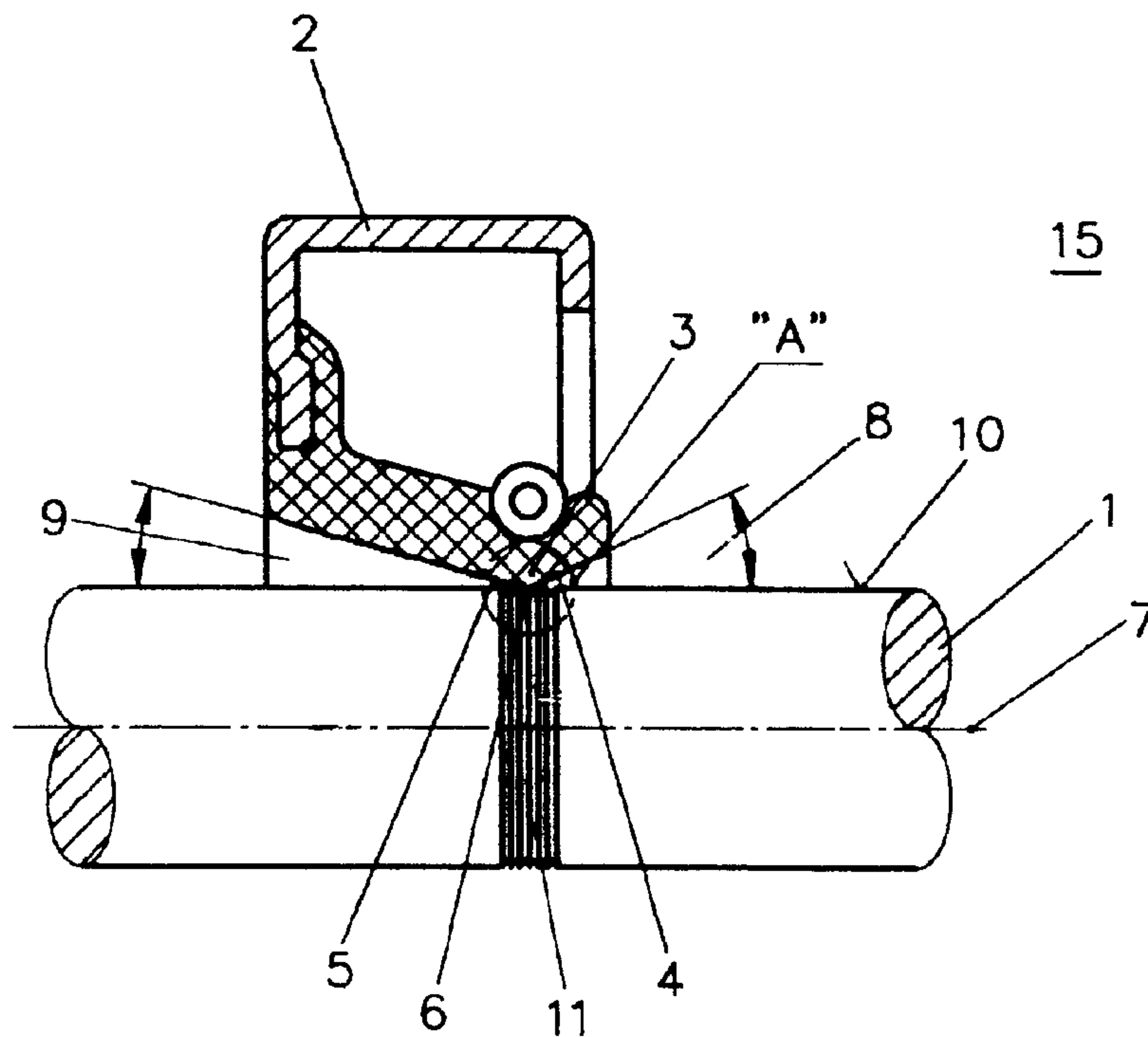




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 (54) Title: SEAL ARRANGEMENT



(57) **Abrégé/Abstract:**

Sealing arrangement for use with a rotatable machine element for maintaining a medium in a sealed space. The sealing arrangement includes a sealing surface on the machine element and a radially sealing ring having a polymeric sealing lip for engagement with the sealing surface. The sealing lip has a sealing edge defined by a pair of intersecting first and second conical surfaces, whereby the first conical surface is directed towards the sealed space and encloses a first angle with the axis of rotation which is steeper than the cone angle of the conical surface directed away therefrom. A helical groove with rounded base is machined into the sealing surface, whereby the groove base has a radius of curvature of 0.4 to 1.6mm and the depth of the groove is less than 15µm. The seal arrangement provides improved sealing characteristics and an extended service period due to reduced wear of the sealing edge.

ABSTRACT

Sealing arrangement for use with a rotatable machine element for maintaining a medium in a sealed space. The sealing arrangement includes a sealing surface on the machine element and a radially sealing ring having a polymeric sealing lip for engagement with the sealing surface. The sealing lip has a sealing edge defined by a pair of intersecting first and second conical surfaces, whereby the first conical surface is directed towards the sealed space and encloses a first angle with the axis of rotation which is steeper than the cone angle of the conical surface directed away therefrom. A helical groove with rounded base is machined into the sealing surface, whereby the groove base has a radius of curvature of 0.4 to 1.6mm and the depth of the groove is less than 15 μ m. The seal arrangement provides improved sealing characteristics and an extended service period due to reduced wear of the sealing edge.

SEAL ARRANGEMENT

The invention relates to seal arrangements for rotating machine elements, in particular to rotary shaft seals and box seals for rotating shafts and to a method for producing a sealing surface.

Box seals and a method for producing a sealing surface are known in the art for example from German published application DE-OS 15 433. This reference teaches a shaft to be sealed which is provided with circumferential grooves that are oriented at an angle to the longitudinal axis of the shaft to produce an angular reconveyance momentum. It is mentioned that the reconveyance momentum is lost after a short period of operation at the point of largest pressure of the sealing ring against the shaft, because of the resulting form change and the associated wear of the sealing ring until no more wear occurs. In the immediate vicinity of the area of lost reconveyance momentum, the existing grooves still provide such a momentum. Thus, the prior art teaches that a reconveying thread would destroy the sealing edge of the radial seal.

The depressions in the surface of the shaft to be sealed for production of the angular momentum for reconveyance of the sealed medium are made by way of a simple plunge cutting process, for example, using rotating abrasion discs, or a polishing disc provided with abrading powder. It is a disadvantage of this surface abrasion process that it is hard to predict whether the resulting seal arrangement will exhibit satisfactory sealing properties during use. The polished surface has a hard to predict number of helical grooves of different depth with several threads. Furthermore, the number and shape of the threads generated during manufacture of the sealing surface varies unpredictably, independent of the condition of the abrasive disc, the vibration characteristics of the disc drive shaft and/or the surface to be polished, and the mutual spacial orientation of the axes of rotation. Due to the almost accidental shape of the multi-thread grooves in the sealing surface, the volume of the sealed medium in the grooves can be so large that the radial seal ring is no longer capable of reconveying the sealed medium into the sealed space.

It is now an object of the invention to provide a seal arrangement of the above disclosed general type which is improved so that the manufacturing process dependent angular reconveyance momentum on the surface is measurable and quantifiable with respect to its effect on the sealing characteristics in order to avoid failure of the sealing arrangement due to undesired characteristics of the sealing surface. The sealing surface is prepared in such a way that the radial sealing ring, independent of the direction of rotation of the rotating machine element, is capable of reconveying the volume required for lubrication of the sealing lip back to

the sealed space.

This object is achieved in accordance with the invention by providing a helical groove which is machined into the sealing surface and has a rounded base. The base has a preselected radius of from 0.4 to 1.6mm and a depth of less than $15\mu\text{m}$.

Accordingly, the invention provides a sealing arrangement for a rotatable machine element, comprising a sealing surface on the machine element, a radially sealing ring having a polymeric sealing lip for engagement with the sealing surface, the sealing lip having a sealing edge defined by a pair of intersecting first and second conical surfaces, whereby the first conical surface which is directed towards the sealed space includes an angle with the axis of rotation which is steeper than the angle between the axis of rotation and the second conical surface directed away from the sealed space, and a helical groove with rounded base machined into the sealing surface, the groove base having a radius of curvature of 0.4 to 1.6mm and a depth of less than $15\mu\text{m}$.

Machined surfaces are much cheaper manufactured than polished surfaces. Furthermore, the angular conveyance momentum on the surface achieved by machining can be measured and its effect on the sealing characteristics of the radial sealing rings quantified. Thus, it is possible to cheaply and easily test whether the machined surface was manufactured to the desired specifications. Depending on the direction of rotation, the machined surface conveys more or less strongly in axial direction along the sealing surface. At a radius of curvature of 0.4 to 1.6mm and a depth of less than $15\mu\text{m}$ the radial seal ring is capable, independent of the direction of rotation, of reconveying the volume of sealed liquid required for lubrication of the sealing lip back to the sealed space. The reconveying momentum on the radially sealing ring is achieved by the two conical surfaces, whereby the first conical surface directed towards the sealed space encloses a more acute angle with the axis of rotation than the conical surface directed away therefrom.

Preferably, the groove base has a maximum depth of $10\mu\text{m}$. Due to the small depth of the groove, the wear on the sealing lip during operation is reduced so that the sealing arrangement in accordance with the invention provides further improved sealing characteristics over an extended service period.

The spacing of adjacent threads of the helical groove is preferably 0.03 to 0.3mm center to center. At distances up to 0.3mm, the angular conveyance momentum on the sealed medium out of the sealed space is, independent of the direction of rotation of the machine element, in any case sufficiently small so that a reliable sealing by the radially sealing ring is maintained. Distances of less than 0.03 are of little use, since the processing of such surfaces

requires a relative long time and the measurement of the momentum becomes considerably more difficult.

To obtain good operating characteristics over a long service period, the width of the sealing lip is preferably 1.5 to 4 times larger than the slope of the groove.

The machine element is preferably a rotatable shaft or the rotating ring of a box seal.

The invention further provides a method for the manufacture of the sealing surface of a sealing arrangement. To achieve this object, the invention provides for a process wherein the sealing surface is machined at a feed of 0.03 to 0.3mm, a cutting speed of 80 to 400m/min and a cutting depth of 0.04 to 0.4mm. With such a process a mean roughness value R_a according to DIN 4762 of 0.05 to $2\mu\text{m}$ is achieved. The mean roughness value R_a is the arithmetic mean of all values of the profile measurements of the roughness profile. Furthermore, a mean roughness depth R_z according to DIN 4768 is achieved which is 0.2 to $10\mu\text{m}$. The mean roughness depth R_z is the mean of the individual roughness depths of adjacent individual measurement tracks. The maximum roughness depth R_{max} according to DIN 4768 which is the largest individual depth along the total measured track, is at most $15\mu\text{m}$ with the process in accordance with the invention.

Preferred embodiments of the sealing arrangement and process in accordance with the invention will be described further by way of example only and with reference to the accompanying drawings, wherein:

Figure 1 is a schematic illustration of a first preferred embodiment of the sealing arrangement in accordance with the invention wherein the machine element is a shaft;

Figure 2 is a schematic illustration of a second preferred embodiment wherein the machine element is the rotating ring of a box seal;

Figure 3 is an enlargement of the detail A identified in Figures 1 and 2; and

Figure 4 shows the sealing surface in enlarged illustration.

Figure 1 illustrates a first preferred embodiment of the invention, wherein the machine element is a sealed rotating shaft 1 engaged about its circumference by a radially sealing ring 2. The sealing lip 3 of the radial sealing ring 2 has a sealing edge 6 which is defined by two intersecting conical surfaces 4, 5. The sealed medium is found within the sealed space identified by reference numeral 15. The first conical surface 4 directed towards the sealed space 15 encloses a first angle 8 with the axis of rotation 7 which is larger than a second angle 9 which the second conical surface encloses with the axis of rotation 7. The sealing edge 6 sealingly engages the surface 10 under radial tension, whereby the width of the sealing edge 6 is 1.5 to 4 times larger than the slope of the groove 11 so that a good static seal is guaranteed even when

the machine element 1 is stationary.

The partial area of the surface 10 which forms the engagement surface for the sealing edge 6 is provided with at least one helical groove 11 which has a rounded base 12, whereby the groove base 12 has a radius of curvature of 0.4 to 1.6mm, in this embodiment 1.0mm.

Figure 2 illustrates a second preferred embodiment of the sealing arrangement in accordance with the invention which is distinguished from the one shown in Figure 1 in that the machine element 1 is the rotating ring 17 of a box seal 18 which has a machined surface 10.

Figures 3 and 4 show an enlargement of the detail A identified in Figures 1 and 2.

It is also possible to manufacture the sealing surface 10 according to the process in accordance with the invention. The sealing surface 10 is thereby machined at a feed of 0.03 to 0.3mm, a cutting speed of 80 to 400m/min, and a cutting depth of 0.04 to 0.4mm.

The manufacture of a machined surface 10 as engagement surface for the radially sealing ring 2 is especially easy and cost efficient. The angular reconveyance momentum created on the surface 10 with the process in accordance with the invention can be exactly measured and quantified in terms of its effect on the sealing characteristics of the radially sealing ring, since the machining creates a momentum with a slope corresponding to the feed.

It is an advantage of the sealing arrangement of the invention that, when the mentioned parameters are followed, the radially sealing ring 2, by way of the shape and positioning of the two conical surfaces 4, 5 and independent of the direction of rotation of the machine element 1, reconveys a sealed medium in axial direction back to the sealed space 15, even when the groove 11 is machined into the sealing surface 10 in such a way that the sealed medium is conveyed away from the sealed space 15.

CLAIMS:

1. Sealing arrangement for use with a machine element rotatable about an axis and for maintaining a medium in a space to be sealed, comprising
 - a sealing surface on the machine element with a helical groove machined thereinto and having a slope and a rounded base, the groove base having a radius of curvature of 0.4 to 1.6mm and a depth of less than 15 μ m;
 - a radially sealing ring having a polymeric sealing lip with a sealing edge for engagement with the sealing surface; and
 - a pair of first and second intersecting conical surfaces on the sealing lip for defining the sealing edge, the first conical surface facing the space to be sealed and enclosing a first angle with the axis, and the second conical surface facing away from the space to be sealed and enclosing a second angle with the axis which is steeper than the first angle.
2. Sealing arrangement according to claim 1, wherein the groove has a maximum depth of 10 μ m.
3. Sealing arrangement according to claim 1 or 2, wherein adjacent threads of the groove are spaced at a distance of 0.03 to 0.3mm on center.
4. Sealing arrangement according to one of claims 1 to 3, wherein the width of the sealing edge is about 1.5 to 4 times larger than the slope of the groove.
5. Sealing arrangement according to one of claims 1 to 4, wherein the machine element is a rotatable shaft.
6. Sealing arrangement according to one of claims 1 to 4, wherein the machine element is the rotating ring of a box seal.
7. Process for the production of the sealing surface of a sealing arrangement as defined in claims 1 to 6, characterized in that the sealing surface is machined with a feed of 0.03 to 0.3mm and a cutting speed of 80 to 400 m/min, and a cutting depth of 0.04 to 4 mm.

Fig.1

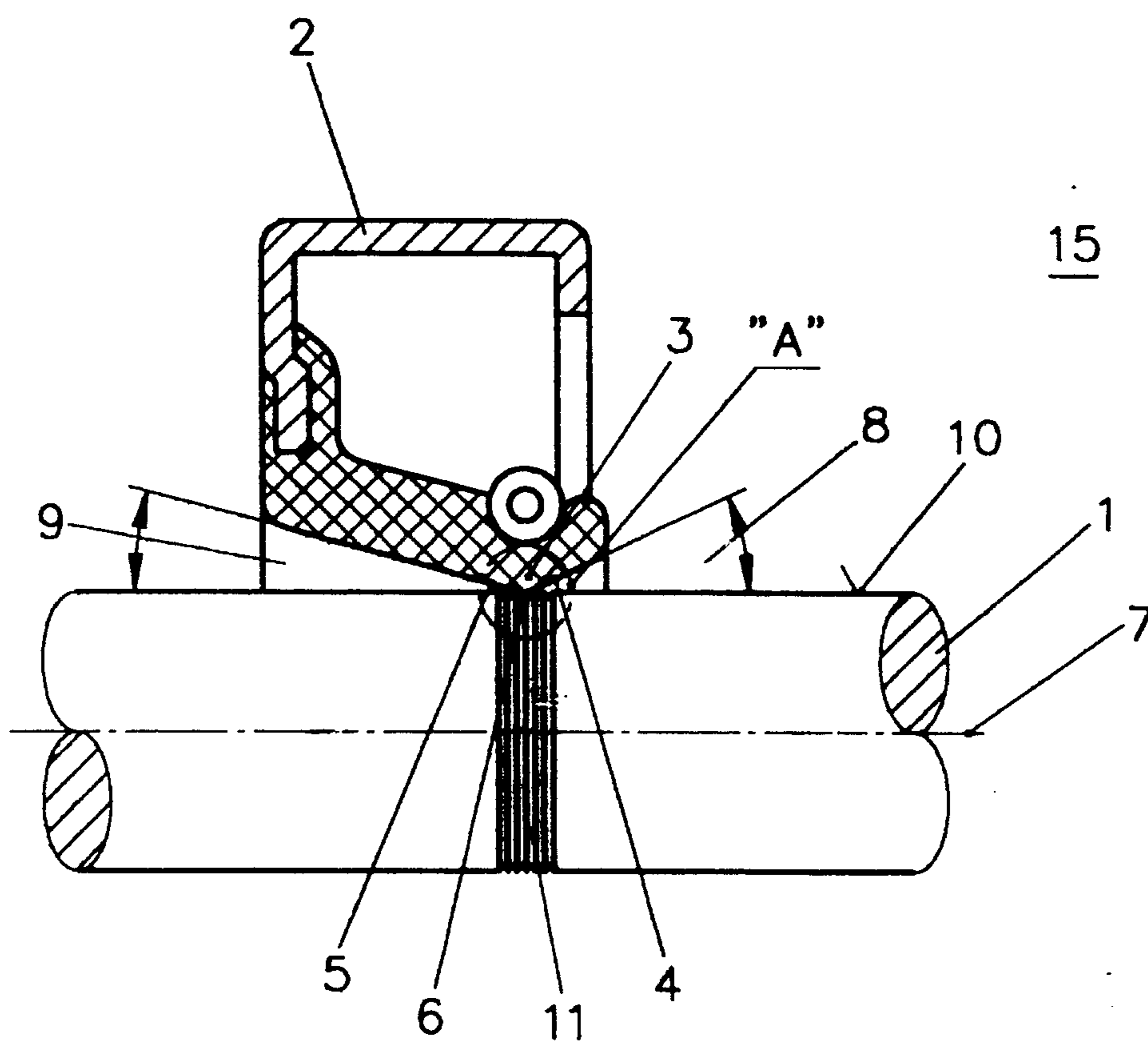


Fig.2

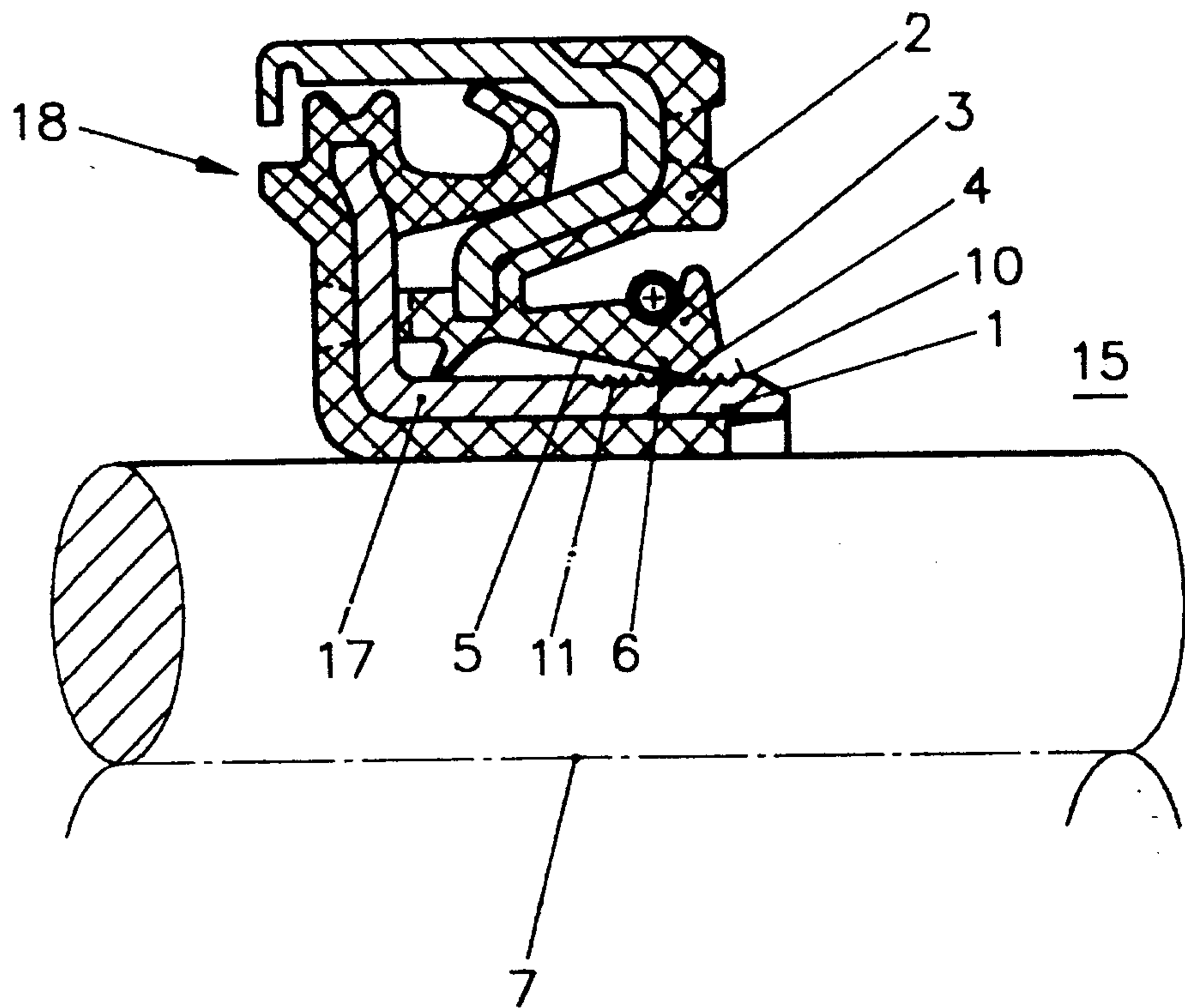
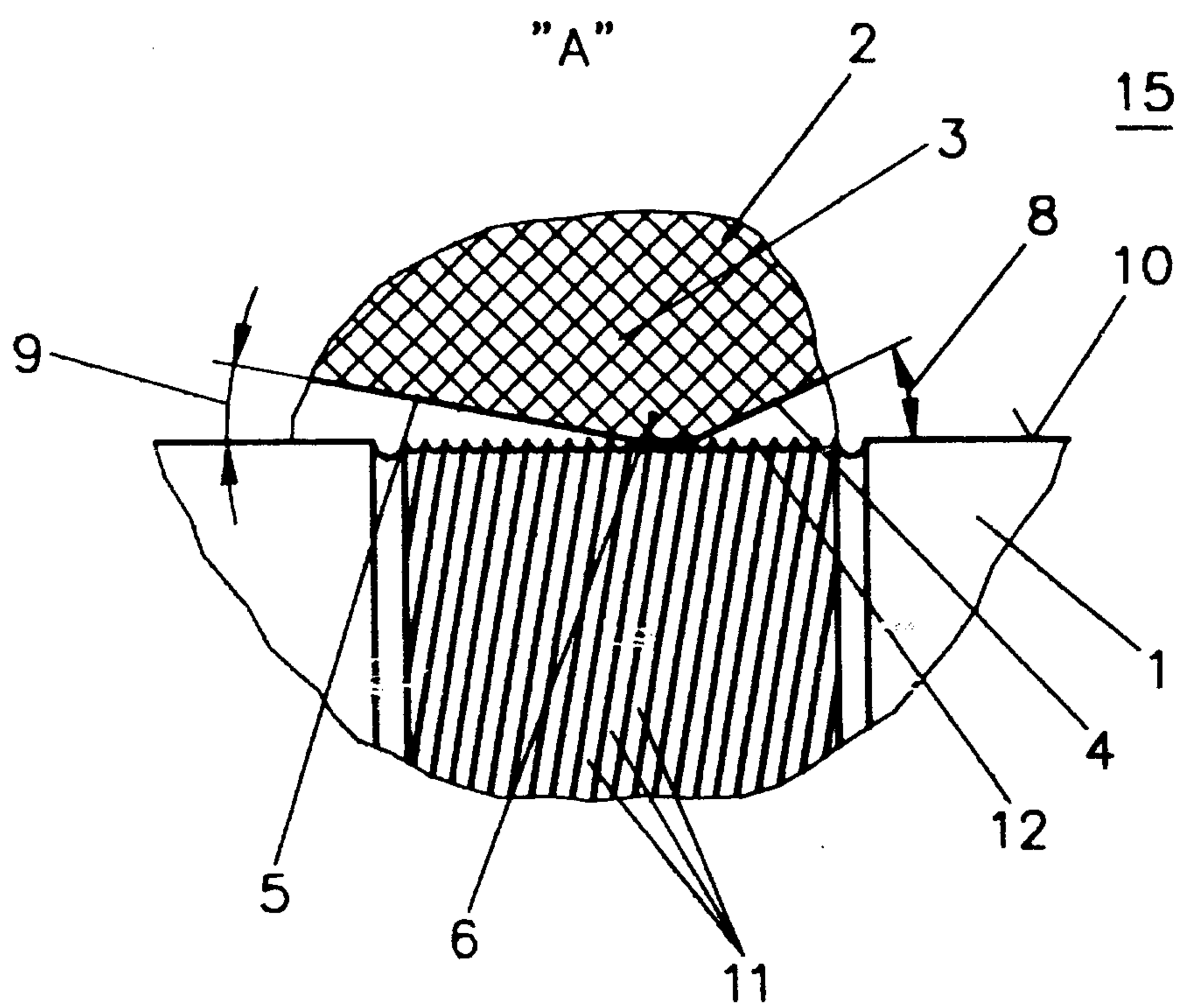
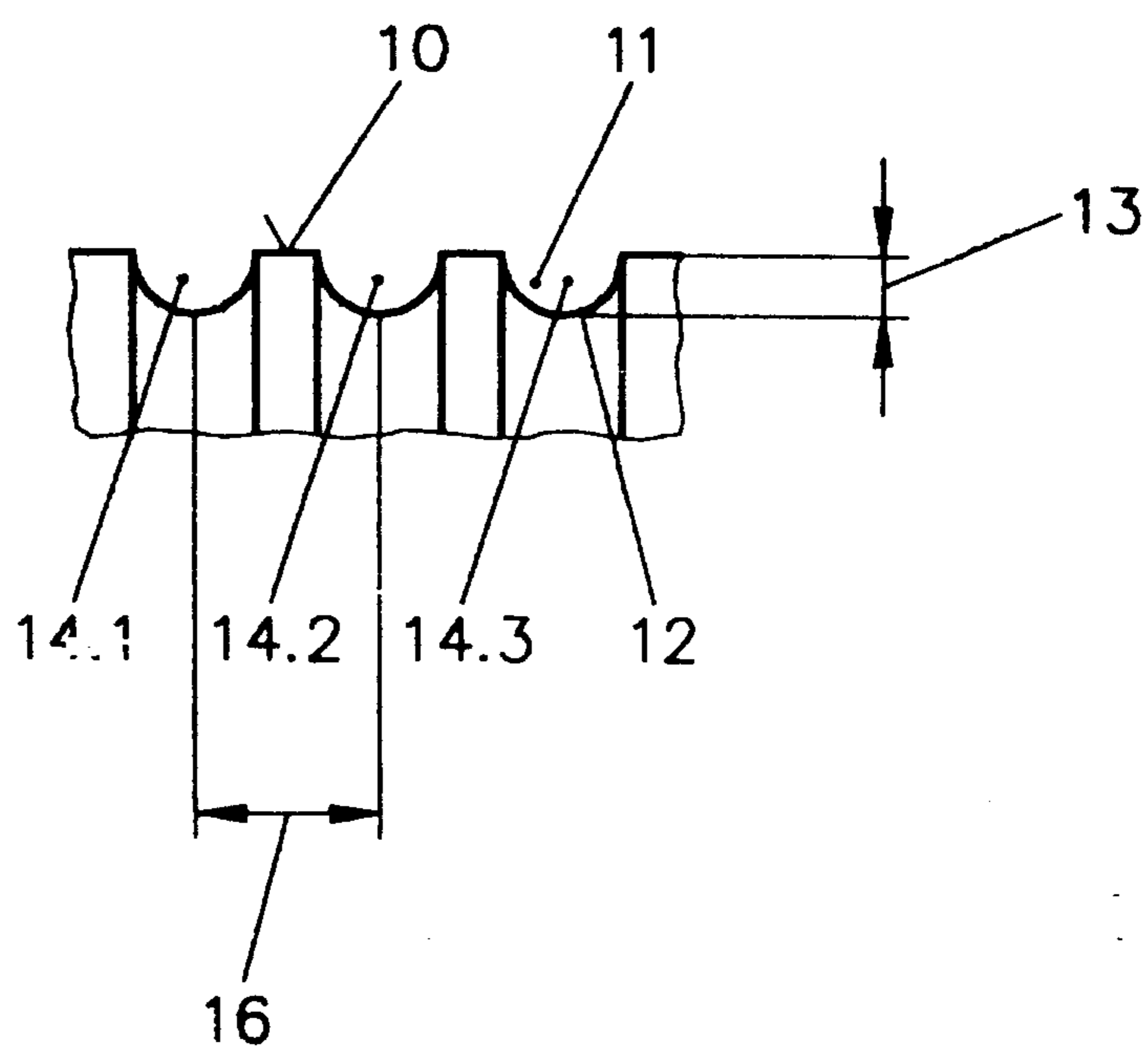


Fig.3



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Fig.4



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