed at right angles to the central axis.

[0033] Each annular disc 14, 15 comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0034] The separating device as disclosed herein may comprise a supporting structure comprising a perforated pipe 7 located in the central annular region 1, 13 (see Figures 1A - 1C) and two end caps 8, 9 (see Figures 1A and 1B) at the upper and lower ends of the central annular region 1, 13.

[0035] The perforated pipe or base pipe is co-centric with the central annular region. The base pipe is perforated, i.e. provided with holes, in the region of the central annular region; it is not perforated outside the region of the central annular region. The perforation 23 serves the purpose of directing the filtered fluid, i.e. the fluid flow freed of the solid particles, such as for example gas, oil or mixtures thereof, into the interior of the base pipe, from where it can be transported or pumped away.

[0036] Threads 24 are usually cut at both ends of the base pipe 7 and can be used for screwing the base pipes together into long strings, for example with a coupling 30.

[0037] The base pipe can consist of a metallic material, a polymer or ceramic material. The base pipe may consist of a metallic material such as steel, for example steel L80. Steel L80 refers to steel that has a yield strength of 80 000 psi (corresponding to about 550 MPa). As an alternative to steel L80, steels that are referred to in the oil and gas industry as J55, N80, C90, T95, P110 and L80Cr13 (see Drilling Data Handbook, 8th Edition, IFP Publications, Editions Technip, Paris, France) may also be used. Other steels, in particular corrosion-resistant alloy and high-alloy steels, may also be used as the material for the base pipe. For special applications in corrosive conditions, base pipes of nickel-based alloys or Duplex stainless steels may also be used. It is also possible to use aluminum materials as the material for the base pipe, in order to save weight. Furthermore, base pipes of titanium or titanium alloys may also be used.

[0038] The inside diameter of the annular discs must be greater than the outside diameter of the base pipe. This is necessary on account of the differences with regard to the thermal expansion between the metallic base pipe and the material from which the annular discs are made and also for technical reasons relating to flow. It has been found to be favorable in this respect that the inside diameter of the annular discs is at least 0.5 mm and at most 10 mm greater than the outside diameter of the base pipe. In particular embodiments, the inside diameter of the annular discs is at least 1.5 mm and at most 5 mm greater than the outside diameter of the base pipe.

[0039] The outside diameter of the base pipe is typically from 2.54 cm to 25.4 cm (1 inch to 10 inches).

[0040] The end caps are produced from metal, usually steel and typically from the same material as the base pipe. The end caps 8, 9 may be firmly connected to the base pipe 7. The end caps may be fastened to the base pipe by means of welding, clamping, riveting or screwing. During assembly, the end caps are pushed onto the base pipe after the central annular region and are subsequently fastened on the base pipe. In the embodiment of the separating device as disclosed herein that is shown in Figures 1A - 1D, the end caps are fastened by means of welding.

[0041] The central annular region 1, 13 of the separating device as disclosed herein comprises a first section 11 and a second section 12.

[0042] The separating device as disclosed herein further comprises an intermediate element 10 which is placed between the first section 11 and the second section 12 of the central annular region 1, 13. For embodiments of the separating device with the supporting structure comprising a perforated pipe, the intermediate element 10 is co-centric with the perforated pipe 7. The intermediate element 10 supports the shroud 22.

[0043] Of course, as described herein, "co-centric", "planar", "plane-parallel" and "at right angles" (and similar terms) mean substantially so, within, for instance, relevant manufacturing, assembly and/or operational tolerances.

[0044] The upper side of the intermediate element 10 in axial direction contacts the underside of the last annular disc at the lower end of the first section 11 of the central annular region 1, 13. The underside of the intermediate element 10 in axial direction contacts the upper side of the first annular disc at the upper end of the second section 12 of the central annular region 1, 13.

[0045] The intermediate element 10 comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ. In some embodiments, the intermediate element 10 is made from a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0046] These materials are erosion resistant to abrasive fluid flows and also corrosion resistant to the media to be extracted and the media used for maintenance such as acids.

[0047] The outer diameter of the intermediate element 10 is larger than the outer diameter of the central annular region 1, 13. The outer diameter of the intermediate element 10 is larger than the outer diameter of the first section 11 and of the second section 12 of the central annular region 1, 13. The intermediate element 10 being supported by the shroud 22 and having an outer diameter being larger than the outer diameter of the central annular region ensures that there is a distance between the shroud 22 and the central annular region 1, 13 during deployment of the separating device, and also in case of bending if the separating device needs to be introduced in curved boreholes.

[0048] In some embodiments of the separating device as disclosed herein, the intermediate element 10 comprises an intermediate core element 26 and a protective bush 20 which is co-centric with the intermediate core element 26.

[0049] The intermediate core element 26 comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ. In some embodiments, the intermediate core element 26 is made from a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0050] The protective bush 20 protects the intermediate core element 26 from mechanical damage. Mechanical damage of the intermediate element may occur during installation of the separating device in the borehole.

[0051] The protective bush 20 may comprise a metallic material or a polymeric material. The protective bush 20 may be made from a metallic material or from a polymeric material. The metallic material of the protective bush may be steel. The polymeric material of the protective bush may be, for example, polytetrafluoroethylene (PTFE) or a polyaramide such as poly(p-phenylene terephthalamide) (PPTA; trade names: Kevlar, Twaron).

[0052] The protective bush 20 is located outside of the intermediate core element 26 (see Figures 1C, 2E, 2F).

[0053] If the protective bush 20 is eroded by the abrasive fluid flows under operating conditions of the separating device, the intermediate core element 26 of the intermediate element 10 ensures that the intermediate element 10 remains erosion and corrosion resistant during the whole service life of the separating device.

[0054] In some embodiments of the separating device as disclosed herein, the protective bush 20 is firmly connected to the intermediate core element 26. For example, if the protective bush is made from a metallic material, the protective bush 20 may be shrunk onto the intermediate core element 26. In some other embodiments, the protective bush 20 may also be only pushed on the intermediate core element 26 and may be not firmly connected to the intermediate core element 26.

[0055] The outer diameter of the protective bush 20 is larger than the outer diameter of the central annular region 1, 13. The outer diameter of the protective bush 20 is smaller than the inner diameter of the shroud 22 at the position of the intermediate element 10. The inner diameter of the protective bush 20 may be larger or smaller than or equal to the outer diameter of the first and second section 11, 12 of the central annular region 1, 13. Preferably, the inner diameter of the protective bush 20 is equal to or larger than the diameter of the circle circumscribed around the planar contact areas 25 of the spacers 5 of the annular discs 2, 14, so that the complete planar contact areas 25 of the spacers 5 have planar contact with the intermediate core element 26. The inner diameter of the protective bush 20 may also be smaller, in this case an annular disc having a rectangular cross-sectional area and no spacers is placed next to the upper and lower end of the intermediate element 10. The area of the upper side and underside of this annular disc having a rectangular cross-sectional area and no spacers may be at least as large as the sum of the planar contact areas 25 of all spacers 5 of the adjacent annular disc 2, 14.

[0056] The outer lateral surface of the protective bush 20 may be cylindrical. It is also possible that the cross-sectional area of the protective bush in axial direction is T-shaped and the outer lateral surface of the protective bush 20 has a recess at the upper axial end and a recess at the lower axial end of the protective bush. These recesses accommodate the shroud 22 for the first and second section 11, 12 of the central annular region 1, 13. In this case, the outer diameter of the protective bush is the largest outer diameter of the protective bush at the central position.

[0057] Figure 1C shows a detail of Figure 1B at the position of the intermediate element 10. The intermediate element 10 is placed between the first section 11 and the second section 12 of the central annular region 1, 13. The intermediate element 10 is co-centric with the perforated pipe 7. The outer diameter of the intermediate element 10 is larger than the outer diameter of the central annular region 1, 13. The outer diameter of the intermediate element 10 is larger than the outer diameter of the first section 11 and of the second section 12 of the central annular region 1, 13. The intermediate element 10 may comprise an intermediate core element 26 and a protective bush 20. The protective bush 20 is co-centric with the intermediate core element 26. The protective bush 20 is located outside of the intermediate core element 26. The protective bush 20 protects the intermediate core element 26 from mechanical damage. The intermediate core element 26 is made from a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed insitu. The protective bush may be made from steel. The protective bush may also be made from other metallic materials or from a polymeric material. The protective bush 20 may be shrunk onto the intermediate core element 26. The outer diameter of the protective bush 20 is larger than the outer diameter of the central annular region 1, 13. The outer diameter of the protective bush 20 is larger than the outer diameter of the first section 11 and of the second section 12 of the central annular region 1, 13. The outer diameter of the protective bush 20 is smaller than the inner diameter of the shroud 22 at the position of the intermediate element 10. The inner diameter of the protective bush 20 may be smaller than the outer diameter of the first and second section 11, 12 of the central annular region 1, 13. The inner diameter of the protective bush 20 may be equal to the diameter of the circle circumscribed around the planar contact areas 25 of the spacers 5 of the annular discs 2, 14. The intermediate element 10 supports the shroud 22.

[0058] Figure 1D shows a detail of Figure 1B at the position of the end cap 8 at the upper end of the separating device. At the upper end of the central annular region 1, 13 and of the first section 11 of the central annular region 1,13, an end element 32 may be provided which forms the end-side, lateral termination of the central annular region. The end element 32 is an annular element which is co-centric with the perforated pipe 7. The end element 32 may be produced from the same material as the annular discs 2, 14, 15. Alternatively, however, corrosion-resistant steels and polymers, such as for example fluoroelastomers or polyether ether ketone (PEEK), may also be used. At the upper end of the central annular region 1, 13 and of the first section 11 of the central annular region 1, 13, a sealing bush 33 may be provided. The sealing bush has the task of preventing the ingress of fluids that are under pressure, into structural cavities, such as for example bevels and gaps, between the end cap and the base pipe. Otherwise, the fluid under pressure could exert a strong axial force on the central annular region over the hydraulically effective annular surface of the uppermost annular disc, which would lead to rupturing of the annular discs. An O-ring 34 is incorporated in the sealing bush 33 on its outer circumferential surface. An O-ring may likewise be incorporated on the inner circumferential surface of the sealing bush. The sealing bush with the O-ring seals has the effect of preventing that fluids under pressure can get into regions of the separating device that have nothing to do with the filtering function. A wear and corrosion resistant material, for example a metallic or ceramic material or else a hard material, is used as the material for the sealing bush. Steel may be used as material for the sealing bush.

[0059] The region of the lower end of the separating device is usually symmetrical to the region of the upper end of the separating device. At the lower end of the separating device, also an end element 32 and a sealing bush 33 may be provided.

[0060] In Figures 1B, 1C and 1D, only a few annular discs of the central annular region 1, 13 are shown for ease of drawing. In reality, of course, the stack of annular discs of the first section 11 of the central annular region 1, 13 is extending from the upper end of the separating device, i.e. from the end element 32 at the upper end of the separating device, to the intermediate element 10, and the stack of annular discs of the second section 12 of the central annular region 1, 13 is extending from the intermediate element 10 to the lower end of the separating device, i.e. to the end element 32 at the lower end of the separating device.

[0061] The separating device as disclosed herein may further comprise one or more bands 29 which are provided on the lateral surface of the perforated pipe 7 and which are inside the central annular region 1, 13 and inside the intermediate element 10 (see Figures 2E, 2F). The annular discs are placed around the one or more bands, whereby the annular discs are centered by the one or more bands on the perforated pipe. Also the intermediate element 10 is placed around the one or more bands 29 and is centered by the one or more bands. The one or more bands are also referred to as centering bands.

[0062] The one or more bands or centering bands 29 may be provided axially parallelly on the lateral surface of the perforated pipe. The centering bands may also be provided helically in axial direction on the lateral surface of the perforated pipe. The centering bands may be provided uniformly spaced apart or with different distances from one another.

[0063] The length of the centering bands 29 corresponds at least to the length of the annular stack, which ensures that all of the annular discs of the annular stack including the first and last annular disc are centered.

[0064] The centering bands 29 may have elastic properties in a direction perpendicular to the central axis of the central annular region. Due to the elastic properties, the centering bands are elastically deformable in radial direction. In some embodiments, the centering bands may have a hollow compressible structure. In some embodiments, the centering bands may have a fibrous compressible structure. In some embodiments, the centering bands may have a compact compressible structure. In some embodiments, the centering bands may have a compressible profiled structure.

[0065] The centering bands 29 may have a planar configuration. The centering bands may also have a profiled configuration in axial direction of the bands.

[0066] If the centering bands 29 have a profiled configuration, the profiled configuration may be a curvature having an outwardly curved side. The outwardly curved side of the curvature may be oriented towards the perforated pipe, i.e. inwards, or towards the central annular region, i.e. outwards. Preferably, the outwardly curved side of the curvature is oriented towards the central annular region, i.e. outwards.

[0067] The material of the centering bands should preferably be chosen such that it does not corrode under operating conditions and it must be oil- water- and temperature-resistant. Metal or plastic is suitable as the material for the centering bands, preferably metal alloys on the basis of iron, nickel and cobalt, more preferably steel, more preferably spring strip steel. For example, spring strip steel with the material number 1.4310, of a spring-hard configuration, may be used as the material for the centering bands. The width of the centering bands may be for example 2 to 30 mm and the thickness may be for example 0.1 to 0.5 mm.

[0068] If steel is used as the material for the centering bands, it must be ensured when selecting the material that undesired electrochemical reactions do not occur on contact with other metallic structural elements of the separating device.

[0069] In some embodiments, the centering bands are fixed on the outer surface of the perforated pipe. The centering bands may be fixed onto the outer surface of the perforated pipe by welding, brazing or gluing.

[0070] In some embodiments, the centering bands are not permanently fixed on the outer surface of the perforated pipe.

[0071] The thickness and width of the centering bands should be chosen such that the annular discs can be axially displaced on the base pipe with a "sliding fit". This means that, in the vertical position, the annular discs are not axially displaced under their own weight. This is generally the case if the force for displacing the annular discs on the base pipe in the horizontal direction, that is to say without the influence of gravitational force, lies between 0.1 N and 10 N, preferably between 0.5 N and 5 N.

[0072] Preferably, the intermediate element 10 is movable in axial direction. Also the annular discs of the central annular region are movable in axial direction. The intermediate element needs to be freely movable in axial direction and may not be firmly connected to the perforated pipe or the supporting structure. The free movability of the intermediate element and the central annular region is required for compensating the differences in thermal expansion of the central annular region and the intermediate element on the one hand and of the perforated pipe or the supporting structure on the other hand. The intermediate element 10 is able to absorb mechanical shock loads in axial direction due to its free movability in axial direction. If more than one intermediate element is present in the separating device, the intermediate elements need to be movable in axial direction.

[0073] The intermediate element 10 may further comprise an annular element 27 which is co-centric with the intermediate core element 26 and which is located inside the intermediate core element 26. The annular element 27 protects the intermediate core element 26 from mechanical damage by radial load.

[0074] The annular element 27 may be firmly connected to the intermediate core element 26. The outer diameter of the annular element 27 corresponds to the inner diameter of the intermediate core element 26. For embodiments of the separating device disclosed herein having a perforated pipe, between the annular element 27 and the base pipe 7 there is a gap which is large enough to ensure the free movability of the annular element 27, and therefore the free movability of the intermediate element 10, in axial direction.

[0075] The annular element 27 may be provided with one or more recesses 28 in axial direction distributed along the circumference of the annular element 27. The recesses 28 are on the inner circumference of the annular element 27. The number of recesses 28 may correspond to or may be larger than the number of bands 29 which are provided on the lateral surface of the perforated pipe 7, and each of the bands 29 is placed in one of the recesses 28 of the annular element 27. The annular element 27 may also be provided with no recesses and around the bands 29.

[0076] The radial thickness of the annular element 27 at the position of the recesses 28 is smaller than the radial thickness of the annular element 27 outside of the recesses 28.

[0077] For annular elements 27 with no recesses on the inner circumference, the inner diameter of the annular element 27 for embodiments with bands 29 corresponds to the diameter of the circumscribed circle around the bands 29. For annular elements 27 with recesses 28, the inner diameter of the annular element 27 for embodiments with bands 29 corresponds to the diameter of the circumscribed circle around the bands 29, at the positions of the recesses 28.

[0078] The recesses 28 may be provided axially parallelly to the central axis of the separating device, or may be provided axially not parallelly to the central axis of the separating device. The recesses may extend from the lower end of the annular element the upper end of the annular element. The annular element 27 may also have openings 31. The openings 31 do not extend from the lower to the upper end of the annular element. The openings are cut through the complete radial thickness of the annular element (see Fig. 2D). The openings do not have a specific form, they may be quadratic, rectangular, circular or have any other form. Preferably, the openings are in the region of the recesses 28.

[0079] The recesses 28 which are provided in axial direction distributed along the circumference of the annular element 27 may be formed in such a way that their depth corresponds to the radial thickness of the annular element 27, thereby dividing the annular element 27 in different segments. The number of segments may correspond to the number of recesses 28. It is also possible that one or more of the recesses 28 of the annular element 27 have a depth corresponding to the radial thickness of the annular element 27 and dividing the annular element in one or more segments, and one or more further recesses 28 have a depth which is smaller than the radial thickness of the annular element 27. For example, an annular element having one recess with a depth corresponding to the radial thickness of the annular element and further recesses with a depth which is smaller than the radial thickness of the annular element, may be easily pushed around the base pipe during assembly of the separating device.

[0080] In some embodiments of the separating device disclosed herein, the supporting structure for axial bracing of the central annular region 1, 13 comprises a perforated pipe 7 which is co-centric with and located inside the central annular region 1, and an end cap 8 at the upper end and an end cap 9 at the lower end of the central annular region 1, the end cap 8, 9 being co-centric with the perforated pipe 7 and being firmly connected to the perforated pipe 7. The intermediate element 10 is co-centric with the perforated pipe 7. The separating device further comprises one or more bands which are provided on the lateral surface of the perforated pipe 7 and which are inside the central annular region 1, 13 and inside the intermediate element 10, the annular discs being centered by the one or more bands 29 on the perforated pipe 7. The intermediate element 10 may further comprise an annular element 27 which is co-centric with the intermediate core element 26 and which is located inside the intermediate core element 26 and between the intermediate core element 26 and the perforated pipe 7. The annular element 27 may be provided with one or more recesses 28 in axial direction distributed along the circumference of the annular element 27. The number of recesses 28 is equal to or larger than the number of bands 29 which are provided on the lateral surface of the perforated pipe 7, and each of the bands 29 is placed in one of the recesses 28 of the annular element 27.

[0081] The material from which the annular element 27 is made should be resistant to compression and suitable for load transfer from the intermediate core element 26 to the perforated pipe 7 or to the supporting structure. The material from which the annular element 27 is made should further have a good chemical resistance to the treatment fluids usually used for flushing out the separating device and stimulating the borehole, such as acids, for example HCl or bases, for example NaOH. Furthermore, the material of the annular element 27 should be temperature-resistant in the temperature range of the application.

[0082] The annular element 27 may comprise a polymer, preferably polytetrafluoroethylene (PTFE). In some embodiments, the annular element 27 consists of a polymer, preferably polytetrafluoroethylene (PTFE). PTFE is highly resistant to compression, has an excellent chemical resistance and good temperature-resistance, and can easily be machined.

[0083] The annular element 27 protects the intermediate core element 26 from mechanical damage by radial loads. Radial loads may arise from side impact, or from bending which occurs when the separating device is introduced in curved boreholes. The annular element 27 improves the resistance of the intermediate part against radial loads. The run-in-hole procedure requires robustness of the separating device against radial loads. Radial loads are mainly introduced through the shroud 22 which is supported by the intermediate element 10 or the protective bush 20, respectively. The annular element 27 impedes that radial loads cause a radial movement of the intermediate element 10 or the intermediate core element 26, respectively, which would press the intermediate core element 26 against the base pipe and could mechanically damage the intermediate core element 26. The annular element 27 avoids that point loads can develop on surface or edges of the intermediate core element 26 during impact.

[0084] Another advantageous property of the annular element 27 is related to the elastic centering bands 29 provided on the lateral surface of the perforated pipe 7 which are bearing the intermediate element 10. The elastic centering bands allow radial movement of the intermediate element 10 under radial load. Under radial load, large radial movement of the intermediate element which would consume the clearance of the shroud protecting the central annular region, i.e. the clearance between shroud and central annular region, can be largely prevented by the annular element 27.

[0085] Furthermore, by the recesses 28 of the annular element 27 it is assured that the centering bands 29 cannot move in tangential direction on the lateral surface of the base pipe. If the centering bands would move in tangential direction, they could lose their centering function which could in turn adversely affect the proper filtering function of the separating device.

[0086] The outer diameter of the annular element 27 may correspond to the inner diameter of the intermediate core element 26.

[0087] Advantageously, the inner diameter of the annular element 27 may be adjusted as close as possible to the outer diameter of the perforated pipe 7. With adjusting the inner diameter to that of the perforated pipe, radial load can be directly transferred to the perforated pipe without considerable movement. The recesses avoid deformation of the centering bands. The radial movement can be kept at a minimum with accurate machining. The minimum is mainly defined by manufacturing tolerances required for assembly and easy axial movement on the perforated pipe. The anti-adhesive properties of PTFE are particularly advantageous and enable to move the intermediate part lined with the annular element with low frictional forces on the perforated pipe in axial direction during assembly and also in operation for purposes of thermal compensation.

[0088] PTFE is a material with large thermal expansion coefficient. During thermal cycling such as under operation of the separating device, the annular element tends to expand. The recesses and openings provided in the annular element enable relaxation of thermal stresses and therefore can reduce the risk of rupture of the intermediate core element.

[0089] Figure 2A shows a cross-sectional view in radial direction of an annular element 27. Figure 2B shows a 3D view of the annular element of Figure 2A. The annular element 27 has three recesses 28 which are provided in axial direction distributed along the circumference of the annular element 27. The recesses 28 are provided axially parallelly to the central axis of the separating device. The recesses are formed in such a way that their depth corresponds to the radial thickness of the annular element 27, thereby dividing the annular element 27 in three different segments. The number of segments corresponds to the number of recesses 28.

[0090] Figure 2C shows a cross-sectional view in radial direction of a further annular element 27. Figure 2D shows a 3D view of the annular element of Figure 2C. The annular element 27 has three recesses 28 which are provided in axial direction distributed along the inner circumference of the annular element 27. The recesses are provided axially parallelly to the central axis of the separating device. The radial thickness of the annular element 27 at the position of the recesses 28 is smaller than the radial thickness of the annular element 27 at the positions outside of the recesses. The annular element 27 at the position of the recesses 28 should be thick enough to ensure the mechanical stability of the annular element as one part. The annular element 27 further may have openings 31. In the example of Figure 2D, two openings 31 with rectangular shape are provided in each of the three recesses 28.

[0091] Figure 2E shows a detail of a cross-sectional view in axial direction of a separating device as disclosed herein. The detail of Figure 2E is at the position of the intermediate element 10 of the separating device.

[0092] Figure 2F shows the cross-sectional view in radial direction of the separating device of Figure 2E. The cross-sectional view of Figure 2F is at the position of the intermediate element 10 of the separating device.

[0093] The intermediate element 10 comprises an intermediate core element 26, a protective bush 20 and an annular element 27. The intermediate core element 26 is produced from a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0094] The intermediate element 10 is placed between the first section 11 and the second section 12 of the central annular region 1, 13. The intermediate element 10 is co-centric with the perforated pipe 7. The outer diameter of the intermediate element 10, i.e. the outer diameter of the protective bush 20, is larger than the outer diameter of the central annular region 1, 13. The protective bush 20 is co-centric with the intermediate core element 26. The protective bush is located outside of the intermediate core element 26. The protective bush 20 protects the intermediate core element 26 from mechanical damage. The protective bush 20 may be made from steel and may be shrunk onto the intermediate core element 26.

[0095] The separating device with the details of Figures 2E and 2F further comprises three bands 29 provided on the lateral surface of the perforated pipe and which are inside the central annular region 1, 13 and inside the intermediate element 10. The three bands 29 may be made from spring strip steel and are elastically deformable in radial direction. The three bands have a profiled configuration with a curvatures having an outwardly curved side oriented towards the central annular region 1, 13 and the intermediate element 10, i.e. outwards.

[0096] The annular element 27 is co-centric with the intermediate core element 26 and is located inside the intermediate core element 26. The annular element 27 protects the intermediate core element 26 from mechanical damage by radial load. The annular element 27 has three recesses 28 in axial direction distributed along the circumference of the annular element 27. The radial thickness of the annular element 27 at the position of the recesses is smaller than the radial thickness of the annular element 27 at the position outside of the recesses. Each of the three bands 29 is placed in one of the recesses 28. The annular element 27 may be made from polytetrafluoroethylene (PTFE). The outer diameter of the annular element 27 corresponds to the inner diameter of the intermediate core element 26. The inner diameter of the annular element 27 corresponds as close as possible to the outer diameter of the perforated pipe 7, while the intermediate element 10 with the annular element 27 inside is movable in axial direction. Under radial load, large radial movement of the intermediate element 10 which would consume the clearance of the shroud 22 protecting the central annular region, i.e. the clearance between shroud and central annular region, can be largely prevented by the annular element 27.

[0097] The annular element 27 shown in Figures 2E and 2F corresponds to the annular element of Figures 2C and 2D. The cross-sectional view in axial direction of Figure 2E is at the sectional line designated by "2E" in Figure 2F. The cross-sectional view of the intermediate element 10 at the upper part of Figure 2E is at a position outside of the recesses 28 of the annular element 27, and the cross-sectional view of the intermediate element 10 at the lower part of Figure 2E is at a position of one of the three recesses 28 of the annular element 27. The radial thickness of the annular element 27 at the position of one of the three recesses 28 as shown in the lower part of Figure 2E is smaller than the radial thickness of the annular element 27 at the position outside of the recesses 28 as shown in the upper part of Figure 2E. In the lower part of Figure 2E, also the openings 31 are shown.

[0098] The intermediate element 10 and the protective bush 20, respectively, support the shroud 22. The inner diameter of the shroud 22 at the position of the intermediate element 10 is larger than the outer diameter of the central annular region 1, 13.

[0099] Each annular disc 2, 14, 15 of the separating device as disclosed herein comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0100] The intermediate element 10 of the separating device as disclosed herein comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0101] The intermediate core element 26 of the separating device as disclosed herein comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0102] In some embodiments, the annular discs 2, 14, 15 are produced from, i.e. consists of a material which is independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0103] In some embodiments, the intermediate element 10 is produced from, i.e. consists of a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0104] In some embodiments, the intermediate core element 26 is produced from, i.e. consists of a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

[0105] These materials are typically chosen based upon their relative abrasion- and erosion-resistance to solid particles such as sands and other mineral particles and also corrosion-resistance to the extraction media and the media used for maintenance, such as for example acids.

[0106] The material which the annular discs comprise can be independently selected from this group of materials, which means that each annular disc could be made from a different material. But for simplicity of design and manufacturing, of course, all annular discs of the separating device could be made from the same material.

[0107] The intermediate element can comprise or can be made from a different material as the annular discs. Typically, the intermediate element comprises or is made from the same material as the annular discs. The intermediate core element can comprise or can be made from a different material as the annular discs. Typically, the intermediate core element comprises or is made from the same material as the annular discs.

[0108] The ceramic materials which the annular discs, the intermediate element and the intermediate core element can comprise or from which the annular discs, the intermediate element and the intermediate core element are made can be selected from the group consisting of (i) oxidic ceramic materials; (ii) non-oxidic ceramic materials; (iii) mixed ceramics of oxidic and non-oxidic ceramic materials; (iv) ceramic materials having a secondary phase; and (v) long- and/or short fiber-reinforced ceramic materials.

[0109] Examples of oxidic ceramic materials are materials chosen from Al_2O_3, ZrO_2, mullite, spinel and mixed oxides. Examples of non-oxidic ceramic materials are SiC, B_4C, TiB_2 and Si_3N_4. Ceramic hard materials are, for example, carbides and borides. Examples of mixed materials with a metallic binding phase are WC-Co, TiC-Fe and TiB2-FeNiCr. Examples of hard material phases formed in situ are chromium carbides. An example of fiber-reinforced ceramic materials is C/SiC. The material group of fiber-reinforced ceramic materials has the advantage that it leads to still greater internal and external pressure resistance of the separating devices on account of its greater strength in comparison with monolithic ceramic.

[0110] The aforementioned materials are distinguished by being harder than the typically occurring hard particles, such as for example sand and rock particles, that is to say the HV (Vickers) or HRC (Rockwell method C) hardness values of these materials lie above the corresponding values of the surrounding rock. Materials suitable for the annular discs of the separating device according to the present disclosure have HV hardness values greater than 11 GPa, or even greater than 20 GPa.

[0111] All these materials are at the same time distinguished by having greater brittleness than typical unhardened steel alloys. In this sense, these materials are referred to herein as "brittle-hard".

[0112] Materials suitable for the annular discs, for the intermediate element and for the intermediate core element, respectively, of the separating device according to the present disclosure have moduli of elasticity greater than 200 GPa, or even greater than 350 GPa.

[0113] Materials with a density of at least 90%, more specifically at least 95%, of the theoretical density may be used, in order to achieve the highest possible hardness values and high abrasion and erosion resistances.

Sintered silicon carbide (SSiC) or boron carbide may be used as the material for the annular discs, the intermediate element and the intermediate core element, respectively. These materials are not only abrasion-resistant but also corrosion-resistant to the treatment fluids usually used for flushing out the separating device and stimulating the borehole, such as acids, for example HCl, bases, for example NaOH, or else steam.

[0114] Particularly suitable are, for example, SSiC materials with a fine-grained microstructure (mean grain size $\leq 5\ \mu m$), such as those sold for example under the names 3M™ silicon carbide type F and 3M™ silicon carbide type F plus from 3M Technical Ceramics, Kempten, Germany. Furthermore, however, coarse-grained SSiC materials may also be used, for example with a bimodal microstructure. In one embodiment, 50 to 90% by volume of the grain size distribution consisting of prismatic, platelet-shaped SiC crystallites of a length of from 100 to 1500 μm and 10 to 50% by volume consisting of prismatic, platelet-shaped SiC crystallites of a length of from 5 to less than 100 μm (3M™ silicon carbide type C from 3M Technical Ceramics, Kempten, Germany).

[0115] Apart from these single-phase sintered SSiC materials, liquid-phase-sintered silicon carbide (LPS-SiC) can also be used as the material for the annular discs, the intermediate element and the intermediate core element, respectively. An example of such a material is 3M™ silicon carbide type T from 3M Technical Ceramics, Kempten, Germany. In the case of LPS-SiC, a mixture of silicon carbide and metal oxides is used as the starting material. LPS-SiC has a higher bending resistance and greater toughness, measured as a Klc value, than single-phase sintered silicon carbide (SSiC).

[0116] In some embodiments, the material of each annular disc (2, 14, 15) is sintered silicon carbide (SSiC).

[0117] In some embodiments, the material of the intermediate element (10) is sintered silicon carbide (SSiC).

[0118] In some embodiments, the material of the intermediate core element (26) is sintered silicon carbide (SSiC).

[0119] The separating device as disclosed herein may further comprise a thermal compensator 21 at the upper end or at the lower end or at both ends of the central annular region (see Figure 1D). The thermal compensator 21 serves to compensate for the different thermal expansions of the base pipe and the central annular region, from ambient temperature to operation temperature. The thermal compensator may for example comprise one or more springs, for example made from a metallic material such as steel, or a compensating bush consisting of a material on the basis of polytetrafluoroethylene (PTFE), or a tubular double-walled liquid-filled container, the outer walls of which are corrugated in the axial direction.

[0120] Preferably, the separating device as disclosed herein does not comprise a thermal compensator located near or incorporated in the intermediate element, i.e. the intermediate element does not comprise a thermal compensator. The thermal compensator 21 is located at the upper end of the first section 11 of the central annular region 1, 13 and at the lower end of the second section 12 of the central annular region 1, 13, i.e. the thermal compensator 21 is located near the end caps 8, 9. Preferably, the thermal compensator is not located at the lower end of the first section 11 of the central annular region 1, 13, and the thermal compensator is not located at the upper end of the second section 12 of the central annular region 1, 13, i.e. the thermal compensator is not located near or incorporated in the intermediate element 10.

[0121] A thermal compensator is not needed located near or incorporated in the intermediate element of the separating device as disclosed herein, as the intermediate element is movable in axial direction and differences in thermal expansion between the central annular region and the base pipe can be compensated by the thermal compensator at the end caps and by axial movement of the intermediate element and the first and second section of the central annular region over the whole length of the central annular region.

[0122] With the thermal compensator not being located near or incorporated in the intermediate element, the filter area of the separating device can be increased by adding more annular discs on the same length of the separating device and thus increasing inflow area for fluid. The inflow area of fluid is essentially not disturbed by the intermediate element of the separating device as disclosed herein. In separating devices of the prior art, the intermediate element has thermal compensators and additional sealing bushes for the thermal compensators which are both located at the upper end and lower end of the intermediate element, and which consume a significantly larger length of the separating device which cannot be used for filtering purposes and which interrupts and disturbs the inflow of fluid, thereby dividing the inflow of fluid in two separate parts.

[0123] The intermediate element 10 of the separating device as disclosed herein is erosion resistant to the abrasive fluid flows and corrosion resistant to the media to be extracted and the media used for maintenance such as acids. As the thermal compensator 21 is not located near or incorporated in the intermediate element 10, and as the intermediate element 10 as well as the central annular region 1, 13 are erosion and corrosion resistant, the complete annular stack composed of central annular region 1, 13 and intermediate element 10, or intermediate core element 26, respectively, is erosion resistant and corrosion resistant. The complete annular stack composed of central annular region 1, 13 and intermediate element 10, or intermediate core element 26, respectively, is not interrupted by any metallic or other parts not being erosion and corrosion resistant. The inflow of fluid is not divided into two separate parts, and the separating device as disclosed herein can be used for harsh environments, that is for reservoirs to be exploited with streaks having high inflow and high erosional impact. The service life of the separating device as disclosed herein is increased for harsh environments, that is for reservoirs to be exploited with streaks having high inflow and high erosional impact. Thus a separating device with a larger filter length can be deployed, irrespective of length of zones with high inflow and high erosional impact.

[0124] The protective bush 20 may have a radial thickness of from 1 to 20 mm. The intermediate core element 26 may have a radial thickness of from 8 to 20 mm. The annular element 27 may have a radial thickness of from 0.5 to 6 mm. The axial length of the intermediate element 10 may be from 10 to 140 mm and typically is from 40 to 70 mm.

[0125] The separating device as disclosed herein may further comprise a number of n further intermediate elements 10, wherein n is an integer from 1 to 10. If a number of n further intermediate elements 10 are present, the central annular region 1, 13 further comprises a number of n further sections, and each further intermediate element 10 is placed between two adjacent sections of the central annular region.

[0126] To protect the brittle-hard annular discs from mechanical damage during handling and fitting into the borehole, the separating device is surrounded by a tubular shroud 22 (see Figures 1A, 2E, 2F) that can be freely passed through by a flow. The shroud is protecting each section of the central annular region.

[0127] This shroud may be configured for example as a coarse-mesh screen and preferably as a perforated plate. The shroud may be produced from a metallic material, such as from steel, particularly from corrosion-resistant steel. The shroud may be produced from the same material as that used for producing the base pipe.

[0128] The shroud can be held on both sides by the end caps, it may also be firmly connected to the end caps. This fixing is possible for example by way of adhesive bonding, screwing or pinning, the shroud may be welded to the end caps after assembly.

[0129] The inner diameter of the shroud must be greater than the outer diameter of the annular discs. For mechanical protection of the annular discs of the central annular region, the inner diameter of the shroud should be at least 0.5 mm larger than the outer diameter of the central annular region. Typically, the inner diameter of the shroud is at most 15 mm larger than the outer diameter of the central annular region. The radial distance between shroud and central annular region can be selected depending on the radial thickness of the shroud and on the radial loads that need to be withstand. The radial thickness of the shroud usually is from 1 to 20 mm, preferably 1 to 8 mm.

[0130] The inner diameter of the shroud being greater than the outer diameter of the annular discs is also necessary for technical reasons relating to flow. It has been found to be favorable in this respect that the inner diameter of the shroud is at least 0.5 mm and at most 15 mm greater than the outer diameter of the annular discs. The inner diameter of the shroud may be at least 1.5 mm and at most 8 mm greater than the outer diameter of the annular discs.

[0131] The inner diameter of the shroud at the position of the intermediate element is such that it fits to the outer diameter of the intermediate element 10. If the intermediate element comprises a protective bush 20, the inner diameter of the shroud at the position of the intermediate element is such that it fits to the outer diameter of the protective bush 20.

[0132] The shroud 22 may be provided in one single part. The shroud may also be provided in two or more separate parts. On the interface between two adjacent parts of the shroud, an intermediate element 10 must be placed as support for the shroud. During assembly, the shroud 22 is placed on the end caps 8, 9 and on the intermediate element 10, and the end caps 8, 9 and the intermediate element 10 support the shroud 22. If the shroud is provided in more than one part, each part of the shroud can be assembled separately. If the intermediate element 10 comprises a protective bush 20, the shroud 22 is placed on the protective bush 20, and the end caps 8, 9 and the protective bush support the shroud 22. The shroud may or may not be firmly connected to the intermediate element.

[0133] The distance of the intermediate elements 10 to one another may be selected depending on the radial loads which need to be withstand and on the thickness of the shroud, without consuming the radial distance between shroud and central annular region.

[0134] The intermediate element 10 has the function of a spacer for the shroud 22. By the intermediate element 10, the shroud is positioned at a distance from the annular discs. A distance between shroud and annular discs is maintained even if the separating device is bended or loaded during installation or operation. If the shroud would touch the annular discs during bending or loading, the annular discs might be damaged which might lead to loss of sand control.

[0135] The central annular region of the separating device disclosed herein can, and typically does, comprise more than 3 annular discs. The number of annular discs in the central annular region can be from 3 to 500, but also larger numbers of annular discs are possible. For example, the central annular region can comprise 50, 100, 250 or 500 annular discs.

[0136] The annular discs 2 and the annular discs 14, 15, respectively, of the central annular region 1, 13 are stacked on top of each other, resulting in a stack of annular discs. The annular discs 2 and the annular discs 14, 15, respectively, are stacked in such a way that a separating gap 6 for the removal of solid particles is present in each case between adjacent annular discs.

[0137] Every upper side 3, 16 of an annular disc 2, 14 which has one or more spacers may be inwardly or outwardly sloping, preferably inwardly sloping, in the regions between the spacers (see Figures 3D, 4D), and every underside 17 of an annular disc 14 which has one or more spacers may be inwardly or outwardly sloping, preferably inwardly sloping, in the regions between the spacers (see Figure 4D).

[0138] If the upper side, or the upper side and underside, respectively, of the annular discs which have one or more spacers, is inwardly or outwardly sloping in the regions between the spacers, in the simplest case, the sectional line on the upper side of the ring cross-section of the annular discs is straight and the ring cross-section of the annular discs in the portions between the spacers is trapezoidal (see Figures 3D, 4D), the thicker side of the ring cross-section having to lie on the respective inlet side of the flow to be filtered. If the flow to be filtered comes from the direction of the outer circumferential surface of the central annular region, the thickest point of the trapezoidal cross-section must lie on the outside and the upper side of the annular discs is inwardly sloping. If the flow to be filtered comes from the direction of the inner circumferential surface of the annular disc, the thickest point of the trapezoidal cross-section must lie on the inside and the upper side of the annular discs is outwardly sloping. The forming of the ring cross-section in a trapezoidal shape, and consequently the forming of a separating gap that diverges in the direction of flow, has the advantage that, after passing the narrowest point of the filter gap, irregularly shaped particles, i.e. non-spherical particles, tend much less to get stuck in the filter gap, for example due to rotation of the particles as a result of the flow in the gap. Consequently, a separating device with a divergent filter gap formed in such a way is less likely to become plugged and clogged than a separating device in which the separating gaps have a filter opening that is constant over the ring cross-section.

[0139] The height of the separating gap, i.e. the filter width, may be from 50 to 1000 μm. The height of the separating gap is measured at the position of the smallest distance between two adjacent annular discs.

[0140] The annular discs 2, 14, 15 may have a height of 1 to 12 mm. More specifically, the height of the annular discs may be from 2 to 7 mm. The height of the annular discs is the thickness of the annular discs in axial direction.

[0141] In some embodiments, the annular discs 14 having one or more spacers on the upper side 16 and the underside 17 have a height of 1 to 12 mm, and the annular discs 15 which do not comprise any spacers may have the same height as the annular discs 14 with spacers, or may be thinner than the annular discs 14 with spacers. The annular discs 15 may have a height of 2 to 7 mm, for example. With the reduced height of the annular discs 15 which do not comprise any spacers, the open flow area can be increased.

[0142] The base thickness of the annular discs is measured in the region between the spacers and, in the case of a trapezoidal cross-section, on the thicker side in the region between the spacers. The axial thickness or height of the annular discs in the region of the spacers corresponds to the sum of the base thickness and the filter width.

[0143] The height of the spacers determines the filter width of the separating device, that is to say the height of the separating gap between the individual annular discs. The filter width additionally determines which particle sizes of the solid particles to be removed, such as for example sand and rock particles, are allowed to pass through by the separating device and which particle sizes are not allowed to pass through. The height of the spacers is specifically set in the production of the annular discs.

[0144] For any particular separating device, the annular discs may have uniform base thickness and filter width, or the base thickness and/or filter width may vary along the length of the separating device (e.g., to account for varying pressures, temperatures, geometries, particle sizes, materials, and the like).

[0145] The outer contours of the annular discs may be configured with a bevel 35, as illustrated in Figures 3C - 3D and 4C - 4D. It is also possible to configure the annular discs with rounded edges. This may, for some applications, represent even better protection of the edges (versus straight edged) from the edge loading that is critical for the materials from which the annular discs are produced.

[0146] The circumferential surfaces (lateral surfaces) of the annular discs may be cylindrical. However, it is also possible to form the circumferential surfaces as outwardly convex, in order to achieve a better incident flow.

[0147] In practice, it is expected that the annular discs are produced with an outer diameter that is adapted to the borehole of the extraction well provided in the application concerned, so that the separating device according to the present disclosure can be introduced into the borehole with little play, in order to make best possible use of the cross-section of the extraction well for achieving a high delivery output. The outer diameter of the annular discs may be 20 - 250 mm, but outer diameters greater than 250 mm are also possible, as the application demands.

[0148] The radial ring width of the annular discs may lie in the range of 8 - 20 mm. These ring widths are suitable for separating devices with base pipe diameters in the range of 6 cm to 14 cm (2⅜ to 5½ inches).

[0149] The spacers arranged on the upper side, or on the upper side and the underside, respectively, of the annular discs have planiform contact with the adjacent annular disc. The spacers make a radial throughflow possible and therefore may be arranged radially aligned on the first major surface of the annular discs, or on the second major surface of the annular discs, respectively. The spacers may, however, also be aligned at an angle to the radial direction.

[0150] The transitions between the surface of the annular discs, i.e. the upper side, or the upper side and the underside of the annular discs, and the spacers are typically not formed in a step-shaped or sharp-edged manner. Rather, the transitions between the surface of the annular discs and the spacers are typically configured appropriately for the material from which the annular discs are made, i.e. the transitions are made with radii that are gently rounded. This is illustrated in Figures 3E and 4E.

[0151] The contact area of the spacers, that is to say the planar area with which the spacers are in contact with the adjacent annular disc are not particularly limited, and may be, for instance, rectangular, round, rhomboidal, elliptical, trapezoidal or else triangular, while the shaping of the corners and edges should always be appropriate for the material from which the annular discs are made, e.g. rounded.

[0152] Depending on the size of the annular discs, the contact area 25 of the individual spacers is typically between 4 and 100 mm^2.

[0153] The spacers 5 may be distributed over the circumference of the annular discs (see Figures 3A and 4A). The spacers 5 may be distributed homogeneously or non-homogeneously over the circumference of the annular discs. The number of spacers may be even or odd.

[0154] The annular discs of the separating device disclosed herein may be prepared by the methods that are customary in technical ceramics or powder metallurgy, that is to say by die pressing of pressable starting powders and subsequent sintering. The annular discs may be formed on mechanical or hydraulic presses in accordance with the principles of "near-net shaping", debindered and subsequently sintered to densities > 90% of the theoretical density. The annular discs may be subjected to 2-sided facing on their upper side and underside.

[0155] In Figures 3A - 3L, one embodiment of a central annular region of a separating device as disclosed herein is represented. Figures 3A - 3F show various details of an individual annular disc 2 of the central annular region 1. Figures 3G - 3L show the central annular region 1 constructed from annular discs 2 of Figures 3A - 3F, representing various details of the stack of annular discs. Figure 3A shows a plan view of the upper side 3 of the annular disc 2, Figure 3B shows a cross-sectional view along the sectional line denoted in Figure 3A by "3B", Figures 3C - 3D show enlarged details of the cross-sectional view of Figure 3B. The enlarged detail of Figure 3C is in the region of a spacer, the enlarged detail of Figure 3D is in the region between two spacers. Figure 3F shows a 3D view of the annular disc 2, and Figure 3E shows a 3D representation along the sectional line denoted in Figure 3A by "3E". Figure 3G shows a plan view of the central annular region 1 constructed from annular discs 2 of Figures 3A - 3F, Figure 3H shows a cross-sectional view along the sectional line denoted in Figure 3G by "3H", Figures 3I - 3J show enlarged details of the cross-sectional view of Figure 3H. The enlarged detail of Figure 3I is in the region of a spacer, the enlarged detail of Figure 3J is in the region between two spacers. Figure 3K shows a 3D view of the central annular region 1, and Figure 3L shows a 3D representation along the sectional line denoted in Figure 3G by "3L".

[0156] The removal of the solid particles takes place at the inlet opening of a separating gap 6, which may be divergent, i.e. opening, in the direction of flow (see Figures 3D and 3J) and is formed between two annular discs lying one over the other. The annular discs are designed appropriately for the materials from which the annular discs are produced and the operational environment intended for the devices made with such annular discs, e.g., materials may be chosen for given pressure, temperature and corrosive operating conditions, and so that cross-sectional transitions may be configured without notches so that the occurrence of flexural stresses is largely avoided by the structural design.

[0157] The upper side 3 of each annular disc 2 has fifteen spacers 5 distributed over its circumference. The underside 4 does not comprise any spacers. The spacers 5 are of a defined height, with the aid of which the height of the separating gap 6 (gap width of the filter gap, filter width) is set. The spacers are not separately applied or subsequently welded-on spacers, they are formed directly in production, during the shaping of the annular discs.

[0158] The contact area 25 of the spacers 5 is planar (see Figures 3C, 3E), so that the spacers 5 have a planar contact area with the underside 4 of the adjacent annular disc. The upper side 3 of the annular discs is plane-parallel with the underside 4 of the annular discs in the region of the contact area 25 of the spacers 5, i.e. in the region of contact with the adjacent annular disc. The underside 4 of the annular discs is formed as smooth and planar and at right angles to the disc axis and the central axis of the central annular region. At the planar contact area of the spacers, the annular discs contact the respective adjacent annular disc.

[0159] The upper side 3 of an annular disc 2 having fifteen spacers 5 is inwardly sloping, in the regions between the spacers. The ring cross-section of the annular discs in the portions between the spacers is trapezoidal (see Figure 3D), the thicker side of the ring cross-section lying on the outside, i.e. on the inlet side of the flow to be filtered.

[0160] In Figures 4A - 4L, a further embodiment of a central annular region of a separating device as disclosed herein is represented. Figures 4A - 4F show various details of individual annular discs 14 of the central annular region 13. Figures 4G - 4L show the central annular region 13 constructed from annular discs 14 and 15, representing various details of the stack of annular discs. Figure 4A shows a plan view of the upper side 16 and of the underside 17 of the annular disc 14, Figure 4B shows a cross-sectional view along the sectional line denoted in Figure 4A by "4B", Figures 4C - 4D show enlarged details of the cross-sectional view of Figure 4B. The enlarged detail of Figure 4C is in the region of the spacers, the enlarged detail of Figure 4D is in the region between the spacers. Figure 4F shows a 3D view of the annular disc 14, and Figure 4E shows a 3D representation along the sectional line denoted in Figure 4A by "4E". Figure 4G shows a plan view of the central annular region 13 constructed from annular discs 14 and 15, Figure 4H shows a cross-sectional view along the sectional line denoted in Figure 4G by "4H", Figures 4I - 4J show enlarged details of the cross-sectional view of Figure 4H. The enlarged detail of Figure 4I is in the region of a spacer, the enlarged detail of Figure 4J is in the region between the spacers. Figure 4K shows a 3D view of the central annular region 13, and Figure 4L shows a 3D representation along the sectional line denoted in Figure 4G by "4L".

[0161] The stack of annular discs 13 is composed of annular discs 14 and 15 which are stacked in an alternating manner. Every second annular disc in the stack is an annular disc 14 having fifteen spacers 5 on the upper side 16 of the annular disc 14 distributed over its circumference (see Figure 4A) and fifteen spacers 5 on the underside 17 of the annular disc 14 distributed over its circumference. The plan view of the upper side 16 of Figure 4A is identical to the plan view of the underside 17. The spacers 5 of the annular discs 14 are of a defined height, with the aid of which the height of the separating gap 6 (gap width of the filter gap, filter width) is set. The spacers are not separately applied or subsequently welded-on spacers, they are formed directly in production, during the shaping of the annular discs.

[0162] The respectively adjacent annular discs of the annular discs 14 in the stack of annular discs 13 are annular discs 15 as shown in Figures 4H - 4J. The upper side 18 and the underside 19 of the annular discs 15 do not comprise any spacers.

[0163] The removal of the solid particles takes place at the inlet opening of a separating gap 6, which may be divergent, i.e. opening, in the direction of flow (see Figures 4D and 4J) and is formed between two adjacent annular discs lying one over the other. The annular discs are designed appropriately for the materials from which the annular discs are produced and the operational environment intended for the devices made with such annular discs, e.g., materials may be chosen for given pressure, temperature and corrosive operating conditions, and so that cross-sectional transitions may be configured without notches so that the occurrence of flexural stresses is largely avoided by the structural design.

[0164] The contact area 25 of the spacers 5 is planar (see Figures 4C, 4E), so that the spacers 5 have a planar contact area with the underside 19 or upper side 18 of the adjacent annular disc 15. The upper side 16 of the annular discs 14 is plane-parallel with the underside 17 of the annular discs 14 in the region of the contact area 258 of the spacers 5, i.e. in the region of contact with the adjacent annular disc. At the planar contact area of the spacers, the annular discs contact the respective adjacent annular disc 15.

[0165] The upper side 18 and the underside 19 of the annular discs 15 is formed as smooth and planar and at right angles to the disc axis and the central axis of the central annular region.

[0166] The upper side 16 and the underside 17 of an annular disc 14 having fifteen spacers 5 is inwardly sloping, in the regions between the spacers 5. The ring cross-section of the annular discs in the portions between the spacers is trapezoidal (see Figure 4D), the thicker side of the ring cross-section lying on the outside, i.e. on the inlet side of the flow to be filtered.

[0167] The separating device according to the present disclosure may be used for removing solid particles from a fluid. A fluid as used herein means a liquid or a gas or combinations of liquids and gases.

[0168] The separating device according to the present disclosure may be used in extraction wells in oil and/or gas reservoirs for separating solid particles from volumetric flows of mineral oil and/or natural gas. The separating device may also be used for other filtering processes for removing solid particles from fluids outside of extraction wells, processes in which a great abrasion resistance and a long lifetime of the separating device are required, such as for example for filtering processes in mobile and stationary storage installations for fluids or for filtering processes in naturally occurring bodies of water, such as for instance in the filtering of seawater. The separating device disclosed herein can also be used in a process for extracting ores and minerals. In the extraction of ore and many other minerals, there are problems of abrasion and erosion in the removal of solid particles from fluid flows. The separating device according to the present disclosure is particularly suitable for the separation of solid particles from fluids, in particular from mineral oil, natural gas and water, in extraction wells in which high and extremely high rates of flow and delivery volumes occur.

Claims

1. A separating device for removing solid particles from fluids, comprising:

a stack of at least three annular discs defining a central annular region (1) along a central axis, each annular disc (2) having an upper side (3) and an underside (4), wherein the upper side (3) of each annular disc (2) each has two or more spacers (5), and wherein the spacers (5) of the upper side (3) of each annular disc (2) contact the underside (4) of the adjacent annular disc, and wherein the annular discs (2) are stacked in such a way that a separating gap (6) for the removal of solid particles is present in each case between adjacent annular discs (2), and wherein the central annular region (1) comprises a first section (11) and a second section (12),

a supporting structure (7, 8, 9) for axial bracing of the central annular region (1), wherein the supporting structure is located inside the central annular region,

a tubular shroud (22) for protection of the central annular region (1) from mechanical damage, and

an intermediate element (10) which is placed between the first section (11) and the second section (12) of the central annular region (1),

wherein the intermediate element (10) supports the shroud (22),
and wherein each annular disc (2, 14, 15) comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ,
and wherein the intermediate element (10) comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

2. A separating device for removing solid particles from fluids, comprising:

a stack of at least three annular discs defining a central annular region (13) along a central axis, each annular disc (14, 15) having an upper side (16, 18) and an underside (17, 19), wherein the upper side (16) and the underside (17) of every second annular disc (14) in the stack each has two or more spacers (5), and wherein the upper side (18) and the underside (19) of the respectively adjacent annular discs (15) do not comprise any spacers, and wherein the spacers (5) of the upper side (16) of every second annular disc (14) in the stack contact the underside (19) of the adjacent annular disc (15), and wherein the spacers (5) of the underside (17) of every second annular disc (14) in the stack contact the upper side (18) of the adjacent annular disc (15), and wherein the annular discs (14, 15) are stacked in such a way that a separating gap (6) for the removal of solid particles is present in each case between adjacent annular discs (14, 15), and wherein the central annular region (13) comprises a first section (11) and a second section (12),
a supporting structure (7, 8, 9) for axial bracing of the central annular region (13), wherein the supporting structure is located inside the central annular region,
a tubular shroud (22) for protection of the central annular region (13) from mechanical damage, and
an intermediate element (10) which is placed between the first section (11) and the second section (12) of the central annular region (13), wherein the intermediate element (10) supports the shroud (22),
and wherein each annular disc (2, 14, 15) comprises a material independently selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ,
and wherein the intermediate element (10) comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

3. The separating device according to claim 1 or 2, wherein the supporting structure for axial bracing of the central annular region (1) comprises one or more rods arranged within the central annular region (1).

4. The separating device according to claim 1 or 2, wherein the supporting structure for axial bracing of the central annular region (1) comprises
a perforated pipe (7) which is co-centric with and located inside the central annular region (1), and
an end cap (8, 9) at the upper end and an end cap at the lower end of the central annular region (1), the end cap (8, 9) being co-centric with the perforated pipe (7) and being firmly connected to the perforated pipe (7),
and wherein the intermediate element (10) is co-centric with the perforated pipe (7).

5. The separating device according to any of claims 1 to 4, wherein the outer diameter of the intermediate element (10) is larger than the outer diameter of the central annular region (1, 13).

6. The separating device according to any of claims 1 to 5, wherein the intermediate element (10) comprises an intermediate core element (26) and a protective bush (20) which is co-centric with and located outside of the intermediate core element (26), and wherein the protective bush (20) protects the intermediate core element (26) from mechanical damage, and wherein the intermediate core element (26) comprises a material selected from the group consisting of (i) ceramic materials; (ii) mixed materials having fractions of ceramic or metallic hard materials and a metallic binding phase; and (iii) powder metallurgical materials with hard material phases formed in-situ.

7. The separating device according to claim 6, wherein the protective bush (20) comprises a metallic material or a polymeric material.

8. The separating device according to claim 6 or 7, wherein the protective bush (20) is firmly connected to the intermediate core element (26).

9. The separating device of any of claims 4 to 8, wherein the separating device further comprises one or more bands (29) which are provided on the lateral surface of the perforated pipe (7) and which are inside the central annular region (1, 13) and inside the intermediate element (10), and wherein the annular discs (2, 14, 15) are centered by the one or more bands (29) on the perforated pipe (7).

10. The separating device according to any of claims 1 to 9, wherein the intermediate element (10) is movable in axial direction.

11. The separating device according to any of claims 1 to 10, wherein the intermediate element (10) further comprises an annular element (27) which is co-centric with the intermediate core element (26) and which is located inside the intermediate core element (26).

12. The separating device according to claim 9, wherein the intermediate element (10) further comprises an annular element (27) which is co-centric with the intermediate core element (26) and which is located inside the intermediate core element (26) and between the intermediate core element (26) and the perforated pipe (7), and wherein the annular element (27) is provided with one or more recesses (28) in axial direction distributed along the circumference of the annular element, and wherein the number of recesses (28) is equal to or larger than the number of bands (29) which are provided on the lateral surface of the perforated pipe (7), and wherein each of the bands (29) is placed in one of the recesses (28) of the annular element (27).

13. The separating device according to claim 11 or 12, wherein the annular element (27) is firmly connected to the intermediate core element (26).

14. The separating device of any of claims 1 to 13, wherein the separating device further comprises a number of n further intermediate elements (10), wherein n is an integer from 1 to 10, and wherein the central annular region (1, 13) further comprises a number of n further sections, and wherein each further intermediate element (10) is placed between two adjacent sections of the central annular region.

15. Use of the separating device of any of claims 1 to 14 for removing solid particles from fluids
in a process for extracting fluids from extraction wells, or
in water or in storage installations for fluids, or
in a process for extracting ores and minerals.

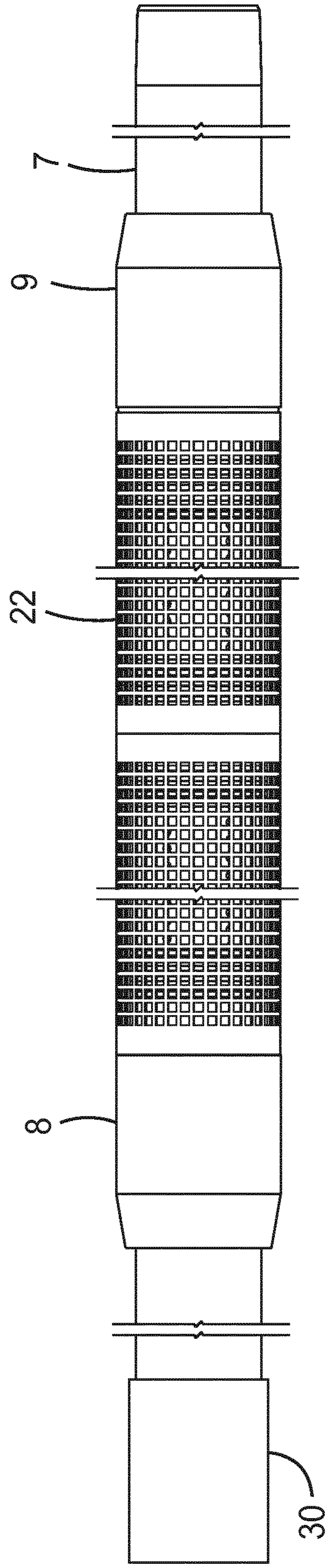

FIG. 1A

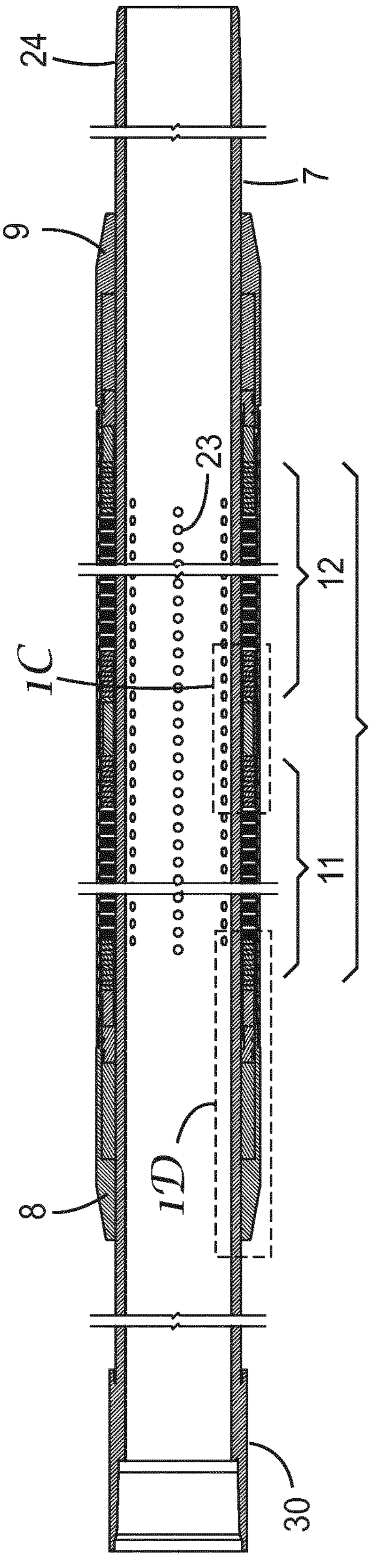

FIG. 1B

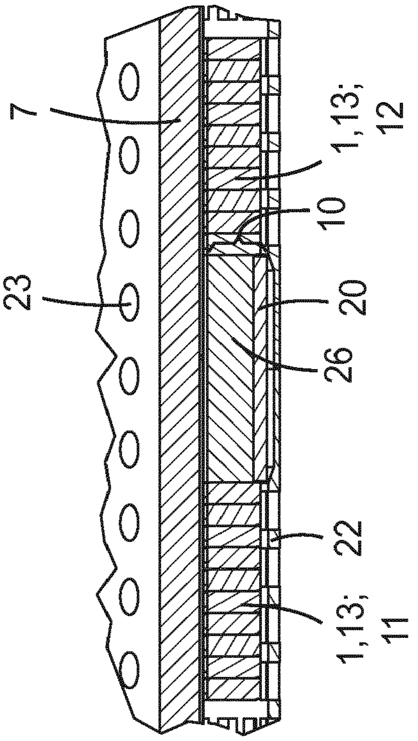

FIG. 1C

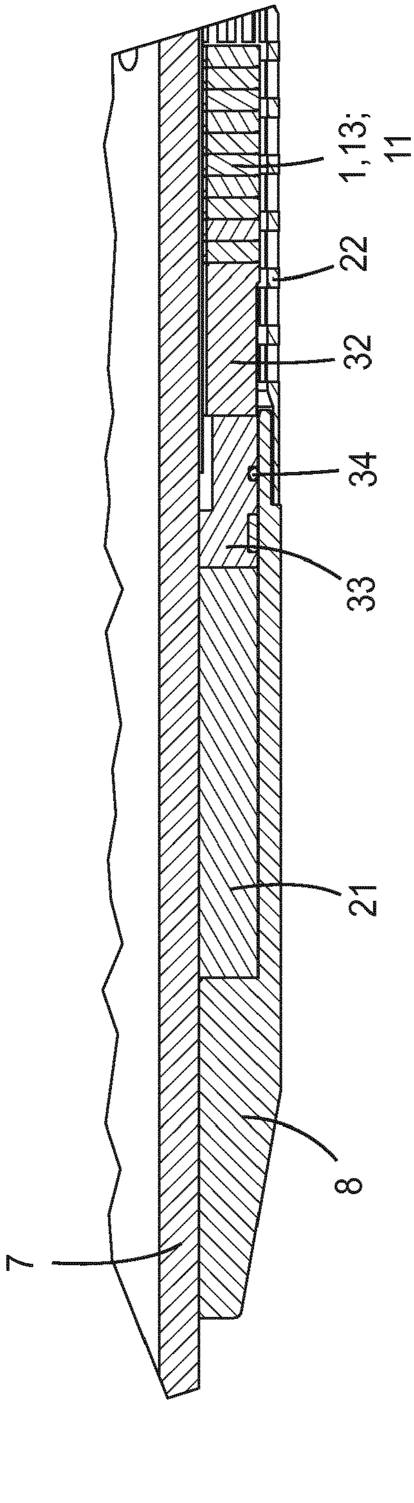

FIG. 1D

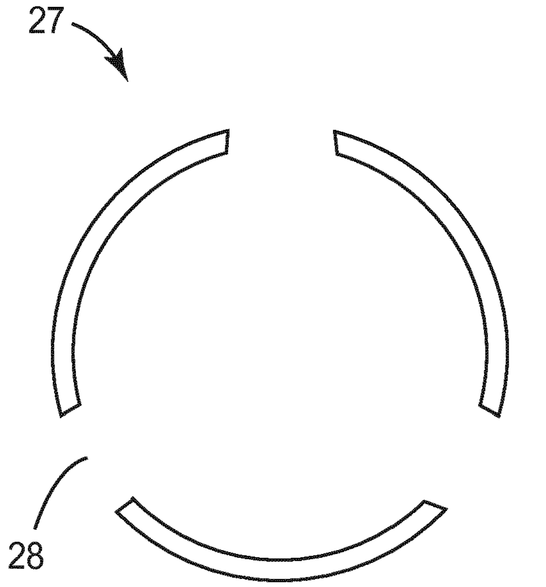

FIG. 2A

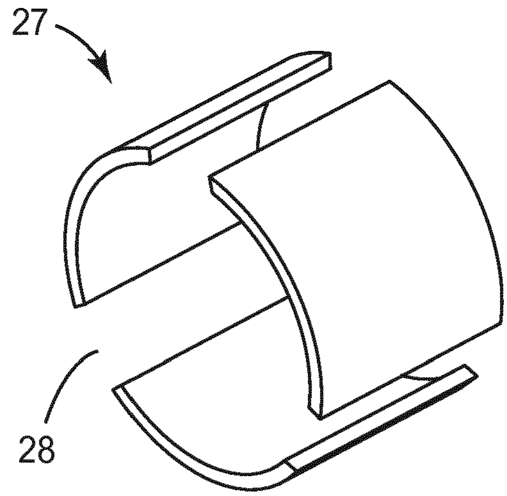

FIG. 2B

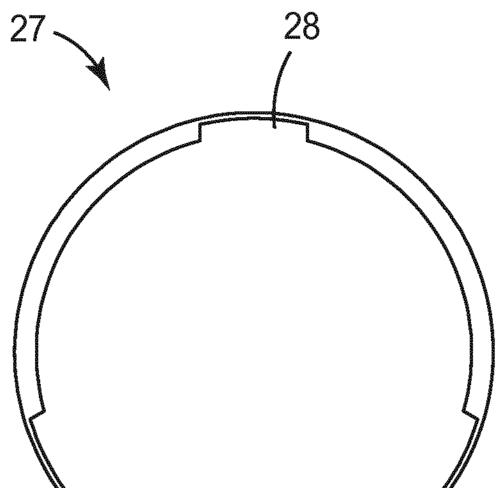

FIG. 2C

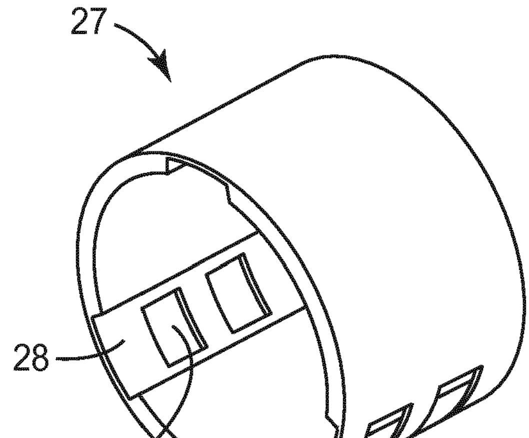

FIG. 2D

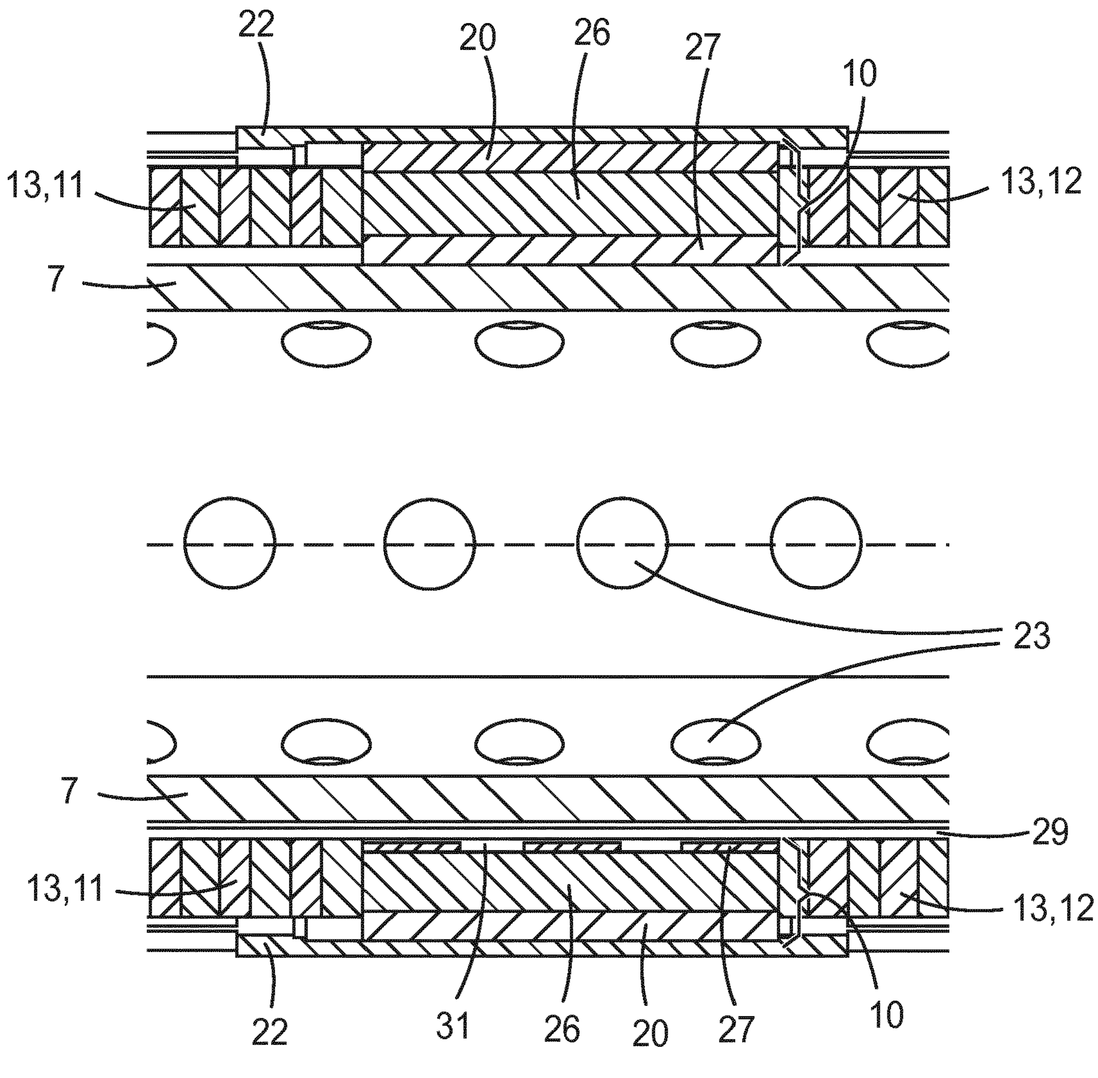

FIG. 2E

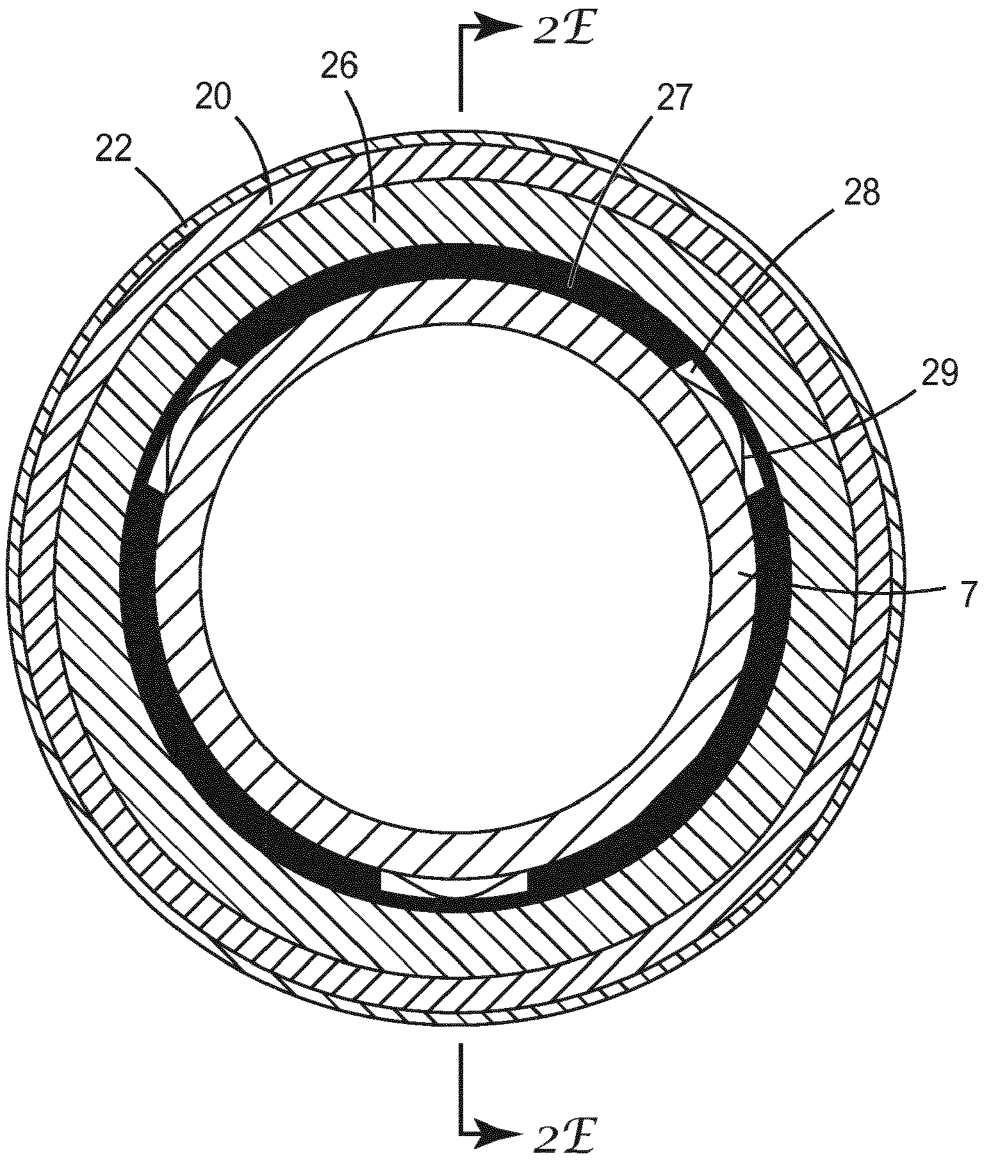

FIG. 2F

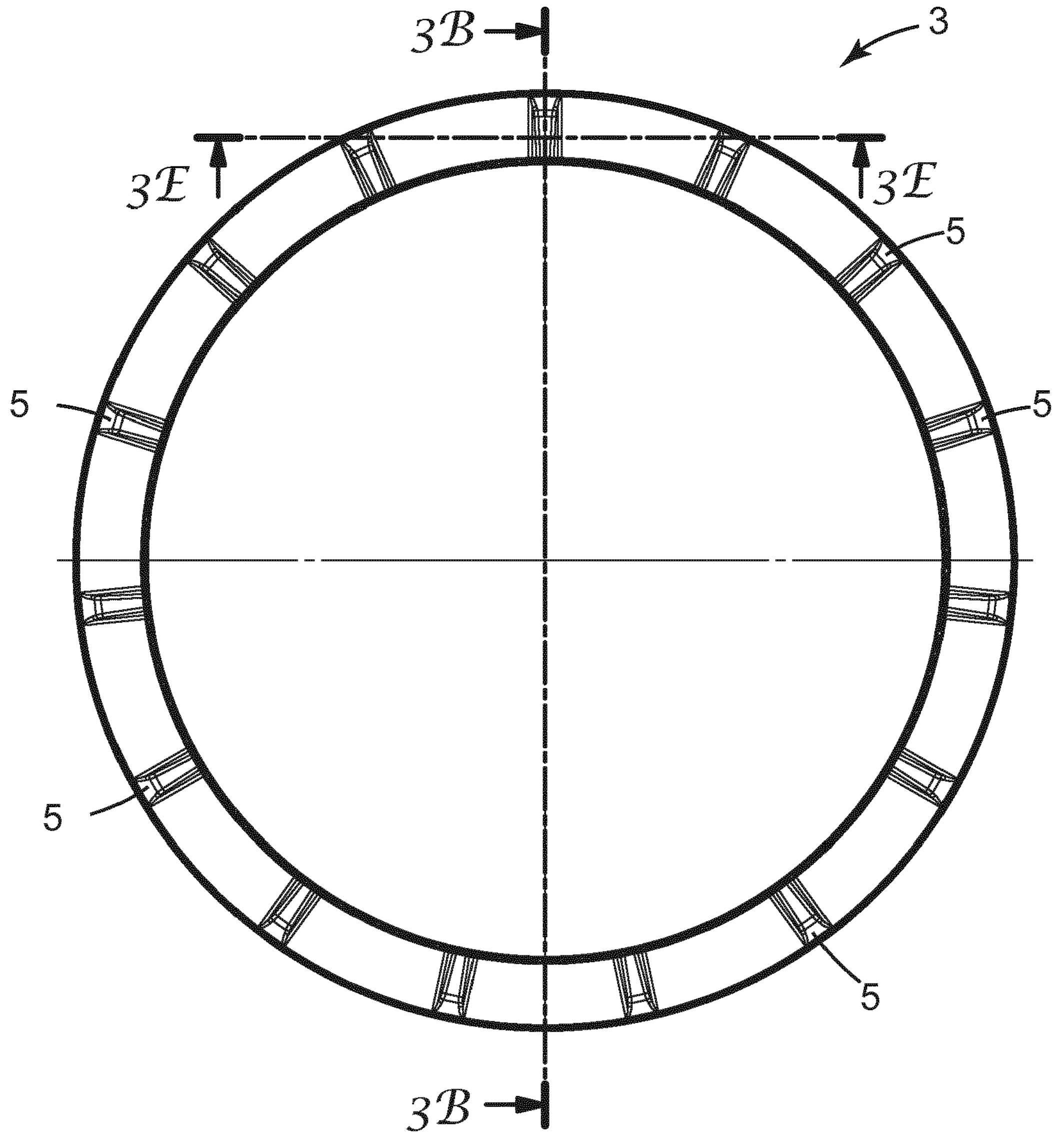

FIG. 3A

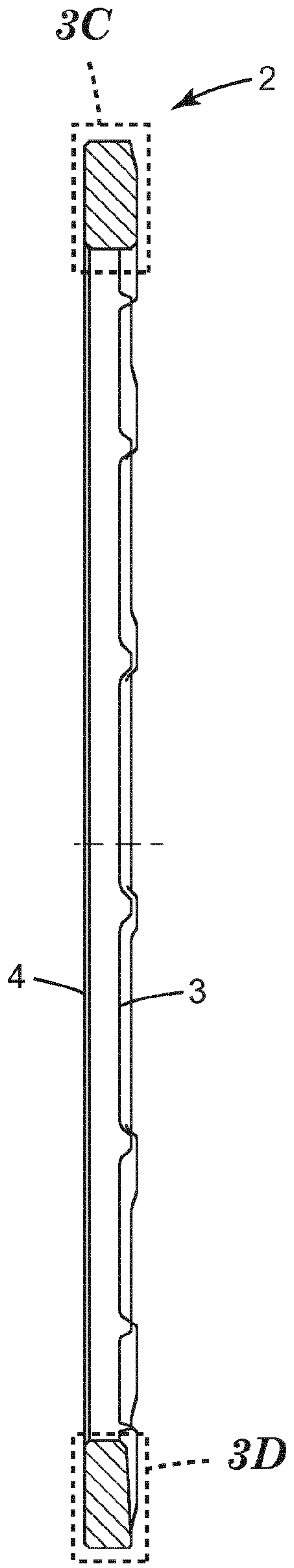

Fig. 3B

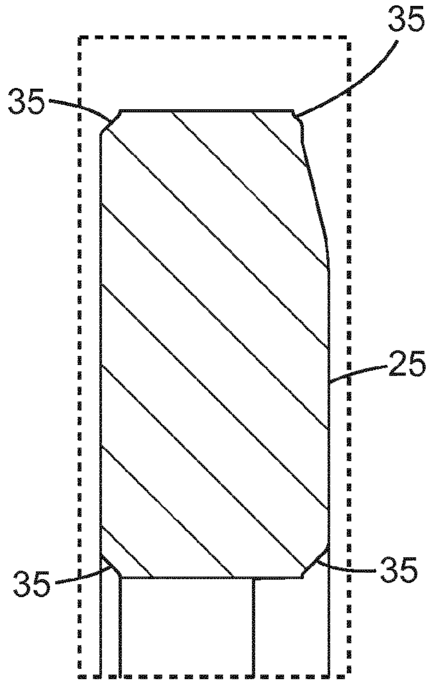

Fig. 3C

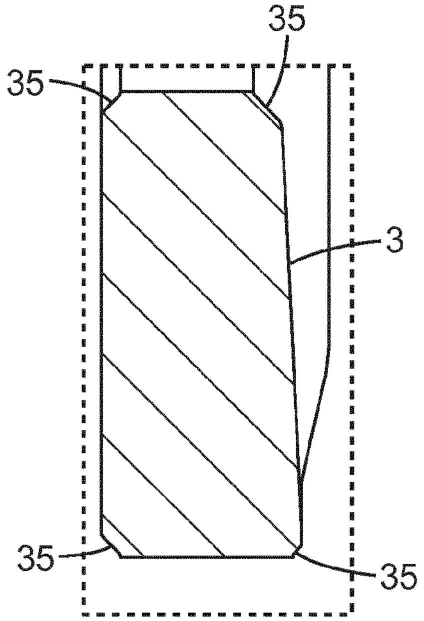

Fig. 3D

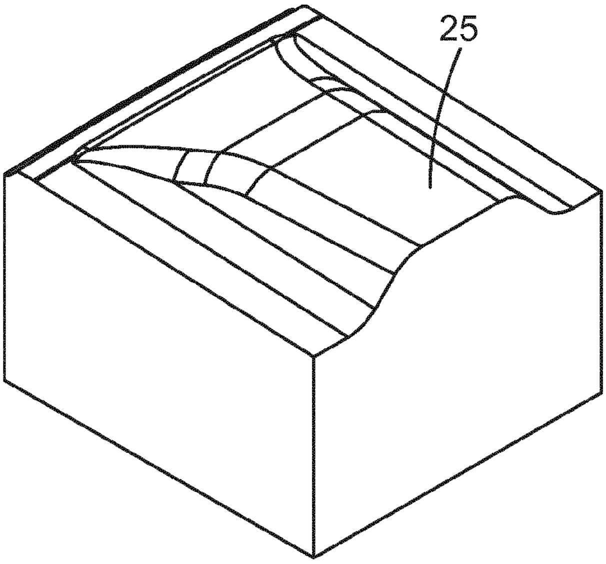

FIG. 3E

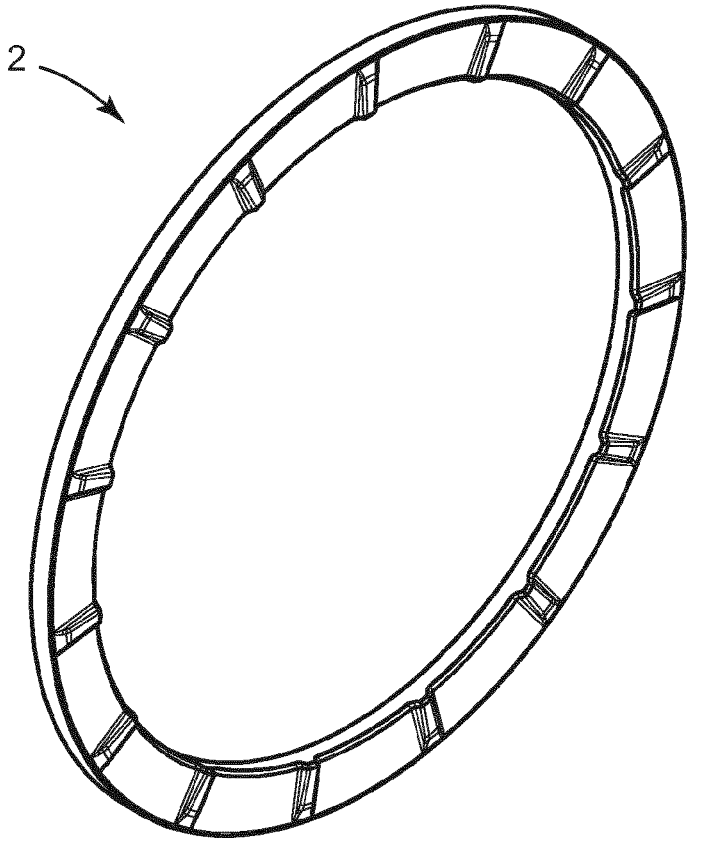

FIG. 3F

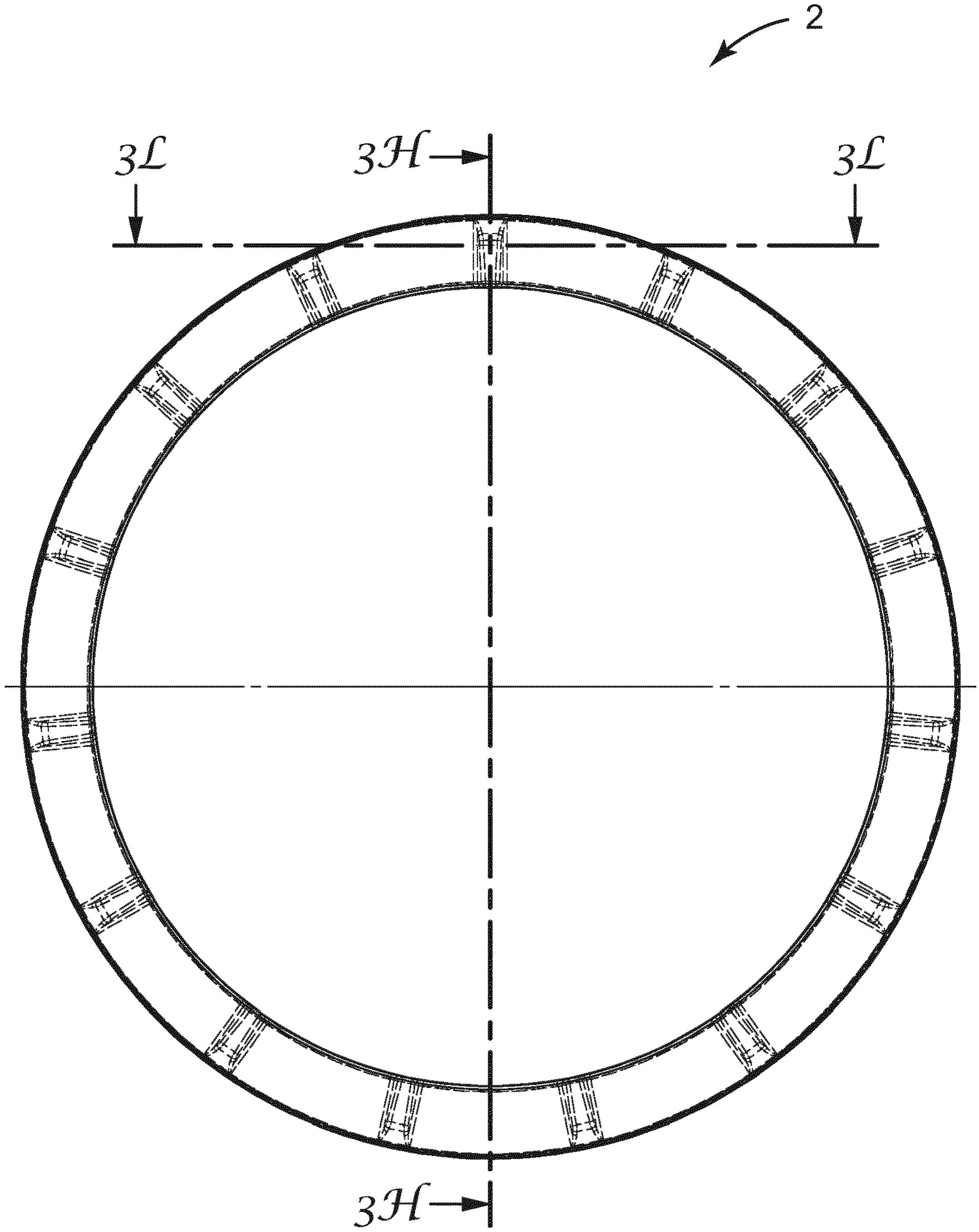

FIG. 3G

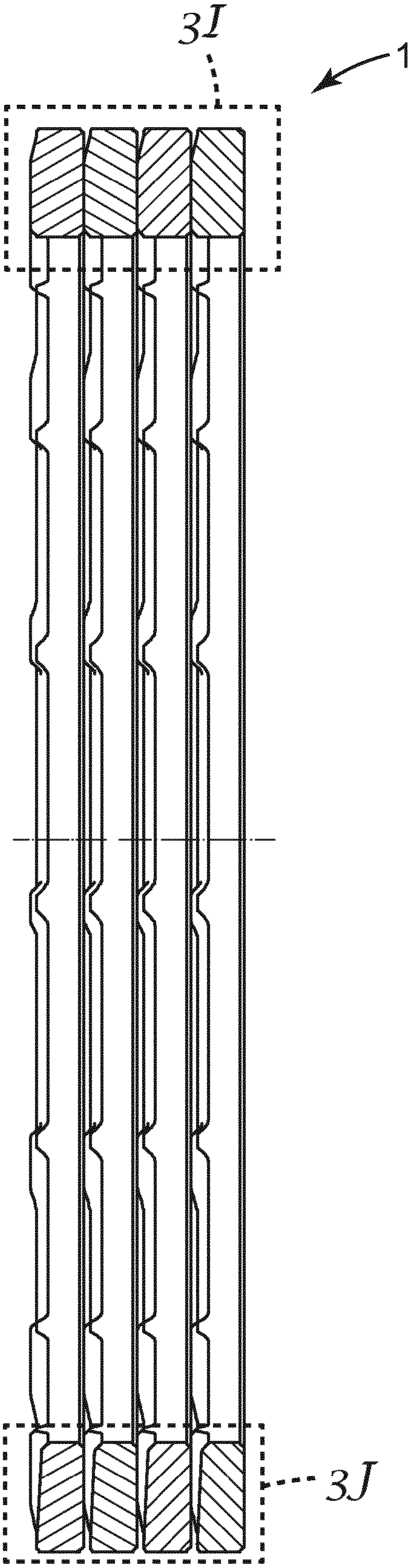

FIG. 3H

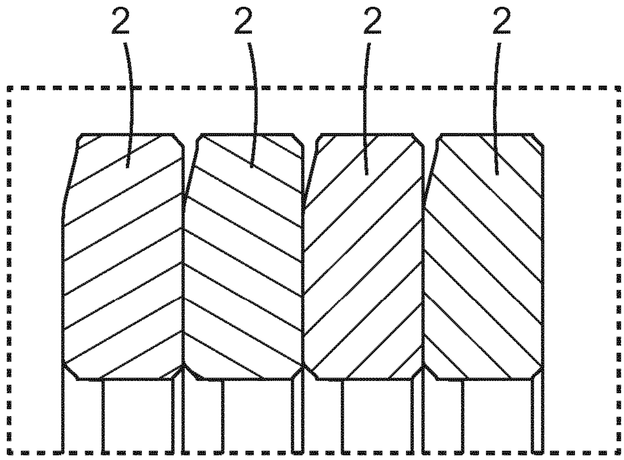

FIG. 3I

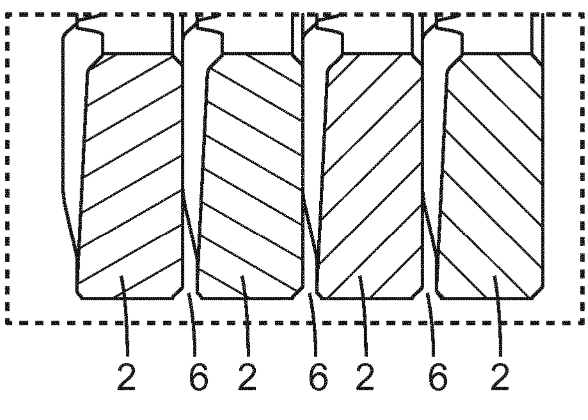

FIG. 3J

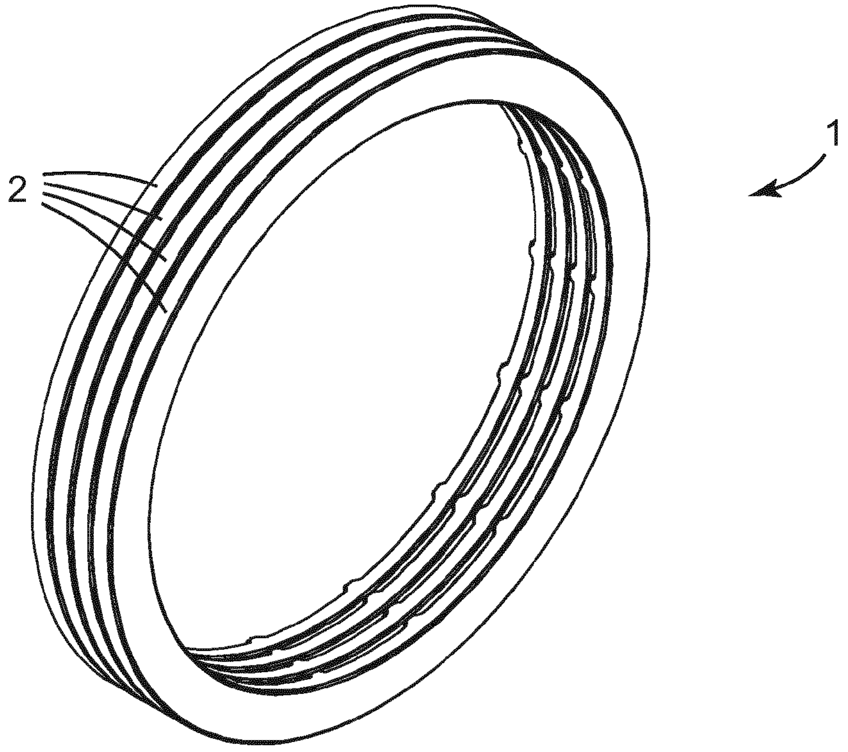

FIG. 3K

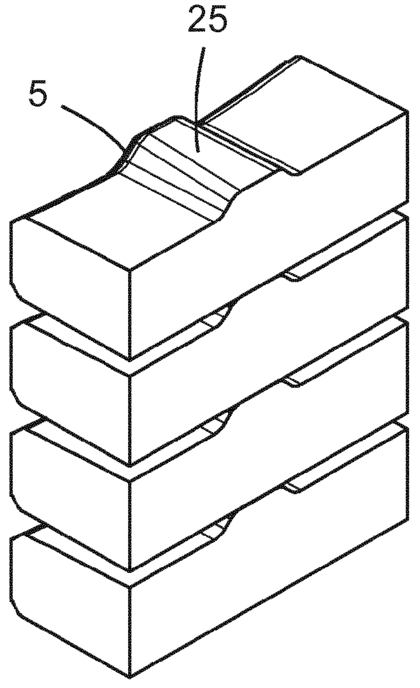

FIG. 3L

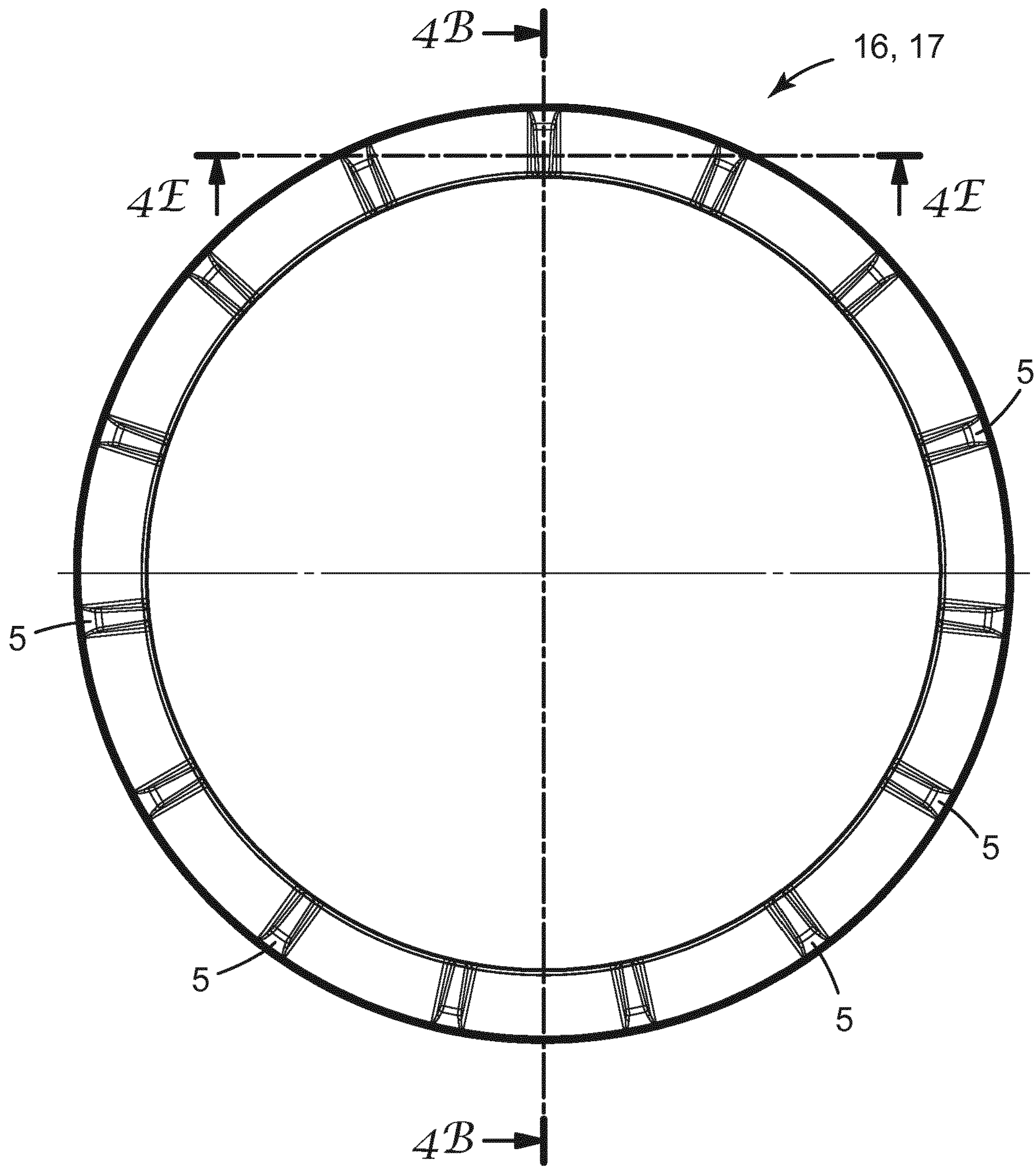

FIG. 4A

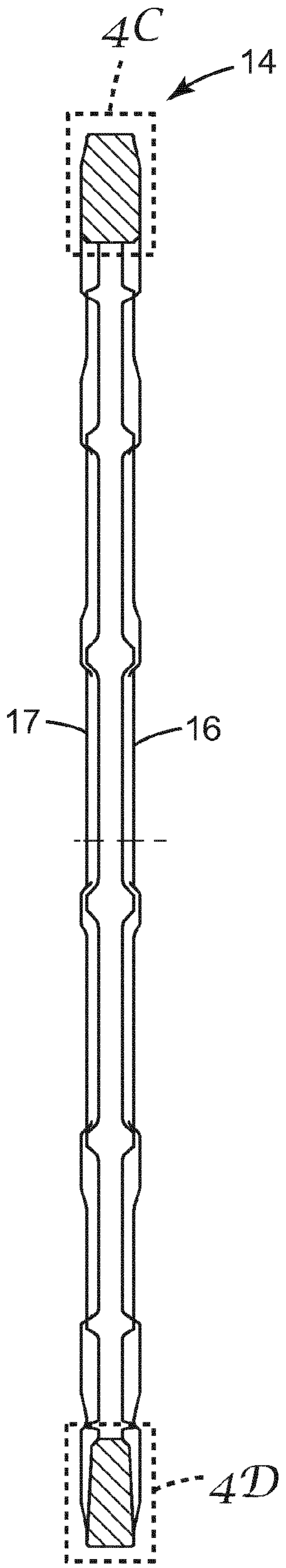

FIG. 4B

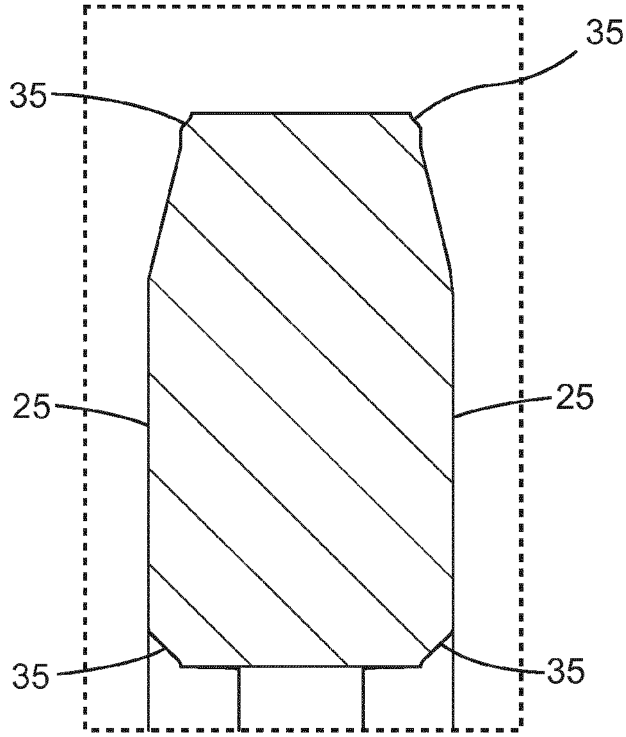

FIG. 4C

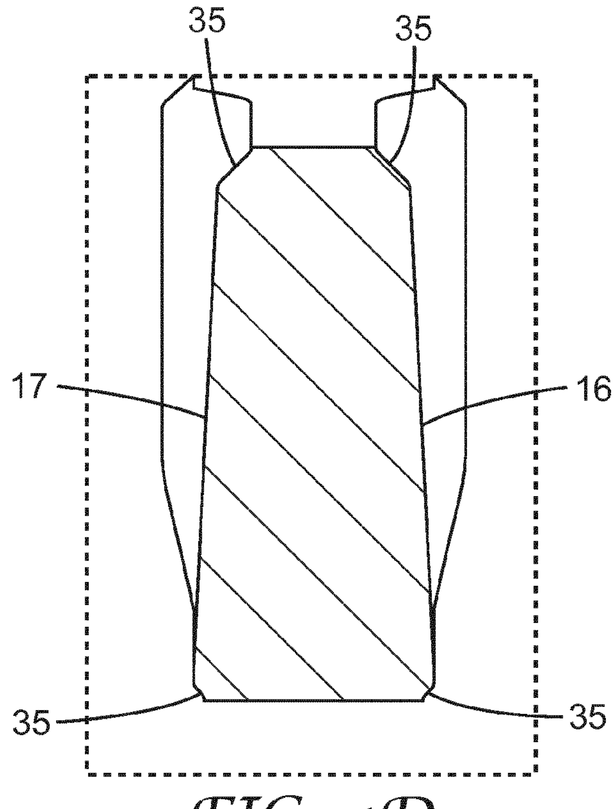

FIG. 4D

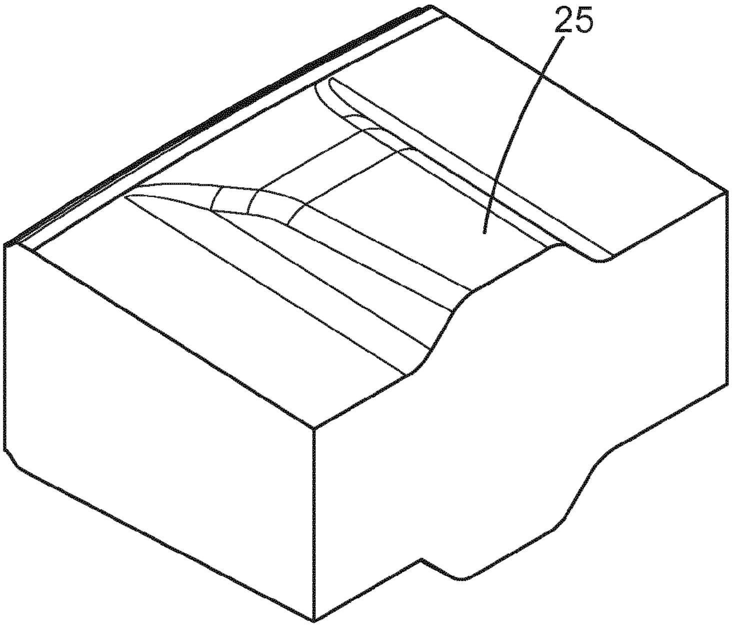

FIG. 4E

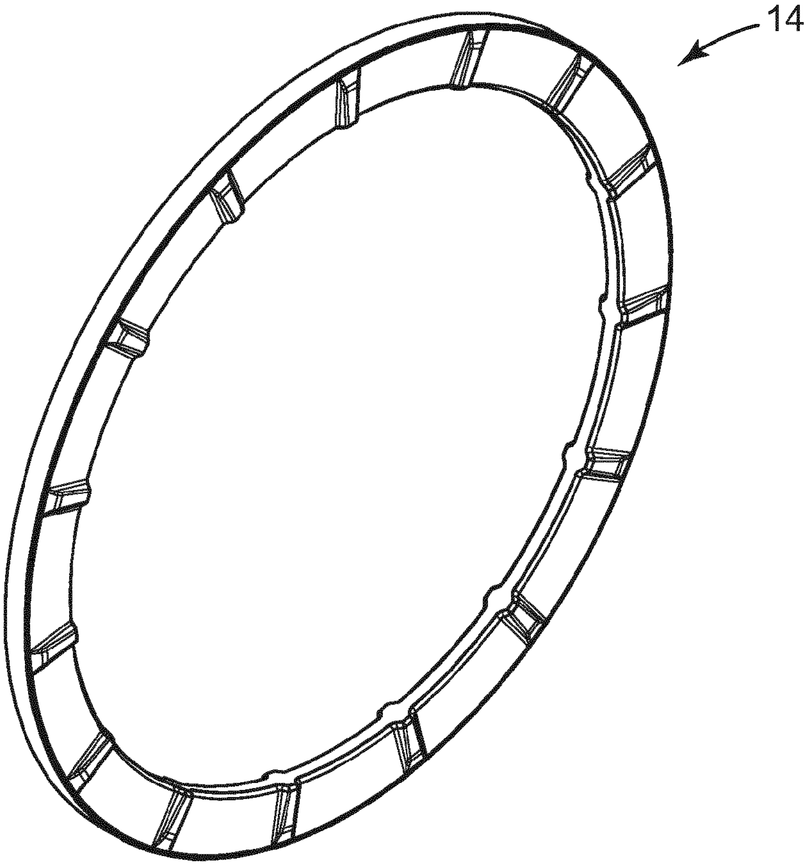

FIG. 4F

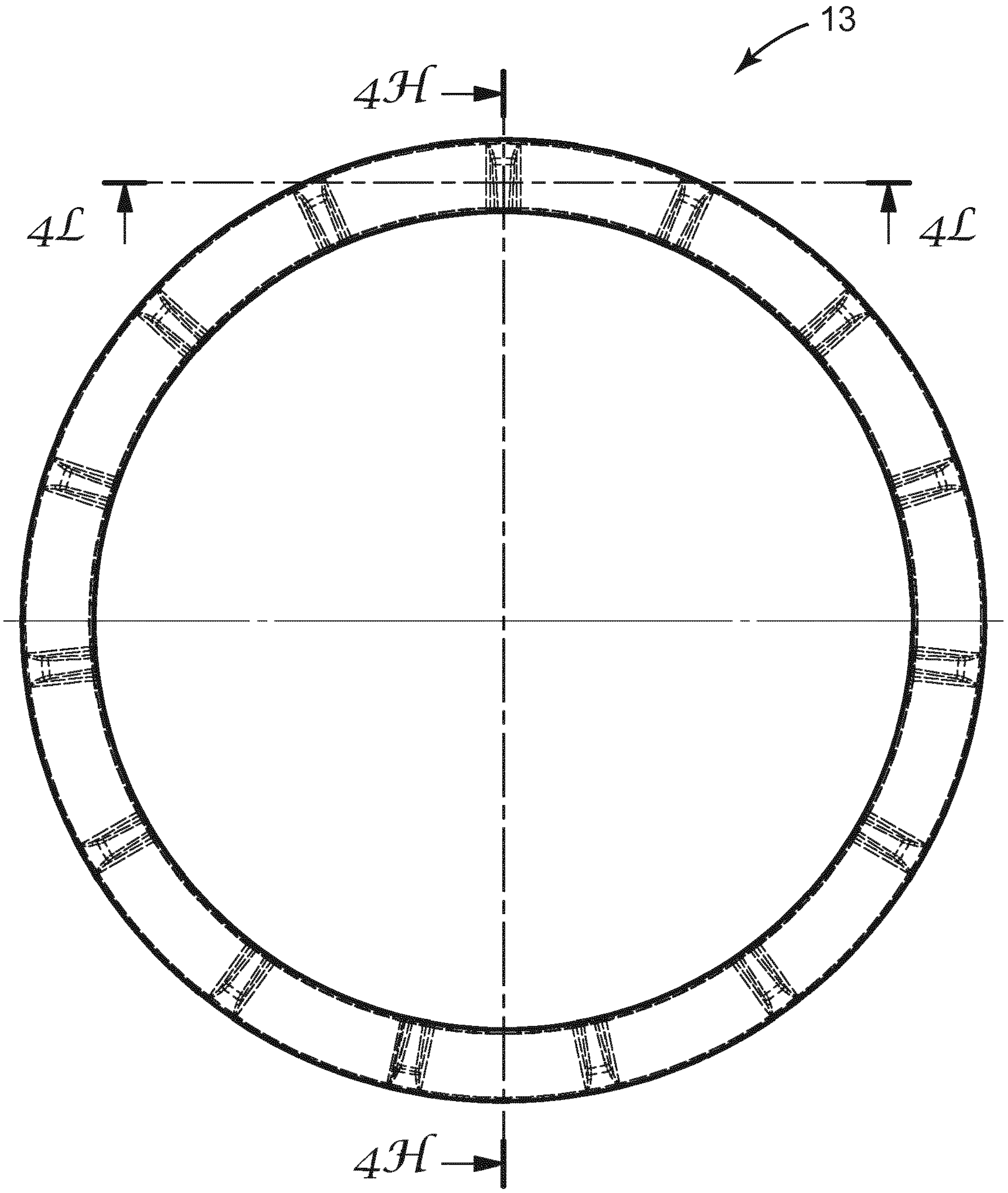

FIG. 4G

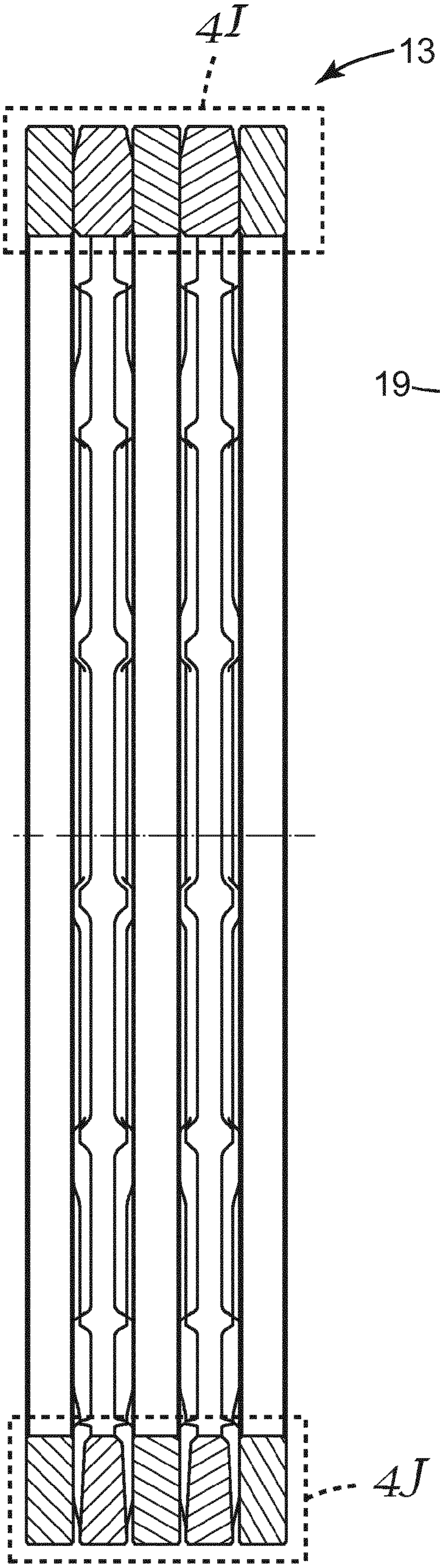

FIG. 4H

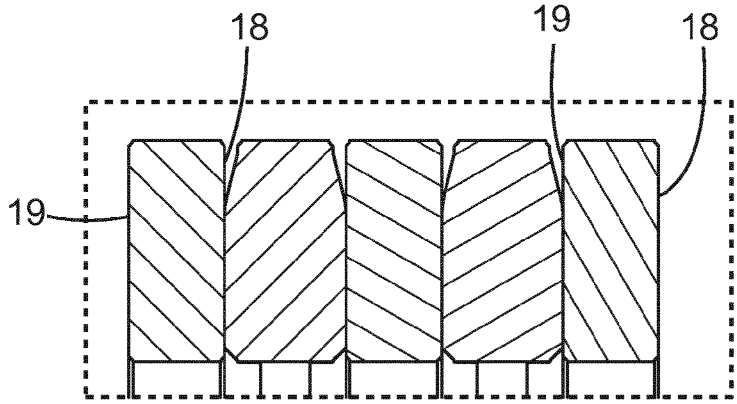

FIG. 4I

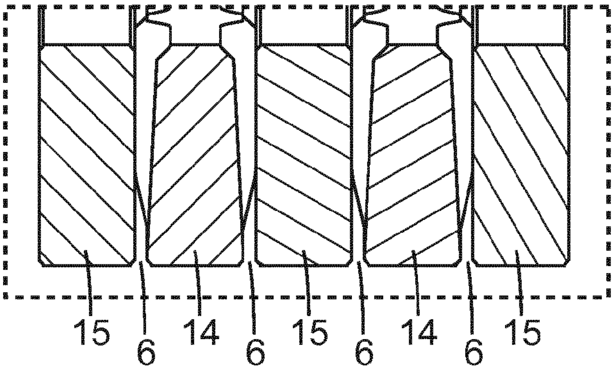

FIG. 4J

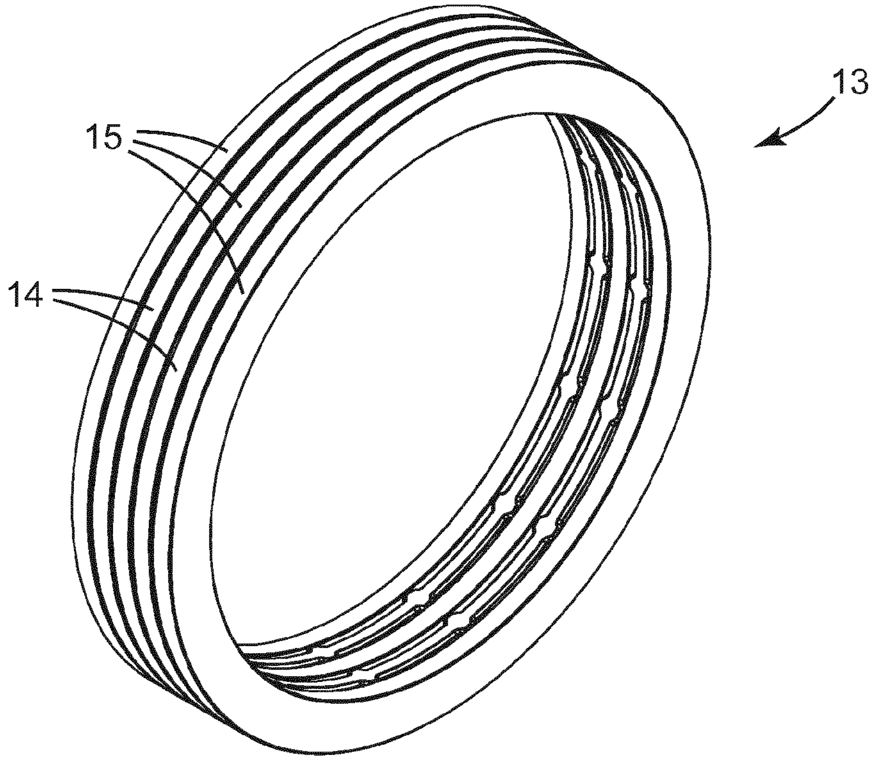

FIG. 4K

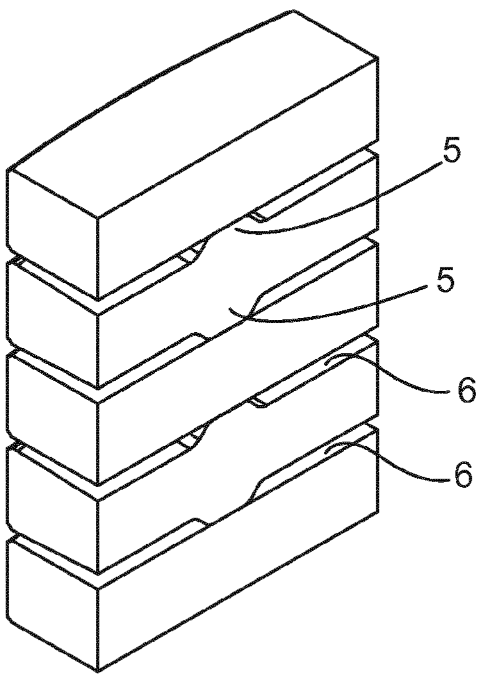

FIG. 4L

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EUROPEAN SEARCH REPORT

Application Number
EP 19 19 1660

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	5 February 2020	Dantinne, Patrick

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