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(54) **SEALING ARRANGEMENT FOR SHAFT AND TUNNEL CONSTRUCTION**

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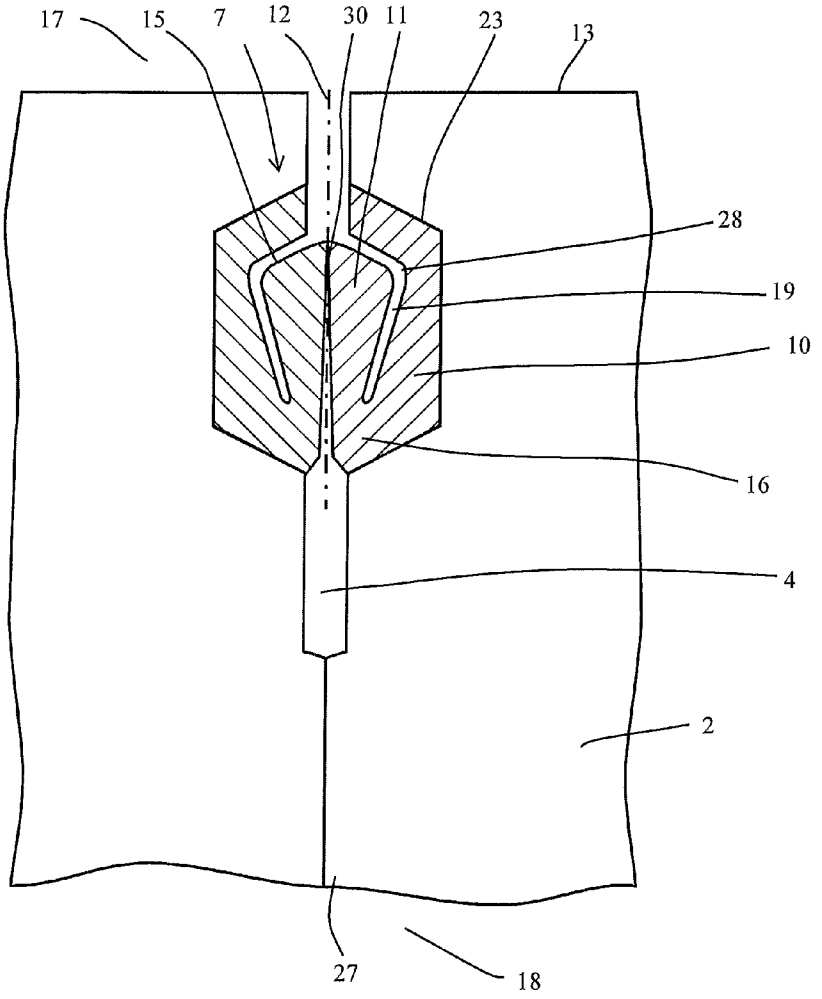
(57) **ABSTRACT**

A sealing arrangement for shaft and tunnel construction. The elastic tension forces that arise when the sealing systems are pressed against each other by reducing the joint clearance, after the systems have been brought into contact with each other, are reduced or completely avoided relative to prior art, and the required surface contact pressure is achieved by means of a self-sealing force effect of the media pressure. In order to achieve the force effect, the geometry of the sealing elements of the sealing system is designed such that the elements comprise pressure surfaces relative to a vacuum or atmosphere after contacting each other. A differential pressure acts on the pressure surfaces, resulting in the force ensuring the required surface contact pressure on the surface, by means of which the sealing elements contact one another at the contact plane.



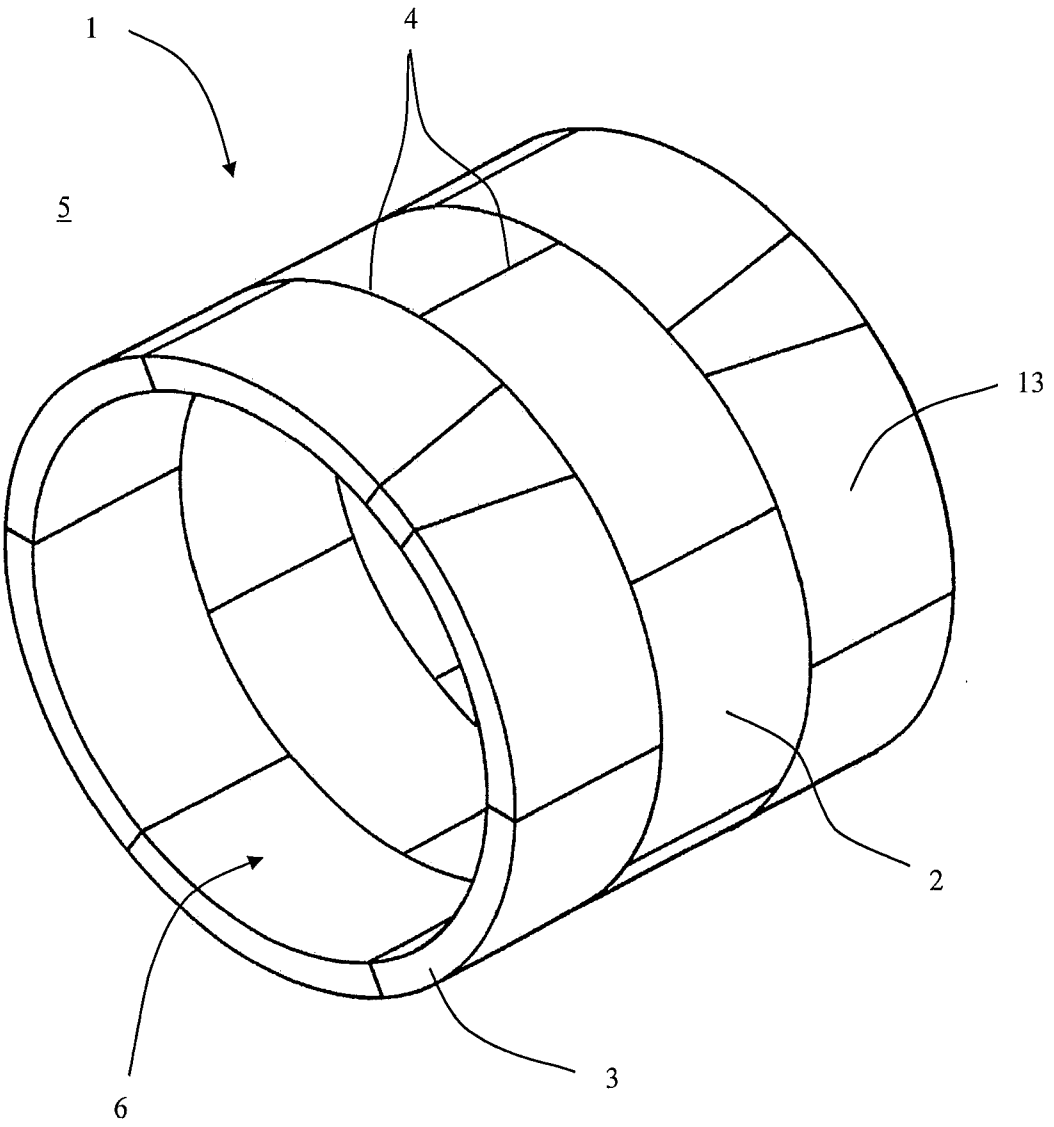



Fig. 1

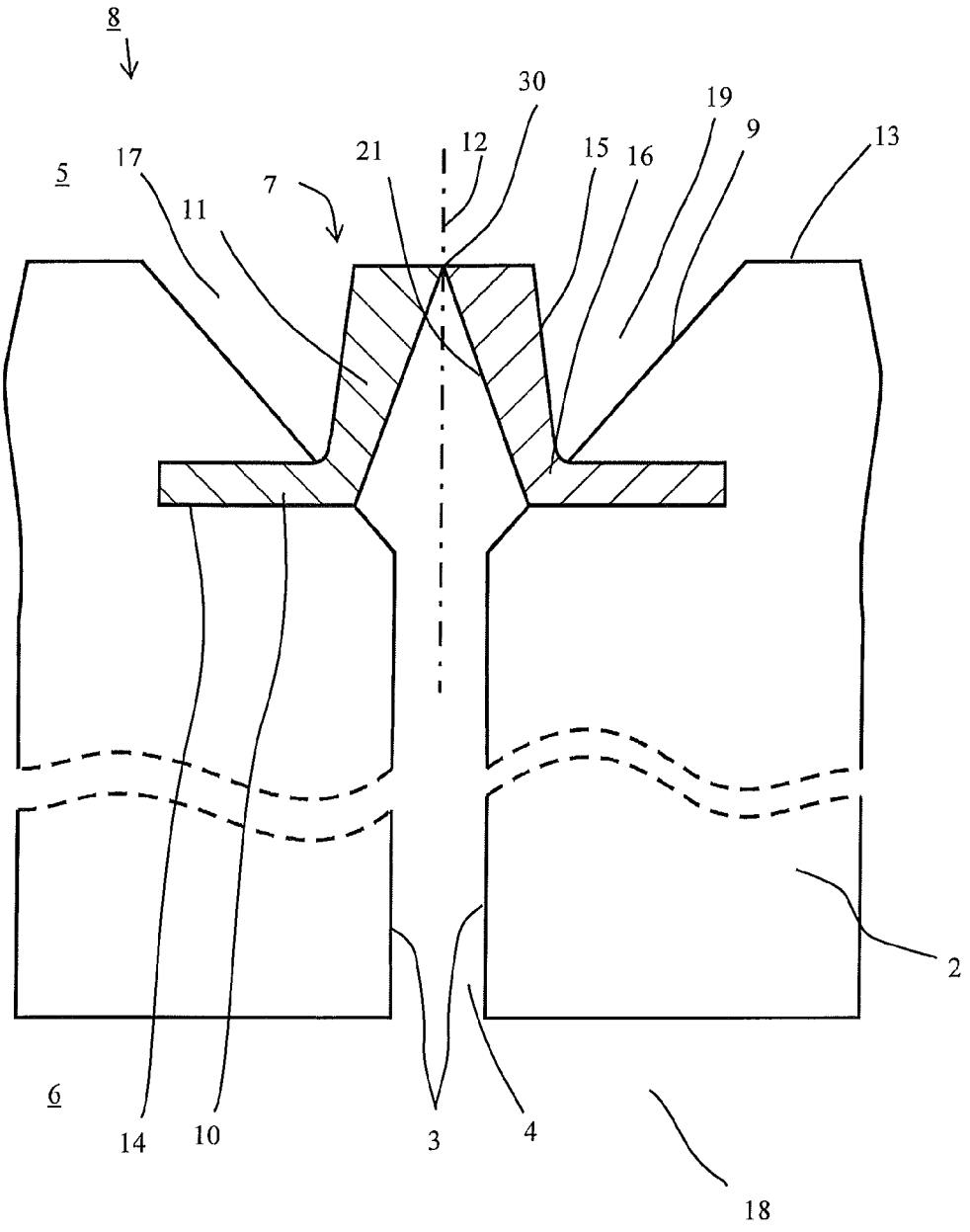



Fig. 2

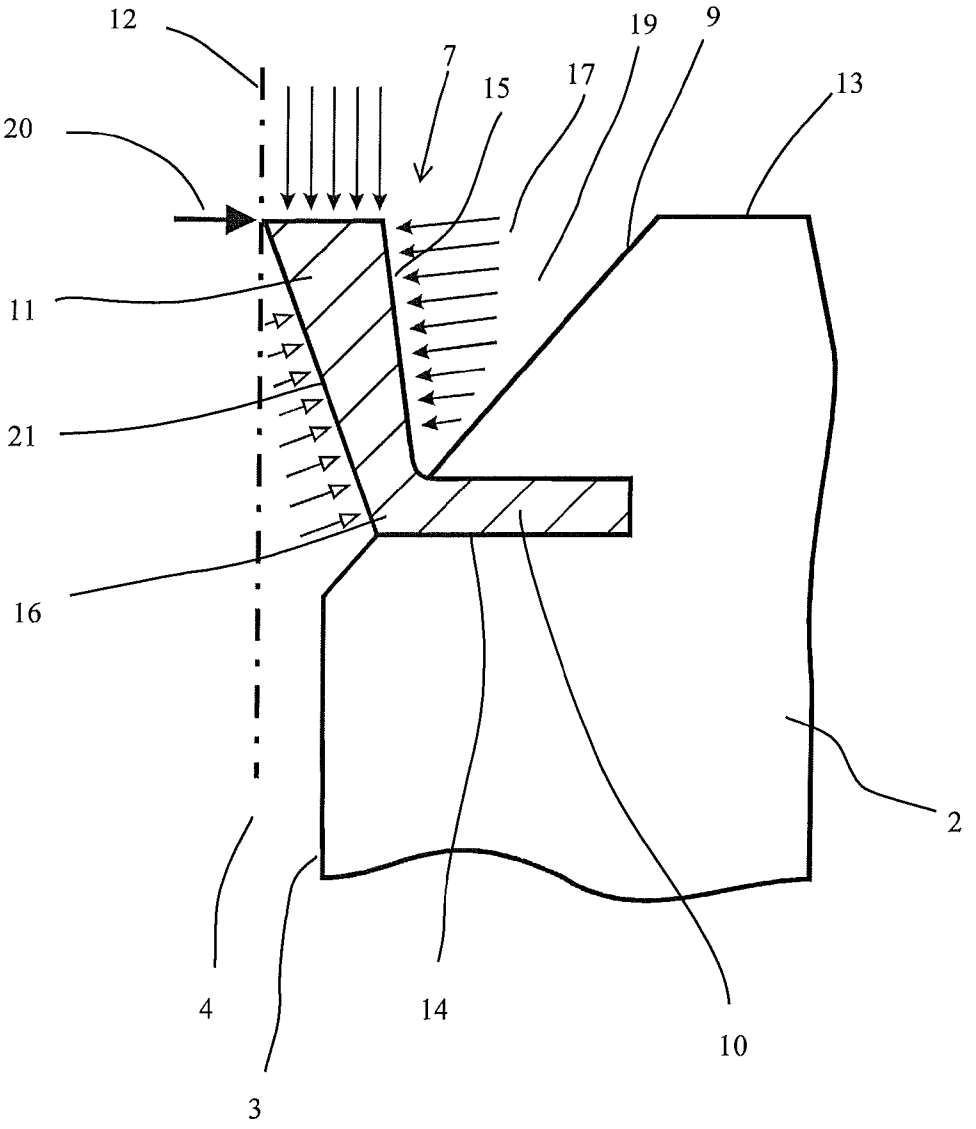



Fig. 3

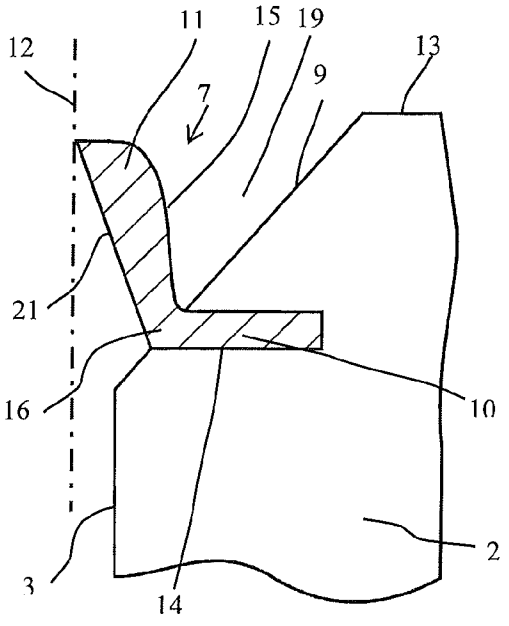



Fig. 4A

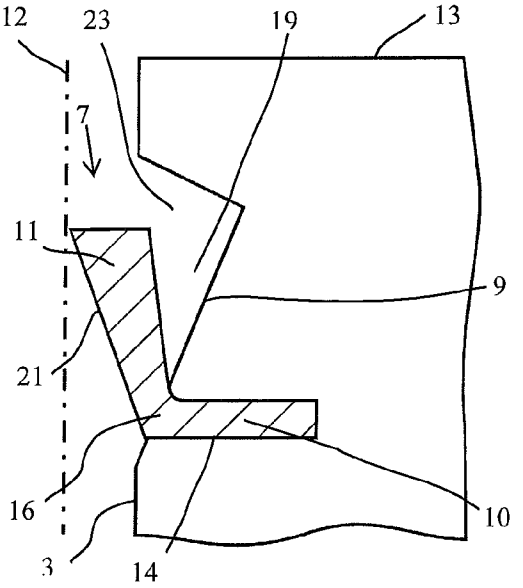



Fig. 4B

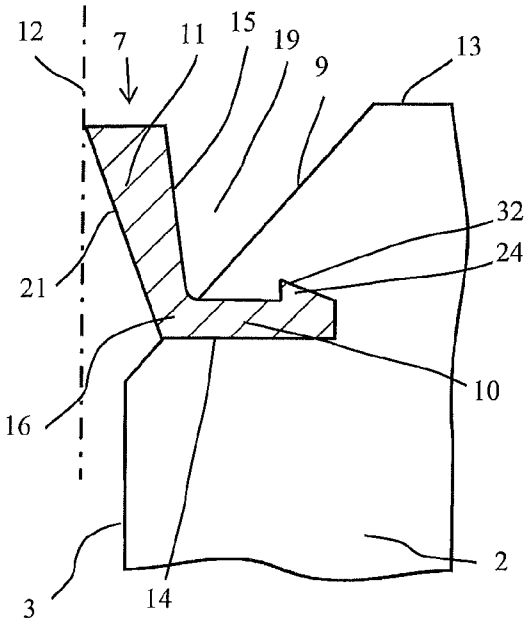



Fig. 4C

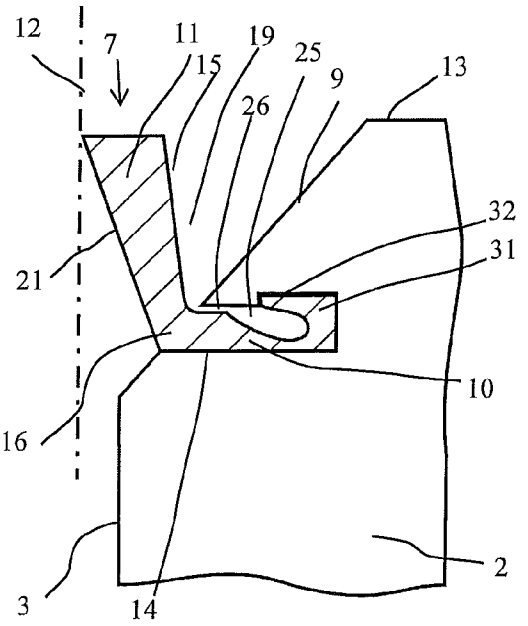



Fig. 4D

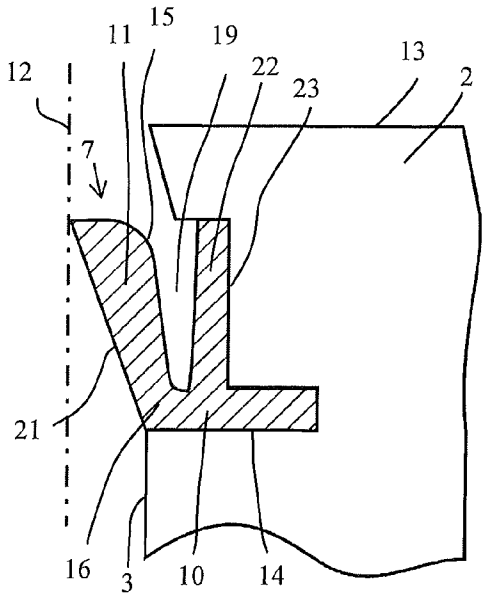



Fig. 5A

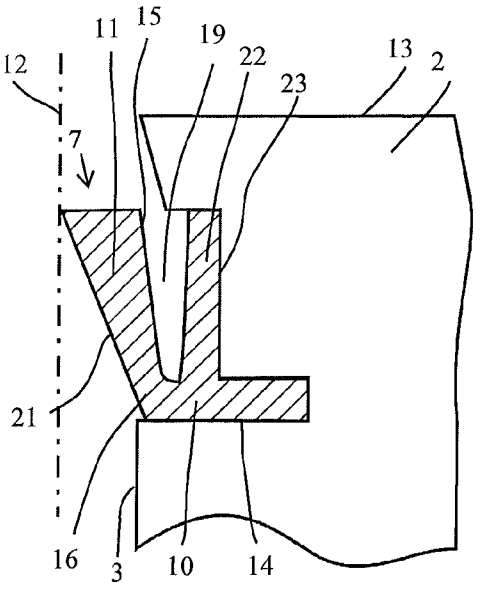



Fig. 5B

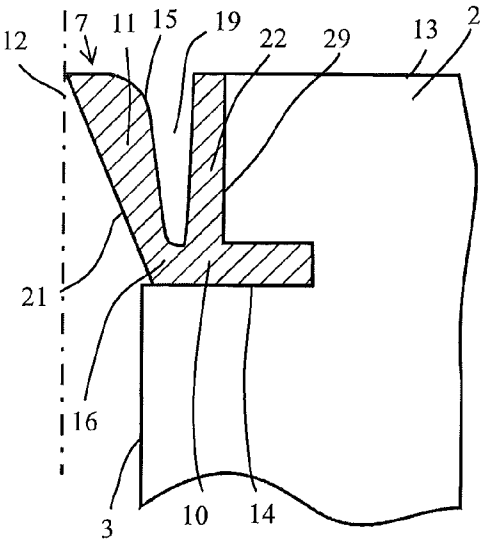



Fig. 5C

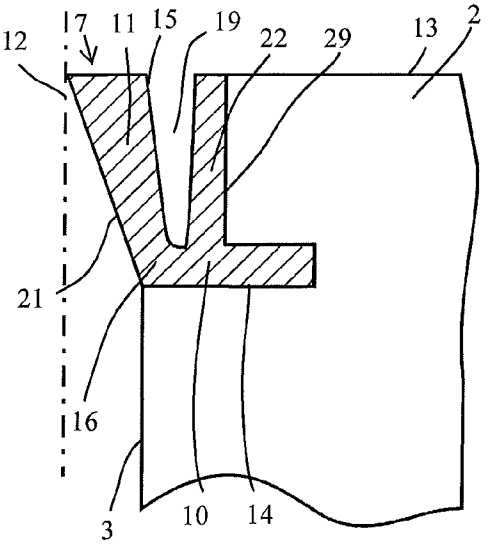



Fig. 5D

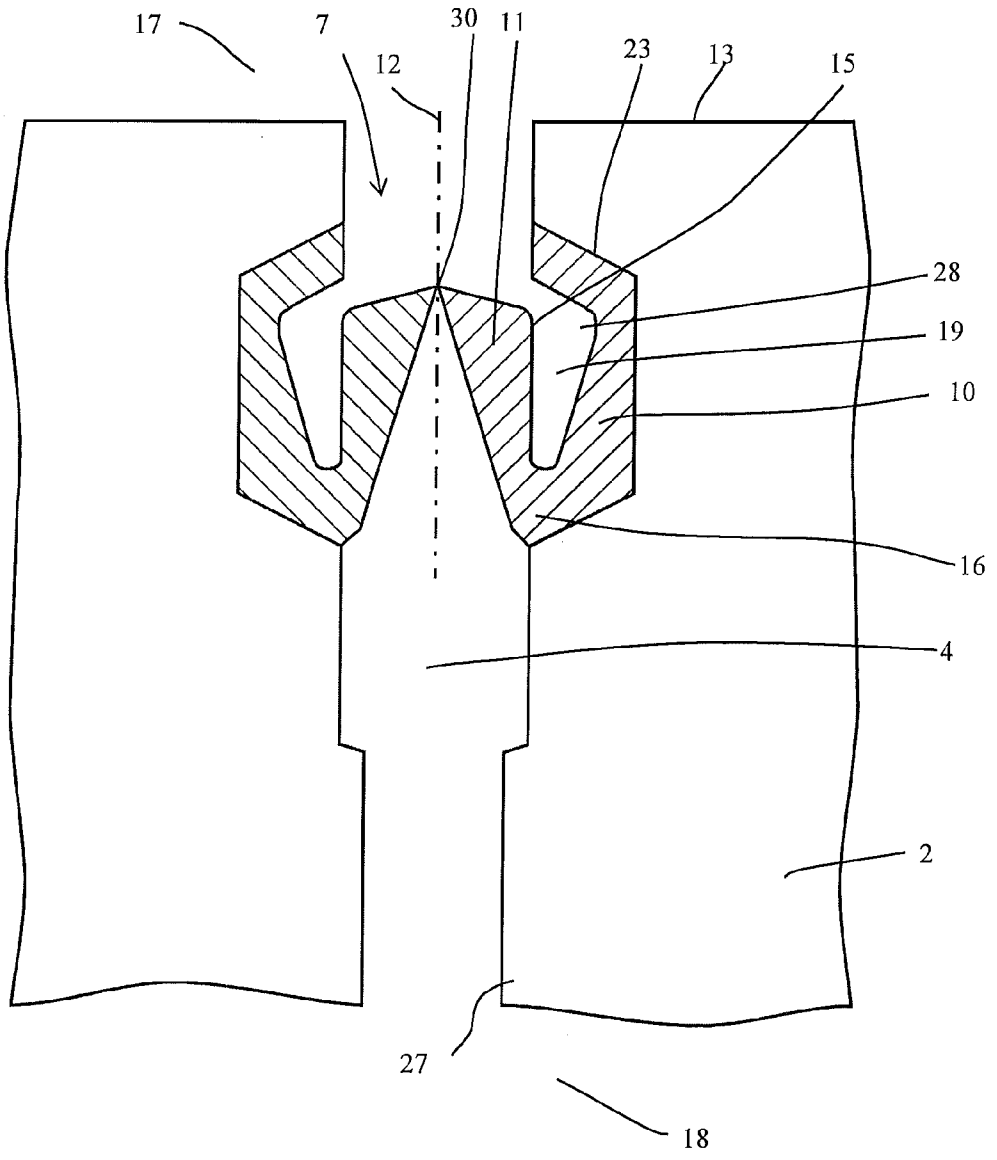



Fig. 6

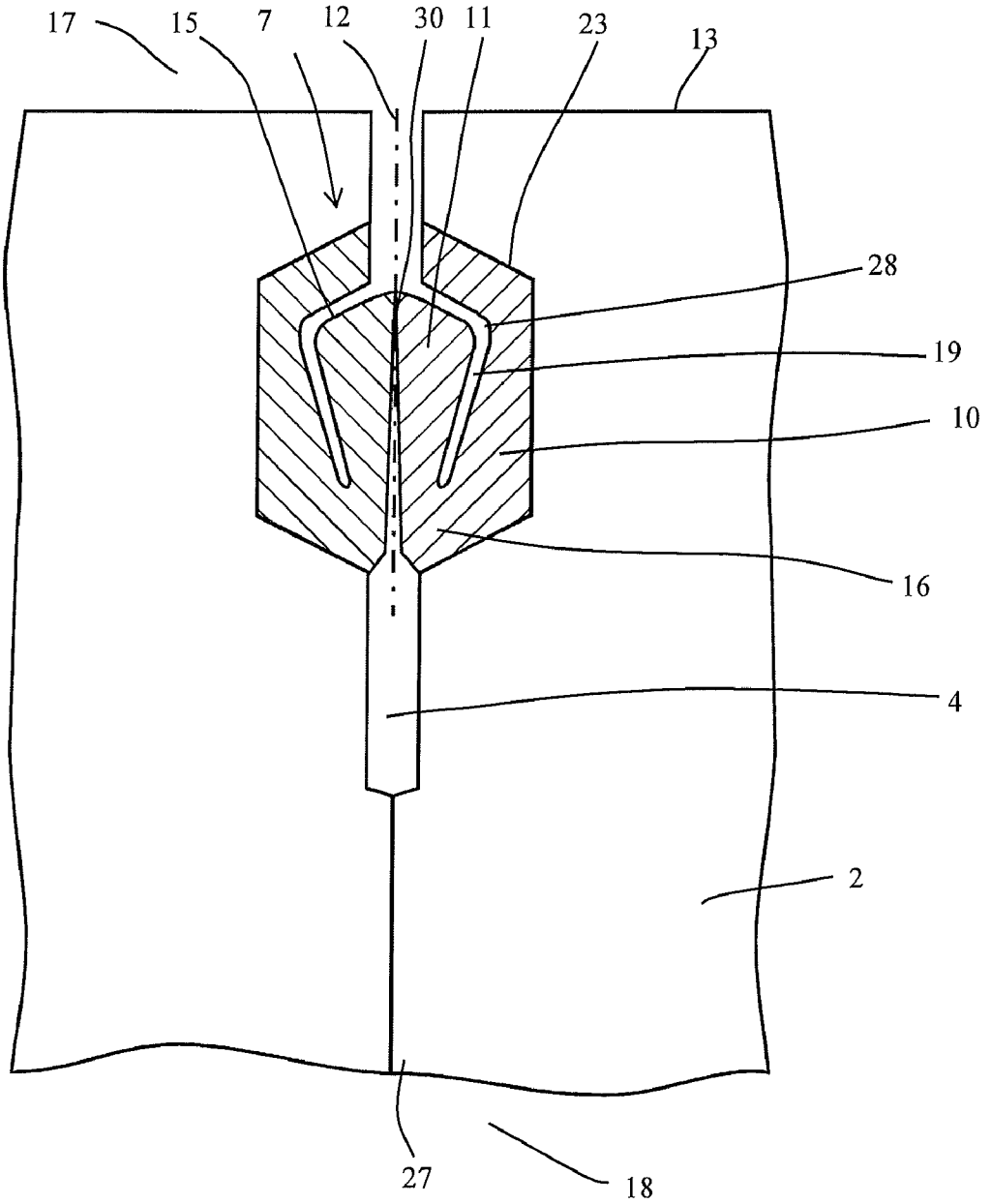



Fig. 7

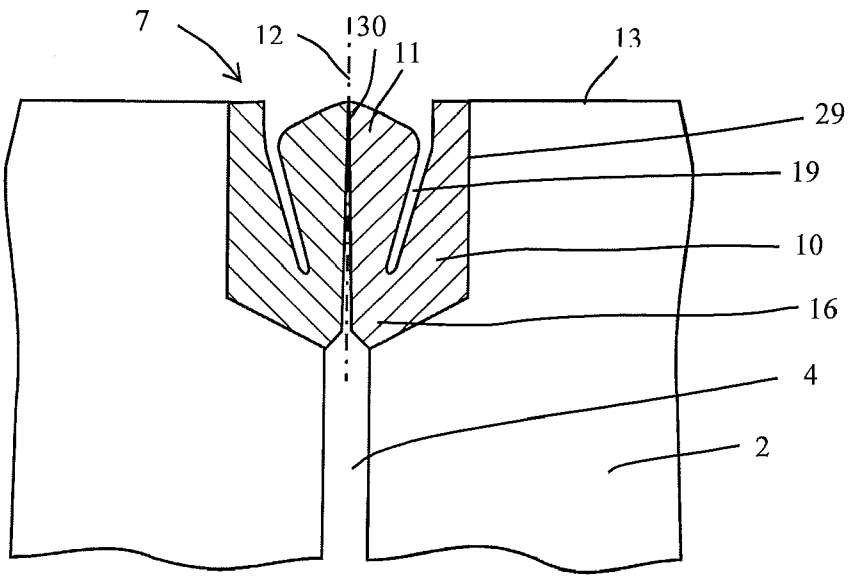



Fig. 8

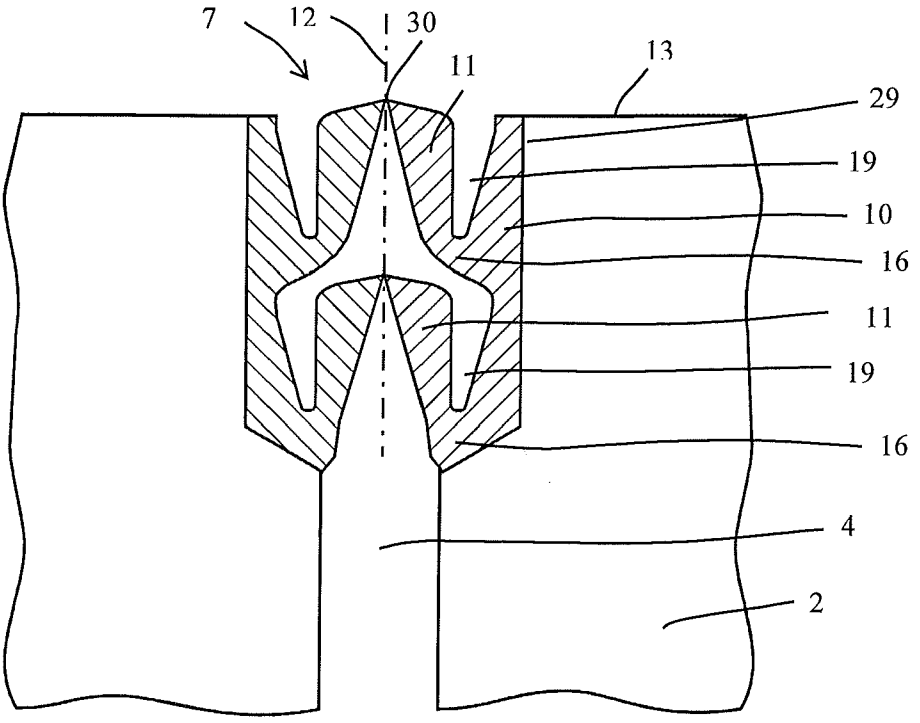



Fig. 9

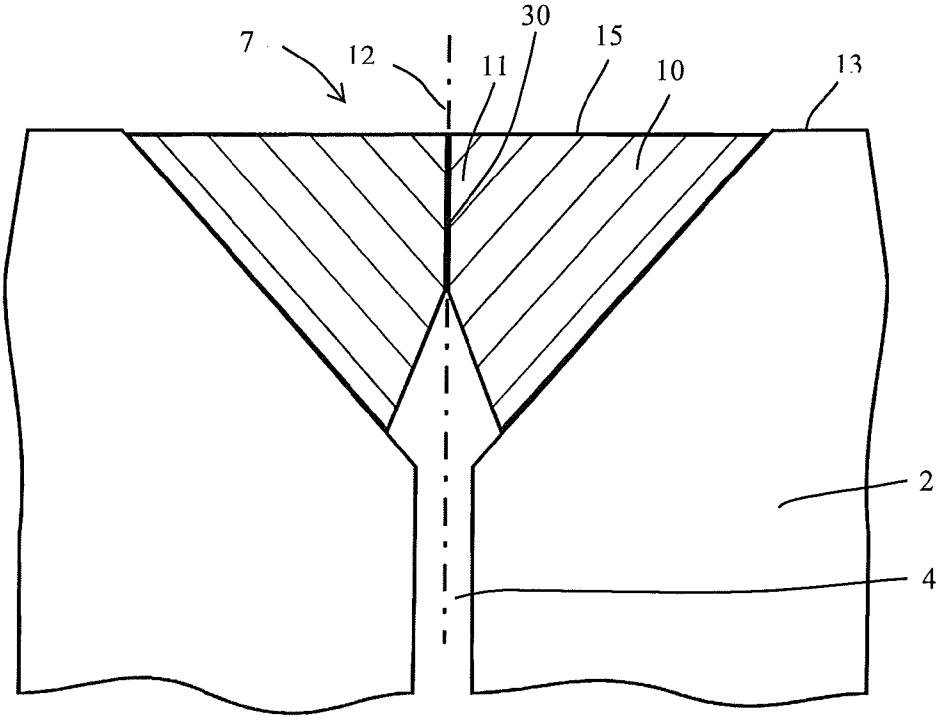



Fig. 10

# SEALING ARRANGEMENT FOR SHAFT AND TUNNEL CONSTRUCTION

**[0001]** The invention relates to a sealing arrangement for shaft and tunnel constructions.

## BACKGROUND AND PRIOR ART

**[0002]** Each body that is assembled from single monolithic components has contact joints. This applies, for example, for shaft end tunnel constructions, which consist of precast elements (lining segments). For example, in case that a tunnel construction shall be constructed and used under groundwater level, there is a need for water tightness of the whole construction. For a construction consisting of a plurality of prefabricated individual parts not only the requirement for water tightness of the monolithic components arises but also that of the sealing of the contact joints between the components against the hydrostatic pressure.

**[0003]** High demands are made on corresponding sealing systems. A closer inspection reveals that these demands change with the advancing construction phase of e.g. a tunnel construction. Therefore, the sealing systems must be able to fulfill their sealing function in different sealing situations and sealing phases. In terms of time there are, for example, different demands (1) during the assembly of the components, (2) during the fluidic bedding of the components and (3) during the solid bedding of the components.

**[0004]** Sealing arrangements for sealing constructive joints in tunnel constructions made of prefabricated components (lining segments) are generally known, see e.g. DE 102005039253, DE 102005039056, U.S. Pat. No. 4,946,309, EP 0222968, EP 0441250 and EP 0995013. A sealing element is glued into a groove circumferential around the abutting sides in a constant distance from the outside surface of the lining segments. The sealing effect of the sealing system is achieved after the assembly of the lining segments in that the sealing elements within the joints are contacting each other mirror-symmetrically. The contact has to be effected at least with a surface pressing power, which is greater than the pressure in the adjacent pressure medium. The desired surface pressing power is adjusted by choosing the elastic compression behavior of the two sealing elements depending on the displacement of the compression.

**[0005]** Known sealing arrangements have several disadvantages. When, for example, a non-compressible elastomer is chosen as material for the sealing elements the pressing force may increase enormously. In extreme cases damages to the sealing arrangement and also the environment cannot be excluded when the associated reaction forces in the component are conferred. Especially when several components contact each other with the corner bodies of their sealing systems this results in leakages or damages.

**[0006]** Under consideration of positioning errors between two components of the tunnel the mirror-symmetric arrangement of the sealing elements is practically accidental. The contact of the two sealing elements then only takes place on a reduced bearing portion. Since the surface pressing power is not independent of this bearing portion the danger of a leakage is increased with the reduced pressing power.

**[0007]** In addition, the intended surface pressing power is reduced in case of a subsequent increase of the joint width, so that the danger of a leakage is hereby also increased.

**[0008]** The sealing elements in the contact joints of the tunnel shall preferably have an unlimited lifetime. The technical requirement is defined as a 100 years lifetime. In order to ensure the minimum required surface pressing power for this long period the characteristic of relaxation of the materials has to be taken into account. The decline of the elastic tension forces (up to 40%) over time has to be accounted for by an increased starting tension when assembling the sealing arrangement. All of the already unwanted force reactions of the elastic tension forces are increased accordingly.

**[0009]** The sealing arrangements according to the prior art only act singularly. A leakage inevitably leads to a leakage stream of surrounding medium, e.g. water, into the tunnel. The targeted localization of the leakage is problematic in view of the wall thickness and the spreading possibilities in the contact joints of the components. A sanitization of the leakage can therefore not be performed locally on the inner side of the sealing system and always requires great efforts. With the means known in the prior art, however, redundant sealing systems can only be realized with great effort and in big tunnels.

**[0010]** It is therefore an object of the present invention to improve the sealing of joints between components of shaft and tunnel constructions, such that the disadvantages of the prior art are avoided, and in particular a reliable sealing of shaft and tunnel constructions in different sealing situations and sealing phases and at a long lifetime is achieved.

**[0011]** The problem is solved with the subject-matter according to claims **1** and **10**. Advantageous embodiments are given in the subclaims.

**[0012]** In a first aspect the invention provides a sealing arrangement for shaft and tunnel constructions comprising

a) at least two components lying against each other with abutting sides so that between the components a joint is formed that connects a first area with a second area, the first area having a first medium with a first medium pressure and the second area having a second medium with a second medium pressure, wherein a pressure difference is present between the first and second medium pressure, and

b) at least one elastic sealing system at each of the abutting sides of the components for sealing the joint,

characterized in that each of the sealing systems has at least one sealing element projecting to the joint, with which the sealing systems lie against each other on a contact plane, and wherein each of the sealing elements has at least one pressure area exposed to the medium with the higher medium pressure, so that a sealing force is applied between the sealing elements at the contact plane, which is greater than the force applied without the pressure difference, and which generates a contact pressing, which is greater than the pressure difference.

**[0013]** In the sealing arrangement according to the invention the elastic tension forces, which are generated when the sealing systems, after the systems have been brought into contact with each other, are pressed against each other by reducing the joint width are reduced or avoided completely compared to sealing arrangements of the prior art, and the necessary surface pressing pressure is achieved by a self-sealing force effect of the medium pressure. In order to achieve this force effect the sealing elements of the sealing system are designed geometrically in such a manner that they exhibit pressure areas against a low pressure or the atmosphere after mutual contact. On these pressure areas a differential pressures acts because of the pressure difference between the media, resulting in the force securing the neces-

sary surface pressing pressure at the area, with which the sealing elements lie at each other at the contact plane. In this manner, the pressing pressure is inevitably always adapted to the respective medium pressure and essentially independent from the joint width achieved after contact. In order to achieve the necessary contact pressing considerably smaller reaction forces are necessary. By adjusting the contact area, achievable for example by the design of the sealing elements, also the contact pressing can be adjusted. Further, also a misalignment of the components does not change the quality of the sealing, because the contact does not depend on the symmetry of the sealing elements.

**[0014]** In a preferred embodiment of the invention the sealing element is pivotable or tiltable about a hinge. The term "hinge" as used herein refers to a region of the sealing system featuring or forming a static center, around which the pivoting motion takes place and which itself does, at least essentially, not participate in the pivoting motion. In the hinge region the deformation motions generated by the pivoting or tilting of the sealing element are comparatively small (near "zero"). The hinge region may have a reduced cross-section compared to the adjacent base body and/or sealing element and/or a softer material. In preferred embodiments the hinge connects the base body of the sealing system with the sealing element. The pivoting or tilting motion can be in the direction of the joint or in the opposite direction.

**[0015]** In the arrangement according to the invention the force component of the contact pressing generated by a possible pretension of the sealing element is as small as possible compared to the force component of the contact pressing generated by the media differential pressure, i.e. the pressure difference between the media. Preferably the force component of the contact pressing generated by the media differential pressure is >50%, further preferred >60%, >70%, >80%, >85% or >90, especially preferred >95%, >96%, >97%, >98% or >99%.

**[0016]** The term "contact pressing" or "surface pressing power" as used herein is to be understood as being the pressure at the contact area, i.e. the area at which the sealing elements are contacting each other at the contact plane. The term "pressure area" as used herein means any surface of the sealing system, in particular of the sealing elements, exposed to the medium pressure.

**[0017]** In an especially preferred embodiment each of the sealing systems has a base body, with which the sealing system is attached to the component. The attachment can be achieved in many ways, for example by way of adhesion, concrete encasement, force fitting, or by means of anchoring feet.

**[0018]** In an especially preferred embodiment the elastic sealing system consists of elastomeric material.

**[0019]** The term "elastic" as used herein designates the characteristic of a body or a material to change its shape under the application of a force and to revert to the original shape after removal of the acting force. As used herein, an elastic body is in particular to be understood as being a body having an elasticity modulus of 0.1 or lower, preferably 0.01 to 0.1. An example of an elastic material is silicone rubber. The term "elastomeric material" as used herein refers to a rigid but elastic natural or synthetic polymer, the glass transition point of which is preferably below room temperature (25° C.). Examples for elastomeric materials are ethylene propylene rubber (EPM), ethylene propylene diene rubber (EPDM), styrene butadiene rubber (SBR), and nitrile butadiene rubber (NBR).

**[0020]** Preferably each of the sealing systems has at least two sealing elements projecting to the joint with which the sealing systems lie against each other at contact planes. The provision of two, three or more, and thus redundant, sealing elements provides enhanced sealing safety.

**[0021]** The sealing systems can be arranged in a groove circumferential around the abutting sides of the components and/or at a bevel of the components circumferential around the abutting sides of the components.

**[0022]** The groove or bevel will not have to be disposed at a distance from the edge of the abutting sides of the components, but can also be arranged at the edge of the abutting sides, in which case the sealing systems are arranged flush with the side surfaces of the components. Thus, leakage channels are avoided, which otherwise would form and, in embodiments according to the prior art, would additionally have to be sealed with a filler strip.

**[0023]** In an especially preferred embodiment of the sealing arrangement according to the invention a crack is present between the component and the sealing element, which crack is open to the medium with the higher medium pressure. In another preferred embodiment a crack between the base body and the sealing element is present, which crack is open to the medium with the higher medium pressure. The at least one sealing element may, for example, be arranged in a recess of the base body, or the base body may be provided with a lip contacting the component. The medium with the higher medium pressure can enter the crack and thus exert a respective force effect on the sealing element leading to the pressing operation of the sealing elements. In these embodiments the sealing element may be designed in the form of a lip connected to the base body via a hinge, the lip being pivotable around the hinge. In these embodiments, the base body and the sealing element pivotable around the hinge form an essentially angulate form, the sealing element or the sealing lip being preferably angled in the direction of the area with the higher medium pressure.

**[0024]** Preferably the sealing systems are each monolithically designed, thus each forming a physical unit. Base body and sealing element preferably form such a physical unit, and may consist e.g. of a single piece of elastomeric material. Also in case of two or more sealing elements the sealing system is preferably designed monolithically. The redundancy already mentioned may, for example, also be achieved by arranging two or more sealing systems, which, for example, each possess a sealing element, twice or multiple times in parallel, e.g. together in a groove or at a bevel.

**[0025]** In a preferred embodiment the sealing systems are arranged generally mirror-symmetric to each other, i.e. mirror-symmetric in relation to the contact plane.

**[0026]** In a further embodiment the sealing systems are designed generally wedge-shaped and are arranged at a bevel of the components circumferential around the abutting sides of the components. In this embodiment the forces acting on the pressure area(s) of the sealing element due to the medium pressure are redirected from the bevel in direction of the contact plane, such that a respective sealing force is generated.

**[0027]** In a second aspect the invention provides a method for sealing a joint between components of shaft and tunnel

constructions, the joint connecting a first area with a first medium and a second area with a second medium, wherein
a) the components are each, at their abutting sides, equipped with an elastic sealing system, which has a sealing element projecting to the joint,
b) the sealing systems are, with their sealing elements, brought into contact at a contact plane, and
c) by means of a pressure difference, which is present or generated between the first medium and the second medium, a force is exerted to pressure areas of the sealing elements directed to one of the areas in such a manner, that a sealing force is generated between the sealing elements at the contact plane, which is greater than the force generated without the pressure difference, and which generates a contact pressing greater than the pressure difference.

**[0028]** In a preferred embodiment of the method a sealing element is used that is pivotable or tiltable about a hinge. The hinge may, for example, be a region of the sealing system having a reduced cross-section or is made of a softer material.

**[0029]** In the method of the invention it is preferred that the force component of the contact pressing generated by the pressure difference is >50%, preferably >60%, >70%, >80%, >85% or >90, especially preferred >95%, >96%, >97%, >98% or >99%.

**[0030]** In the method of the invention it is preferred that the contact area, with which the sealing elements are brought in contact at the contact plane is smaller than the pressure area(s) exposed to the higher medium pressure, wherein the ratio of the pressure area(s) to the contact area is preferably at least 2:1, further preferred at least 5:1, at least 10:1, at least 20:1 or at least 30:1, and especially preferred at least 50:1.

**[0031]** The sealing systems used in the method preferably have a base body and are attached to the component with this base body, for example by adhesion, concrete encasement, force fitting, or by means of anchoring feet.

**[0032]** In the method of the invention sealing systems of elastomeric material are preferably used.

**[0033]** Further, it is preferred to use sealing systems that have at least two sealing elements projecting to the joint with which the sealing systems are brought into contact at contact planes.

**[0034]** In a preferred embodiment the sealing systems are arranged in a groove circumferential around the abutting sides of the components and/or at a bevel of the components circumferential around the abutting sides of the components.

**[0035]** Further preferred, the sealing systems are arranged flush with the side surfaces of the components in a groove or bevel at the edge of the abutting sides of the components.

**[0036]** In the method of the invention a crack may be provided between the component and the sealing element and/or between the base body and the sealing element, the crack being open to the medium with the higher medium pressure. The at least one sealing element may, for example, be arranged in a recess of the base body, or the lip of the base body can be arranged between the sealing element and the component in such a manner, that a crack remains between the base body and the sealing element, in which crack medium can enter.

**[0037]** It is preferred to use monolithically designed sealing systems.

**[0038]** It is especially preferred to arrange the sealing systems generally mirror-symmetric to each other.

**[0039]** In a further embodiment of the method of the invention sealing systems are used that are designed generally wedge-shaped, and the sealing systems are arranged at a bevel of the components circumferential around the abutting sides of the components.

**[0040]** In a third aspect the invention also relates to a tunnel or shaft construction with a sealing arrangement according to the invention.

**[0041]** In the following, the invention is further exemplified by means of figures showing preferred embodiments of the invention.

**[0042]** FIG. **1** Schematic illustration of a part of a tunnel construction.

**[0043]** FIG. **2** Schematic cross-sectional view of an embodiment of the arrangement of the invention

**[0044]** FIG. **3** Detail of the cross-sectional view of FIG. **1**.

**[0045]** FIG. **4** Partial views of cross sections through different embodiments of the arrangement of the invention.

**[0046]** FIG. **5** Partial views of cross-sections through further embodiments of the arrangement of the invention.

**[0047]** FIG. **6** Cross-sectional view of a further embodiment of the arrangement of the invention.

**[0048]** FIG. **7** Cross-sectional view of the embodiment of the arrangement of the invention according to FIG. **6** with minimum joint width.

**[0049]** FIGS. **8** to **10** Cross-sectional views of further embodiments of the arrangement of the invention.

**[0050]** FIG. **1** shows schematically a section of a tunnel construction **1** composed of individual components **2**, e.g. ready-mix concrete components. Between abutting sides **3** of the components **2** joints **4** are formed connecting the outer area **5** with the inner area **6**. The joints **4** are sealed with sealing systems **7** not visible here.

**[0051]** FIG. **2** schematically shows a cross-section through an embodiment of the sealing arrangement **8** of the invention. Shown is a part of two components **2** lying at each other with their abutting sides **3**. The abutting sides **3** of the components **2** are forming a joint **4** and each have a peripherally circumferential bevel **9**, in which an elastic sealing system **7** is inserted. The elastic sealing system **7** can, for example, glued into a recess **14** of the components **2**. Other fixing possibilities, for example concrete encasement, anchoring by means of an anchoring foot etc. or combinations thereof are, of course, also possible. The sealing systems **7**, which are preferably made in one piece of an elastomeric material, are arranged mirror-symmetric in relation to a contact plane **12** and have a base body **10** and a sealing element **11**. The sealing element **11** is connected with the base body **10** via a hinge region or a hinge **16** and is tiltable or pivotable around the hinge **16**, such that the sealing elements **11** are tilted or pivoted in the direction of the respective bevels **9** when the distance between the abutting sides **3** is reduced, i.e. The joint with is reduced. The sealing elements **11** contact each other at the contact plane **12** and bridge the joint **4** in this manner. The sealing systems **7** are each attached with their base body **10** at the component **2**.

**[0052]** The sealing system **7** serves the sealing of the joint **4**, whereby the sealing of two areas **5**, **6** on opposite sides of the sealing systems **7** against each other is achieved.

**[0053]** The first area **5** may, for example, be the exterior and the second area **6** the interior of a tunnel, both during the fluidic as well as the solid bedding of the tunnel. In both areas **5**, **6** are different or, as the case may be, also identical media **17**, **18**, which, however, exhibit different pressures, such that a pressure difference is present between the first medium **17** in the first area **5** and the second medium **18** in the second area

6. In the embodiment shown in FIG. 2 the first medium 17 in the first area 5, i.e. the outer medium, for example water and/or soil, has a higher pressure than the second medium 18 in the second area 6, i.e. the inner medium, for example the atmosphere inside the tunnel. The medium 17 with the higher pressure exerts a force on the pressure areas 15 of the sealing elements 11, such that the sealing elements 11 generate a sealing force at the contact plane 12 that is greater than the force that would be generated without the pressure difference, and that generates a contact pressing that is greater than the media differential pressure, i.e. the pressure difference between the media 17, 18 (see in addition also FIG. 3). The sealing force is predominantly or even completely, as the case may be, generated by the pressure difference, and not or in any case not significantly by the elastic tension forces due to the compression of the elastic sealing systems 7. In this way, a contact pressing is generated, which is independent from the joint width and the elastic pretension.

**[0054]** In FIG. 3 the principle underlying the sealing arrangement according to the invention is schematically illustrated with the sealing arrangement shown in FIG. 2 as an example. For a better overview only half of the sealing arrangement 8 is depicted. Arrows symbolize the forces acting on the sealing element 11. The arrows with solid arrowheads denote forces exerted by the medium 17 with the higher medium pressure, arrows with open arrowheads denote the forces exerted on the sealing element 11 by the medium 18 with the lower medium pressure. The medium pressure of the medium 17, directly or indirectly after redirection at e.g. the bevel 9, here in the region of the joint 19 formed between component 2 and the sealing element 11, exerts forces on the pressure area(s) 15. The resulting force in direction of the contact area 12 generates a respective contacting pressure at the contact area 12. Of course, the force generated by the medium pressure depends on the pressure area(s) 15 or the relation of the pressure area(s) 15 to the pressure areas 21, on which the pressure of the medium 18 with the lower pressure acts. The geometry of the sealing elements 11 is therefore chosen in such a way that the product of the pressure area(s) 15 and the first medium pressure is always greater than the product of the pressure area(s) 21 and the second medium pressure.

**[0055]** FIG. 4 shows different variants and installation situations of sealing arrangements 8 of the invention. For reasons of better overview, again only one half of the otherwise essentially mirror-symmetric arrangements is depicted. The reference numerals used correspond to the ones already used in FIGS. 1 to 3 and denote same or corresponding features, for which reason a repeated description is omitted and only deviating or additional features are described in more detail. The sealing arrangement 8 shown in FIG. 4A essentially corresponds to that of FIGS. 2 and 3, with the difference that the sealing element 11 has a more rounded contour. The sealing system 7 here is arranged peripherally, i.e. at the edge of the abutting sides 3 to the side surfaces 13 of the components 2. In contrast, in FIG. 4B the installation of the sealing system 7 in a groove 23 being arranged spaced from the side surface 13 of the component 2 is depicted. The sealing system 7 is, for example by adhesion, inserted with its base body 10 in a bevel 9 provided in the groove 23. The sealing system 7 in FIG. 4C features an anchoring foot 24, which engages a corresponding recess 23 of the component 2 or is encased in concrete. In the sealing system 7 shown in FIG. 4D the base body 10 has a sealing lip 31 being formed by the provision of a chute 25 in the base body 10. The chute 25 is connected to the crack 19 by means of a connecting channel 26, so that medium 17 can enter here and provide for a reliable sealing between the base body 10 and the component 2 and preclude a circulating leakage by exerting a corresponding pressure. The sealing lip 31 provides its sealing function in the same way as the sealing element 11. The sealing lip 31 shown in FIG. 4D is in engagement with a corresponding recess 32 and thus has also the function of an anchoring foot. This is, however, not necessary. Rather, also in the sealing arrangements shown in FIG. 4A and FIG. 4B a corresponding chute 25 may be provided, which is connected with the medium 17 via a corresponding connecting channel 26, so that the medium pressure provides for the sealing lip 31 being pressed to the component 2.

**[0056]** FIG. 5 shows further embodiments and installation situations, respectively, of sealing arrangements 8 of the invention. For reasons of better overview, here also only one half of the otherwise essentially mirror-symmetric arrangements 8 is depicted. The base body 10 of the sealing system 7 is designed in such a way that a lip 22, when installed, lies against the wall of the groove 23, 29 of the component 2. The lip 22 and the sealing element 11 form a crack 19, in which medium 17 can enter. By means of the contact pressing of the lip 22 at the component 2 a circulating leakage around the base body 10 is avoided. Base body 10 and sealing element 11 form an angular structure, the sealing element 11 is tiltable or pivotable around the hinge 16. The sealing system 7 in FIGS. 5A and 5B is arranged in a groove 23 being provided in the abutting side 3 of the component 2 and spaced to the side surface 13 of the component 2. In contrast, the sealing system 7 in FIGS. 5C and 5D is arranged in a peripheral groove 29 open to the side surface 13 of the components 2. The lip 22 is flush with the side surface 13. In FIGS. 5A and 5C the contours of each the sealing elements 11 directed to the medium 17 are designed rounded. In FIGS. 5B and 5C the sealing system 7 is arranged slightly set back in relation to the abutting side 3. This is a simple way to avoid that the sealing elements 7 come to lie at each other with the whole area directed to the area 6 or the medium 18.

**[0057]** FIG. 6 shows a further embodiment of the sealing arrangement 8 of the invention. The sealing arrangement 8 of this embodiment is provided in a groove 23 arranged spaced from the side surfaces 13 of the components 2 in abutting sides 3 thereof. Here also, two sealing systems 7 arranged mirror-symmetric in relation to the contact plane 12 are provided, which contact each other with their sealing elements 11 at the contact plane 12. The sealing systems 7 are fixed in the groove 23 with their base bodies 10. The base body 10 exhibits a recess 28 in direction of the joint 4, which recess 28 is designed in such a way that the sealing element 11 pivotable around the hinge region 16 may be at least partially incorporated therein, such that the crack 19, which in this case is formed between the base body 10 and the sealing element 11, is not sealed completely and the medium 17 with the higher medium pressure can enter or remain in the crack 19 (see also FIG. 7). The medium pressure generates a sealing contact pressing also on the attachment side in the groove 23. In this figure an installation situation with maximal joint width is depicted, i.e. the components 2 lie so close to one another with the abutting sides 3 that the sealing systems 7 just contact each other with the sealing elements 11. Here, the sealing elements 11 are not pivoted in direction of the recess 28 of the base body 10. In such an installation situation the sealing force 20 acting upon the contact plane 12 is generated and

maintained completely by the pressure difference between the medium **17** and the medium **18**.

**[0058]** In FIG. **7** the sealing arrangement **8** according to FIG. **6** is shown in an installation situation with minimal joint width. The abutting sides **3** lie directly at each other with projections **27** serving as spacers. The sealing elements **11** are pivoted around the hinge region **16**, such that they are largely incorporated in the recess **28** of the base body **10**. The crack **19** between the base body **10** and the sealing element **11**, however, remains still open enabling the entry of the medium **17** with the higher medium pressure. This provides for the sealing elements **11** being pressed against each other at the contact plane **12**. The corresponding design of the sealing systems **7** provides for the surfaces with which the sealing elements **11** lie at each other at the contact plane being as small as possible, preferably smaller than the pressure areas **15**. This leads to a higher contact pressing at the contact plane **12**. In this embodiment the sealing system **7** is designed in such a way that, in the region of the hinge region **16**, it protrudes to a lesser extent into the joint **4** than the projections **27**. The elastic force generated by the pivoting of the sealing elements **11** around the hinge region **16** is marginal in relation to the contact pressing generated by the media differential pressure.

**[0059]** FIG. **8** shows a further embodiment of the sealing arrangement **8** of the invention, the sealing system **7** largely corresponding to the sealing system **7** described in FIGS. **6** and **7**, with the difference, however, that the sealing systems **7** are arranged in grooves **29** at the edge of the abutting sides **3** of the components **2** and essentially flush with the side surfaces **13** of the components **2**.

**[0060]** FIG. **9** shows a further embodiment of the sealing arrangement **8** according to the invention, in which a redundancy of the sealing elements **11** is provided. Each base body **10** of the sealing systems **7** has two sealing elements **11**, which are arranged one after another in longitudinal direction of the joint and are in contact with the opposite sealing elements **11** of the other sealing system **7** at the contact plane **12**. The sealing elements **11** can at least partly be incorporated in the recesses **28** of the base bodies **10** while retaining the crack **19**. The serial arrangement of two sealing elements **11** each increases the safety of the sealing. If a leakage occurs at the first barrier exposed to the medium **17** with the higher medium pressure the further entry of the medium **17** is prevented by the second barrier. In the embodiment shown here two sealing elements are provided in each case at the base body. However, also three, four, five or more sealing elements **11** may be present. This depends on the intended use and safety standards. The peripherally arranged sealing arrangement **8** shown in FIG. **9** can, of course, also be arranged spaced from the edge, i.e. from the side surfaces **13** of the components **2**. It is, of course, also possible to arrange two ore more sealing systems **7** in series in order to achieve the desired redundancy.

**[0061]** FIG. **10** shows an embodiment of the sealing arrangement **8** of the invention, in which the sealing system **7** has a conical form and the base body **10** is attached to a bevel **9** of the components **2**. This embodiment lacks a hinge region **16**. The force exerted by the medium **17** on the pressure area(s) **15** is redirected via the bevel plane in direction of the contact plane **12**, whereby a corresponding sealing force is generated.

LIST OF REFERENCE NUMERALS

**[0062]** **1** tunnel construction
**[0063]** **2** component
**[0064]** **3** abutting side
**[0065]** **4** joint
**[0066]** **5** area
**[0067]** **6** area
**[0068]** **7** sealing system
**[0069]** **8** sealing arrangement
**[0070]** **9** bevel
**[0071]** **10** base body
**[0072]** **11** sealing element
**[0073]** **12** contact plane
**[0074]** **13** side surface
**[0075]** **14** recess
**[0076]** **15** pressure area
**[0077]** **16** hinge
**[0078]** **17** medium
**[0079]** **18** medium
**[0080]** **19** crack
**[0081]** **20** sealing force
**[0082]** **21** pressure area
**[0083]** **22** lip
**[0084]** **23** groove
**[0085]** **24** anchoring foot
**[0086]** **25** chute
**[0087]** **26** connecting channel
**[0088]** **27** projection
**[0089]** **28** recess
**[0090]** **29** groove
**[0091]** **30** contact area
**[0092]** **31** sealing lip
**[0093]** **32** recess

**1**. A sealing arrangement for shaft and tunnel constructions, comprising

a) at least two components (**2**) lying against each other with abutting sides (**3**) so that between the components (**2**) a joint (**4**) is formed that connects a first area (**5**) with a second area (**6**), the first area (**5**) having a first medium (**17**) with a first medium pressure and the second area (**6**) having a second medium (**18**) with a second medium pressure, wherein a pressure difference is present between the first and second medium pressure, and

b) at least one elastic sealing system (**7**) at each of the abutting sides (**3**) of the components (**2**) for sealing the joint (**4**),

wherein each of the sealing systems (**7**) has at least one sealing element (**11**) projecting to the joint (**4**), wherein the sealing systems (**7**) lie against each other on a contact plane (**12**), and wherein each of the sealing elements (**11**) has at least one pressure area (**15**) exposed to the medium (**17**) with the higher medium pressure, so that a sealing force is applied between the sealing elements (**11**) at the contact plane (**12**), which is greater than the force applied without the pressure difference, and which generates a contact pressing, which is greater than the pressure difference.

**2**. The sealing arrangement according to claim **1**, wherein the sealing element (**11**) is pivotable or tiltable about a hinge (**16**).

**3**. The sealing arrangement according to claim **1**, wherein the force component of the contact pressing generated by the pressure difference is >50%, preferably >60%, >70%, >80%, >85% or >90, especially preferred >95%, >96%, >97%, >98% or >99%.

**4**. The sealing arrangement according to claim **1**, wherein the contact area (**30**), with which the sealing elements (**11**) lie

against each other at the contact plane (**12**) is smaller than the pressure area(s) (**15**), wherein the ratio of the pressure area(s) (**15**) to the contact area (**30**) is preferably at least 2:1, further preferred at least 5:1, at least 10:1, at least 20:1 or at least 30:1, and especially preferred at least 50:1.

**5**. The sealing arrangement according to claim **1**, wherein each of the sealing systems (**7**) has a base body (**10**), with which the sealing system (**7**) is attached to the component (**2**).

**6**. The sealing arrangement according to claim **1**, wherein the sealing systems (**7**) consist of elastomeric material.

**7**. The sealing arrangement according to claim **1**, wherein each of the sealing systems (**7**) has at least two sealing elements (**11**) projecting to the joint (**4**) with which the sealing systems (**7**) lie against each other at contact planes (**12**).

**8**. The sealing arrangement according to claim **1**, wherein the sealing systems (**7**) are arranged in a groove (**23**) circumferential around the abutting sides (**3**) of the components (**2**) and/or at a bevel (**9**) of the components (**2**) circumferential around the abutting sides (**3**) of the components (**2**).

**9**. The sealing arrangement according to claim **1**, wherein the groove (**23**) or the bevel (**9**) are arranged at the edge of the abutting sides (**3**) and the sealing systems (**7**) are arranged flush with side surfaces (**13**) of the components (**2**).

**10**. The sealing arrangement according to claim **1**, wherein between the component (**2**) and the sealing element (**11**) a crack (**19**) is present, which is open to the medium (**17**) with the higher medium pressure.

**11**. (canceled)

**12**. The sealing arrangement according to claim **1**, wherein the sealing systems (**7**) are monolithically designed.

**13**. The sealing arrangement according to claim **1**, wherein the sealing systems (**7**) are arranged generally mirror-symmetric to each other.

**14**. The sealing arrangement according to claim **3**, wherein the sealing systems (**7**) are designed generally wedge-shaped and are arranged at a bevel (**9**) of the components (**2**) circumferential around the abutting sides (**3**) of the components (**2**).

**15**. A method for sealing a joint between components of shaft and tunnel constructions, the joint connecting a first area with a first medium and a second area with a second medium, wherein

a) the components are each, at their abutting sides, equipped with an elastic sealing system, which has a sealing element projecting to the joint,

b) the sealing systems are, with their sealing elements, brought into contact at a contact plane, and

c) by means of a pressure difference, which is present or generated between the first medium and the second medium, a force is exerted to pressure areas of the sealing elements directed to one of the areas in such a manner, that a sealing force is generated between the sealing elements at the contact plane, which is greater than the force generated without the pressure difference, and which generates a contact pressing greater than the pressure difference.

**16**. The method according to claim **15**, wherein a sealing element is used that is pivotable or tiltable about a hinge.

**17**. The method according to claim **15**, wherein the force component of the contact pressing generated by the pressure difference is >50%, preferably >60%, >70%, >80%, >85% or >90, especially preferred >95%, >96%, >97%, >98% or >99%.

**18**. The method according to claim **15**, wherein the contact area, with which the sealing elements are brought in contact at the contact plane is smaller than the pressure area(s) exposed to the higher medium pressure, wherein the ratio of the pressure area(s) to the contact area is preferably at least 2:1, further preferred at least 5:1, at least 10:1, at least 20:1 or at least 30:1, and especially preferred at least 50:1.

**19**. (canceled)

**20**. The method according to claim **15**, wherein sealing systems are used that consist of elastomeric material.

**21**. The method according to claim **15**, wherein sealing systems are used that have at least two sealing elements projecting to the joint with which the sealing systems are brought into contact at contact planes.

**22**.-**28**. (canceled)

**29**. A tunnel or shaft construction with a sealing arrangement according to claim **1**.

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