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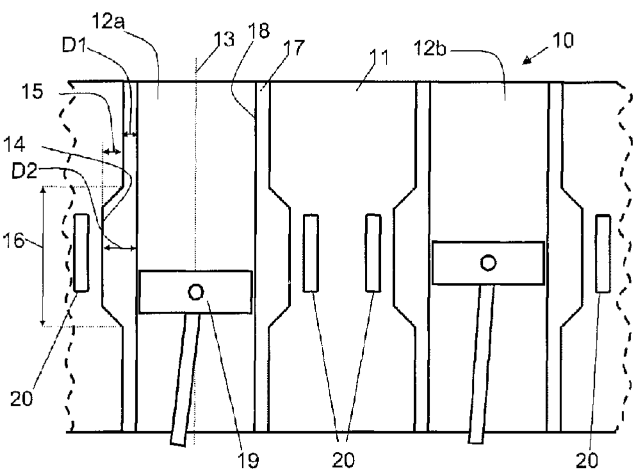
(54) Title: WORKPIECE HAVING A CUT-OUT FOR RECEIVING A PISTON



(57) Abrégé/Abstract:
The invention relates to a workpiece, for example in the form of a crankcase of an internal combustion engine, having a cut-out for receiving a piston.

The invention starts from a workpiece (10) having cut-outs (12a, 12b) which have a coating (17). This allows a coefficient of friction between the piston (19) and the cut-out (12a, 12b) which is as small as possible.

To be able to set a desired heat transfer from regions of the cut-out (12a, 12b) into an environment of the workpiece (11) particularly exactly, it is proposed in accordance with the invention that the cut-out (12a, 12b) has a shape differing from a hollow-cylindrical shape so that a different thickness of the coating (17) results. An ideal heat transfer can thus be set for every region of the cut-out (12a, 12b) by a suitable choice of the contour of the cut-out (12a, 12b) and thus of the coating (17).

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Abstract

The invention relates to a workpiece, for example in the form of a crankcase of an internal combustion engine, having a cut-out for receiving a piston.

The invention starts from a workpiece (10) having cut-outs (12a, 12b) which have a coating (17). This allows a coefficient of friction between the piston (19) and the cut-out (12a, 12b) which is as small as possible.

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(Fig. 1)

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Workpiece having a cut-out for receiving a piston

The invention relates to a workpiece having a cut-out for receiving a piston.

A workpiece in the form of an engine block or of a crankcase of an internal combustion engine is described in EP 1 022 351 A1 which has a plurality of cut-outs for receiving a piston movable to and from along an axial direction. The cut-outs in the form of the cylinders have a coating which forms a running surface for the piston, with the running surface being hollow-cylindrical. The coating is applied to achieve a coefficient of friction between the piston and the cylinder which is as small as possible and additionally to achieve a very small tendency to scuffing.

In addition to the named effects of the coating, it also influences a heat exchange between the cylinder and a coolant flowing around the cylinder. The thicker the coating is, the smaller the named heat exchange typically is. The heat exchange can thus be influenced by the selection of the thickness of the coating.

Against this background, it is in particular the object of the invention to propose a workpiece having a cut-out for receiving a piston, wherein a desired heat transfer from regions of the cut-out into an environment of the workpiece can be set particularly exactly.

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According to an aspect of the present invention, there is provided a workpiece having a base body which has a cut-out for receiving a piston movable to and fro along an axial direction, wherein the cut-out has a coating which forms a running surface for the piston and wherein the running surface is hollow cylindrical, wherein the cut-out of the base body has a shape differing from a hollow-cylindrical shape in the region of the running surface, wherein the coating has a first layer and a second layer, with the first layer being arranged at least sectionally above the second layer, and wherein the cut-out of the base body has a hollow-cylindrical base shape and at least one completely peripheral incision in the radial direction.

The workpiece in accordance with the invention has a base body which has a cut-out for receiving a piston movable to and fro along an axial direction. The cut-out has a coating which forms a running surface for the piston. The running surface is in this respect hollow-cylindrical.

In accordance with the invention, the cut-out of the base body has a shape different from the shape of a hollow cylinder in the region of the running surface. Since the running surface for the piston is hollow-cylindrical, a different thickness of the coating results in the region of the running surface. The cut-out thus has a shape differing from the shape of a hollow cylinder in every case in the axial region in which the piston moves to and fro. An ideal heat transfer can thus be set by a suitable choice of the contour of the cut-out and thus of the thickness of the coating for every region of the cut-out.

In addition, the coating can be thicker in regions with increased wear.

The named workpiece is in particular designed as an engine block or as a crankcase comprising an aluminum alloy or a magnesium alloy or cast iron or as a cylinder liner, in particular comprising cast iron, for an internal combustion engine.

Since the running surface does have exactly the required dimensions for the later operation of the workpiece after the application of the coating, the running surface for the piston is post-machined, in particular honed.

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The coating can, for example, be designed as a layer containing iron such as is described in EP 1 022 351 A1 of the applicant. The layer can, for example, also comprise a material such as is described in EP 1 507 020 A2 or EP 1 174 524 A2 of the applicant. Furthermore, further suitable materials for the coating are naturally conceivable.

The thickness of the layer can in particular amount to between 30 μm and approximately 2 mm, with the layer in particular having only two different thicknesses apart from transition regions. On the one hand, a first region having a thin coating with a first thickness of 30 to 200 μm and, on the other hand, a second region having a thick coating with a second thickness of 0.5 - 2 mm. The heat transfer to a coolant flowing around the workpiece is thus considerably different, in particular smaller, than in the first region. Whether the heat transfer in the second region reduces or increases in this respect depends on the thermal conductivity of the material of the coating in comparison with the thermal conductivity of the material of the workpiece. If the thermal conductivity of the material of the coating is smaller than the thermal conductivity of the material of the workpiece, the heat transition in the second region reduces. In the other case, the heat transfer increases.

In an aspect of the invention, the cut-out of the base body has a hollow-cylindrical basic shape and at least one incision in the radial direction. Apart from a transition region at a margin or at margins in the axial direction, the incision in particular has the same depth in the radial direction. The transition region can in particular be designed as a slope, as a chamfer, a radius or a combination of different radii. The incision can be arranged at the margin of the cut-out or also spaced apart from the margin. The cut-out can have one or also more incisions in the axial direction. The cut-out of the base body can thus be produced simply.

The incision or incisions is/are in particular completely peripheral and this of circular ring shape. They can thus be produced particularly simply. The coating is in particular applied by means of a rotating plasma torch which is introduced into the cut-out. It is also possible that a stationary torch is used in conjunction with a rotating base body. If an incision is completely peripheral, a coating can first only be applied in the incision and, when it is filled, the coating can be extended to the total cut-out. Material thus does not first have to be applied in the production of the coating which has to be removed again in a later workstep. This allows a fast and inexpensive production of the workpiece.

In addition, in the design of the workpiece as a cylinder liner, the latter can be designed symmetrical with respect to its longitudinal axis, which allows a particular simple installation of the cylinder liner into an engine block or a crankcase.

In an aspect of the invention, the incision has different depths, with the depth relating to the radial extent of the incision outside the above-named transition regions. The incision in particular has a recess which is arranged in an axial marginal region of the incision. An axial marginal region of the incision is to be understood as a region which adjoins one of the named transition regions. To manage with as little material as possible on the application of the coating, it is sensible not always to apply the coating over the total axial extent of the cut-out, but in a locally restricted manner only in the region of the incision. The plasma torch thus only has to reverse within the cut-out, and indeed in the named axial marginal regions of the incision. This has the result that more material is applied in the region of the reversal points and thus in the marginal regions than outside the marginal regions. If the cut-out has a constant depth, this material in the marginal regions has to be removed again in a post-treatment. If, in contrast, the incision has a recess in the marginal regions, the additional material can at least be received in part in the recess, which makes a smaller effort possible and thus an inexpensive post-treatment.

The incision can be arranged at the margin of the cut-out or within the cut-out. On an arrangement at the margin of the cut-out, the incision in particular only has a recess at the transition region disposed opposite the margin of the cut-out. In the other case, it in particular has a respective recess at both transition regions.

In an aspect of the invention, the incision has a depth between 0.5 and 2 mm and a height in the axial direction between 5 and 50 mm.

In an aspect of the invention, the coating has a first layer and a second layer, with the first layer being arranged at least sectionally above the second layer. The two layers in this respect have different properties and in particular comprise different materials. A second layer in the form of a thermal barrier coating is, for example, arranged between the first layer, which forms the running surface, and the base body. The thermal barrier coating can in this respect be formed in the total region of the running surface for the piston or only in one or more part regions thereof. The thermal barrier coating can, for example, only be formed within the above-named incisions. The material of the second layer can also be selected such that an increased heat transfer results. The second layer can also be designed as a so-called undercoat which allows a particularly strong connection between the workpiece and the first layer. The undercoat can also have an effect on the heat transfer.

The heat transfer from the cut-out to the environment can be set particularly exactly by the provision of the second layer and in partiuclar of a thermal barrier coating.

The coating can also have more than two layers, that is, for example, three or four different layers.

In an aspect of the invention, only the first layer forms the running surface for the piston. The second layer is thus arranged between the first layer and the workpiece in the total region of the running surface.

The above-described recesses at marginal regions of the incision are in particular advantageous when the coating has two layers and only the first layer should form the running surface for the piston. There is the risk without the named recesses that so much material has to be removed in the post-treatment in the marginal regions of the incision that the first layer becomes unacceptably thin or even no longer covers the second layer. An unwanted or even unacceptable contact of the piston with the second layer would then occur. The named recesses thus make it possible that the desired coating can also be reliably produced in this case.

In an aspect of the invention, the first layer forms the running surface in the region of the incision and otherwise the second layer. This is in particular realized such that first the second layer is applied with a constant thickness and subsequently the first layer is applied over the second layer. The layers thus follow the contour of the incision. On the post-treatment of the running surface, that is in particular on the honing, a treatment plane and thus the position and contour of the running surface are fixed such that the first layer forms the running surface in desired regions in the environment of the incision and otherwise the

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second layer. A running surface can thus be provided in a simple and inexpensive manner with sectionally different properties.

The second layer can, for example, be composed of a tough metallic material with a high service life, whereas the first layer can, for example, have a ceramic character. The ceramic character has advantages in the reduction of friction. The first layer can also be designed as a metallic layer which is produced with a powder which is coarser in comparison with the second layer and which has a particle size of approximately 30 - 60 μm, which typically results in a higher surface porosity. The increased surface porosity can in this respect assist a piston ring of the piston in reaching a state of a so-called hydrodynamic lubrication faster or in reducing the tendency to scuffing, for example.

The thermal barrier coating in particular comprises a ceramic material. It can, for example, be produced from a powder which comprises 75 percent by weight zirconium oxide (ZrO_2), between 18 and 22 percent by weight yttrium oxide (Y_2O_3) and further oxides as the remainder. Such a powder is marketed by the applicant under the sales name "Metco 202NS". The thermal barrier coating, for example, has a thickness between 0.5 and 2 mm. A particularly small heat transfer from the cut-out to the environment can thus be achieved in the regions with a thermal barrier coating.

The second layer can also comprise another suitable material such as an alloy of iron or cobalt and/or nickel as well as of chromium, aluminum and yttrium, which are known as so-called MCrAlY alloys. Such alloys are frequently used as undercoats.

The coating can also have more than two different layers with different properties and/or compositions.

In an aspect of the invention, the coating is applied by means of a thermal spray process, in particular by means of a plasma spray process. The coating can thus be applied particularly inexpensively. In addition, a particularly resistant coating can thus be applied.

The application of the coating is in particular carried out by means of a plasma spray process at atmospheric pressure, that is by means of a so-called APS coating process. A high-quality coating can thus be produced particularly inexpensively. The coating material can, for example, be present in powder form. The particle size can in this respect amount to between 5 and 90 μm.

Other thermal coating processes such as high velocity flame spraying or arc spraying can also be used.

Further advantages, features and details of some embodiments of the invention result with reference to the following description of embodiments and with reference to the drawings in which elements which are the same or have the same function are provided with identical reference numerals.

There are shown:

Fig. 1 a section of a crankcase with two internally coated cylinders;

Fig. 2 a sectional representation of an internally coated cylinder liner;

Fig. 3 a section of a cylinder liner with a two-layer coating in a first embodiment;

Fig. 4 a section of a cylinder liner with a two-layer coating in a second embodiment;

Fig. 5 a section of a cylinder liner with a two-layer coating in a third embodiment;

Fig. 6 a section of a cylinder liner with a single-layer coating in a second embodiment;

Fig. 7 a section of a cylinder liner with a two-layer coating in a fourth embodiment;

Fig. 8 a section of a cylinder liner in accordance with Fig,. 7 with a two-layer coating designed differently in comparison therewith; and

Fig. 9 a section of a cylinder liner with a two-layer coating in a fifth embodiment.

A section of a workpiece designed as a crankcase 10 of an internal combustion engine, not further shown, is shown in Fig. 1. The crankcase 10 is not to scale and is only shown very schematically. The parts of relevance here are in particular shown greatly magnified.

The crankcase 10 comprises aluminum and has a base body 11 which has a total of four cut-outs in the form of cylinders of which, however, only two cut-outs 12a, 12b are shown. The two cut-outs 12a, 12b shown are of identical design so that the descriptions apply equally to both cut-outs 12a, 12b.

The cut-outs 12a, 12b have a hollow cylindrical base shape which has an incision 14 which is arranged approximately centrally with respect to an axial direction 13 and is directed outwardly and thus in the radial direction. It thus results that the cut-out 12a, 12b of the base body 11 has a shape differing from a hollow-cylindrical shape. The incision 14 is completely peripheral and thus has a cross-section of circular ring shape. Transitions from the hollow-cylindrical base shape to the incision 14 are each designed as a slope. The incision 14 has a depth 15 in the radial direction of 0.5 to 2 mm, that is of 1 mm, for example, with respect to the hollow-cylindrical base shape. A height 16 of the incision 14 amounts to between 5 and 50 mm, that is 20 mm, for example, with a diameter of the hollow-cylindrical base shape being able to amount to 80 mm, for example. The height 16 of the cut-out 14 is in this respect considered as the axial extent of the region differing from the hollow-cylindrical base shape.

The cut-out 12a, 12b has a coating 17 which forms a running surface 18 for a piston 19 arranged within the cut-out 12a, 12b. The running surface 18 is hollow cylindrical and the piston 19 can move in a known manner in the axial direction 13 within the cut-out 12a, 12b. The piston 19 in this respect moves beyond the incision 14 in the operation of the internal combustion engine. The coating 17 is applied using an APS plasma spray process and is subsequently post-treated using a honing process. The coating 17 is manufactured using a material containing iron such as is described in EP 1 022 351 A1 of the applicant. On application of the coating 17, the coating 17 is first applied within the total cut-out 12a, 12b. When a sufficient layer thickness is achieved outside the incision 14, coating is continued in a targeted manner only in the region of the incision 14.

However, only a coating within the incision can first be applied and, only when it is filled, also outside the incision. A further possibility is to apply such a thick coating within the whole cut-out during the total coating process that a hollow cylindrical running surface can arise on a post-treatment.

A non-uniform thickness of the coating 17 results in the radial direction due to the combination of a hollow-cylindrical running surface 18 and the shape of the cut-out 12a, 12b differing from a hollow-cylindrical shape. The coating 17 is admittedly of the same thickness all around at a specific axial position; however, the thickness can be different at another axial position.

In the axial direction 13 outside the incision 14, the coating 17 has a first thickness D1 of 100 to 200 μm, that is, for example 150 μm. The thickness increases over the slopes of the incision 14 up to a maximum second thickness D2 of 0.5 - 21 mm, that is, for example, 1 mm.

The base body 11 of the crankcase 10 additionally has coolant channels 20 in which a coolant circulates and transports heat away from the crankcase 10 in operation of the internal combustion engine. The coolant channels 20 extend around the cut-outs 12a, 12b and are arranged in the region of the incision 14.

A workpiece designed as a cylinder liner 110 is shown in Fig. 2. The cylinder liner 110 is provided to be used in a crankcase, not shown, of an internal combustion engine. The cylinder liner 110 is not to scale and is only shown very schematically. The parts of relevance here are in particular shown greatly magnified.

The cylinder liner 110 comprises cast iron and has a base body 111 which has a cut-out 112. The cut-out 112 has a hollow-cylindrical base shape which has an incision 114 directed outwardly at the margin with respect to an axial direction 113 and thus directed in the radial direction. It thus results that the cut-out 112 of the base body 111 has a shape differing from a hollow-cylindrical shape. The incision 114 is likewise completely peripheral and thus has a cross-section of circular ring shape. A transition from the incision 114 to the hollow-cylindrical base shape is designed as a slope. The depth and the length of the incision 114 are comparable with those of the incision 14 of Fig. 1.

The cut-out 112 has a coating 117 which forms a hollow cylindrical running surface 118 for a piston, not shown, which can be arranged within the cut-out 112. The coating 117 comprises the same material and is manufactured using the same method as the coating 17 of Fig. 1.

A non-uniform thickness of the coating 117 results in the radial direction due to the combination of a hollow-cylindrical running surface 118 and the shape of the cut-out 112 differing from a hollow-cylindrical shape. The thickness of the coating 117 is in this respect comparable with the thickness of the coating 17 of Fig. 1.

A section of a cylinder liner in accordance with Fig. 2 is shown in Figs. 3, 4 and 5 respectively. In this respect, a respective section is shown with an incision of a cut-out. The base bodies and cut-outs in Figs. 3, 4 and 5 have an identical design. The embodiments only differ in the manner of the coating, with all three coatings comprising two different layers lying over one another.

In accordance with the embodiment corresponding to Fig. 3, a coating 217 of a cut-out 212 has a first layer 221 which forms a running surface 218 for a piston, not shown. The layer 221 comprises the same material and is manufactured using the same method as the coating 17 of Fig. 1. The thickness of the coating 217 is in this respect also comparable with the thickness of the coating 17 of Fig. 1.

A second layer in the form of a thermal barrier coating 222 is arranged over the complete axial extent between the first layer 221 and a base body 211. The thermal barrier coating 222 comprises a ceramic material, and indeed a powder which is marketed by the applicant under the sales name "Metco 202NS". The thermal barrier coating has a uniform thickness between 0.5 and 2 mm, that is, for example, 1 mm. The thermal barrier coating 222 is likewise applied by means of an APS plasma spray process.

So that the running surface 218 is of hollow cylindrical design, the first layer 221 has a thickness variable in the axial direction comparable to the coating 117 of Fig. 2. An incision 214 of the cut-out 212 and the uniform thickness of the thermal barrier coating 222 are thus compensated.

The embodiment in accordance with Fig. 4 only differs a little from the embodiment in accordance with Fig. 3 so that only the differences will be looked at. In the embodiment in accordance with Fig. 4, a first layer 321 of a coating 317 has a uniform thickness and a thermal barrier coating 322 has a variable thickness. The thermal barrier coating 322 is designed so that it compensates an incision 314 of a cut-out 312 so that the first layer 321 can already be applied to a hollow-cylindrical contour.

The embodiment in accordance with Fig. 5 only differs a little from the embodiment in accordance with Fig. 4 so that only the differences will be looked at. In the embodiment in accordance with Fig. 5, a thermal barrier coating 422 of a coating 417 is designed so that it only fills an incision 414 of a cut-out 412 such that a hollow-cylindrical contour arises onto which a uniformly thick first layer 421 can be applied.

The embodiment in accordance with Fig. 6 only differs a little from the embodiment in accordance with Fig. 2 so that only the differences will be looked at. In the embodiment in accordance with Fig. 6, an incision 514 has a differing depth. The incision 514 has a peripheral recess 524 in an axial marginal region 523. The recess 524 is arranged such that it is connected via a constant chamfer 525 to a margin 526 of the incision 514. The recess 524 likewise has a chamfer 527 on the side disposed opposite the margin 526. The recess 524 serves to receive material, which is additionally deposited on the reversal of a plasma torch, on an application of a coating 517 only in the region of the incision 514.

In the embodiment in accordance with Fig. 7, an incision 614 of a cut-out 612 has an arrangement and a contour generally comparable with the incisions 14 in accordance with Fig. 1. In addition to these, the incision 614 has recesses 624a, 624b corresponding to the recess 524 in accordance with Fig. 6 at its two axial marginal regions 623a, 623b. A coating 617 has a first layer 621 and a second layer 622, with the second layer 622 only having been applied in the region of the incision 614.

The embodiment in accordance with Fig. 8 only differs from the embodiment in accordance with Fig. 7 in that a second layer 722 is arranged not only in the region of an incision 714, but also outside it.

The embodiment in accordance with Fig. 9 only differs a little from the embodiment in accordance with Fig. 1 so that only the differences will be looked at. An incision 814 likewise has a constant depth. A second layer 822 is applied first and over it a first layer 821 having a respective approximately constant thickness. The two layers 821, 822 thus largely follow the contour of the incision 814. On a subsequent post-treatment, a treatment plane is fixed so that the first layer 821 forms the running surface 818 in the environment of the incision 814 and otherwise the second layer 822.

CLAIMS:

1. A workpiece having a base body which has a cut-out for receiving a piston movable to and fro along an axial direction, wherein the cut-out has a coating which forms a running surface for the piston and wherein the running surface is hollow cylindrical, wherein the cut-out of the base body has a shape differing from a hollow-cylindrical shape in the region of the running surface, wherein the coating has a first layer and a second layer, with the first layer being arranged at least sectionally above the second layer, and wherein the cut-out of the base body has a hollow-cylindrical base shape and at least one completely peripheral incision in the radial direction.

2. A workpiece in accordance with claim 1, wherein the incision is of different depths.

3. A workpiece in accordance with claim 2, wherein the incision has a recess which is arranged in an axial marginal region of the incision.

4. A workpiece in accordance with any one of claims 1 to 3, wherein the incision has a depth between 0.5 and 2 mm.

5. A workpiece in accordance with any one of claims 1 to 4, wherein the incision has a height in the axial direction between 5 and 50 mm.

6. A workpiece in accordance with any one of claims 1 to 5, wherein only the first layer forms the running surface.

7. A workpiece in accordance with any one of claims 1 to 5, wherein the first layer forms the running surface in the region of the incision and otherwise the second layer.

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8. A workpiece in accordance with any one of claims 1 to 7, wherein the second layer comprises a ceramic material.

9. A workpiece in accordance with any one of claims 1 to 8, wherein the second layer has a thickness between 0.5 and 2 mm.

10. A workpiece in accordance with any one of claims 1 to 9, wherein the coating is applied by means of a thermal spray process.

11. A workpiece in accordance with claim 10, wherein the coating is applied by means of a plasma spray process.

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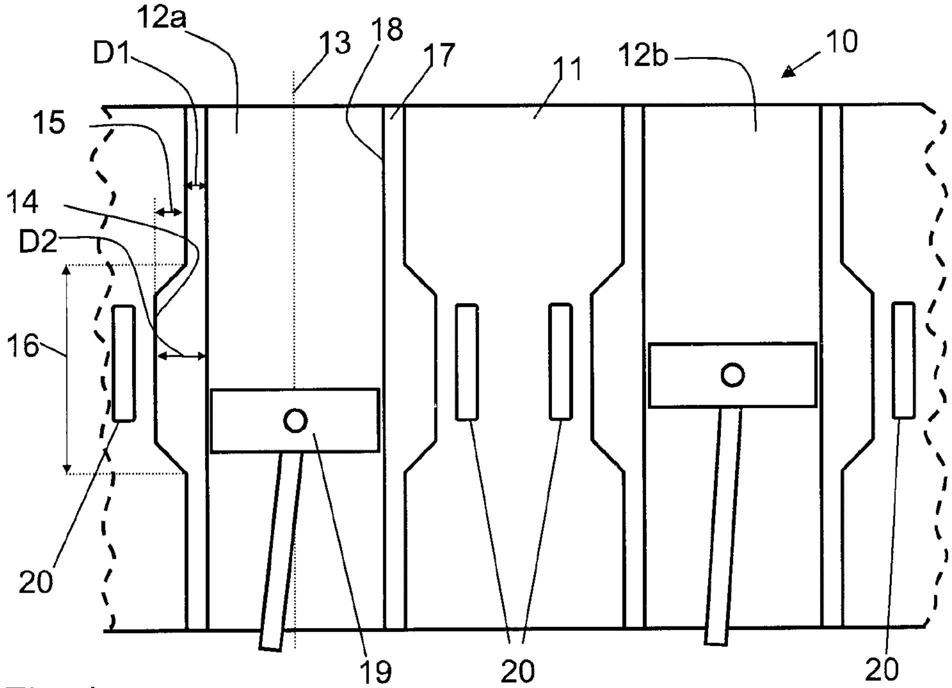

Fig. 1

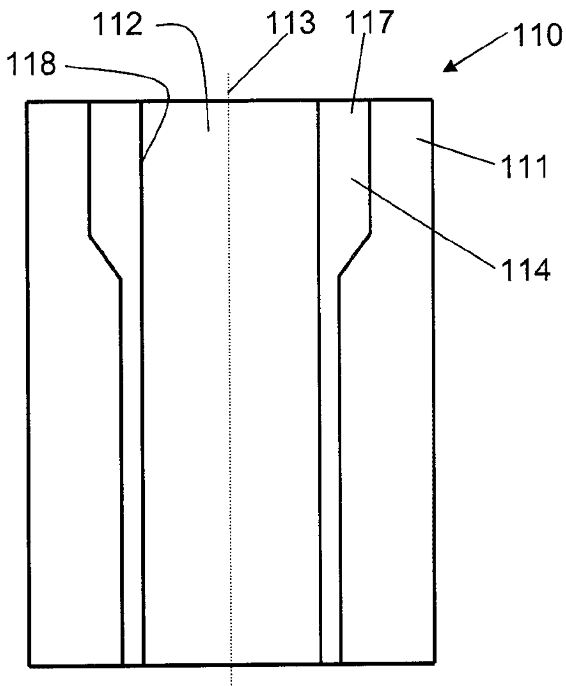

Fig. 2

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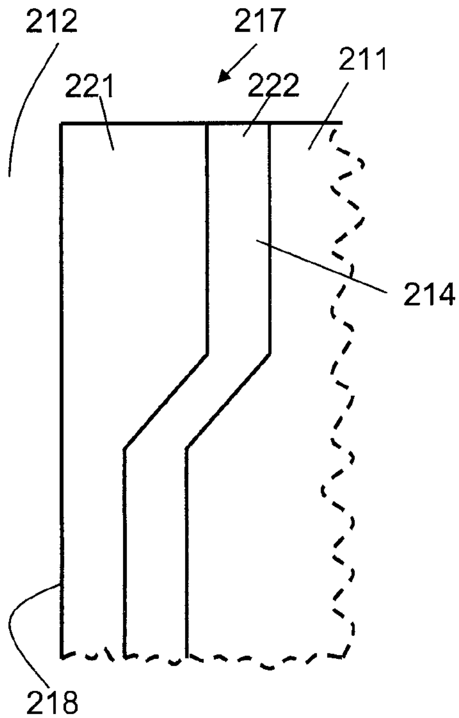

Fig. 3

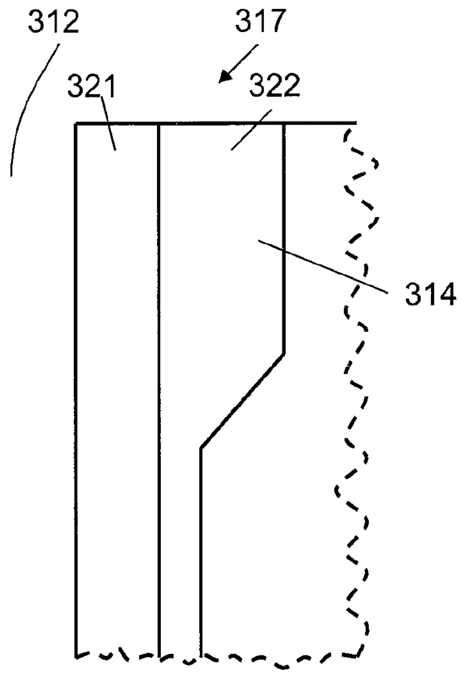

Fig. 4

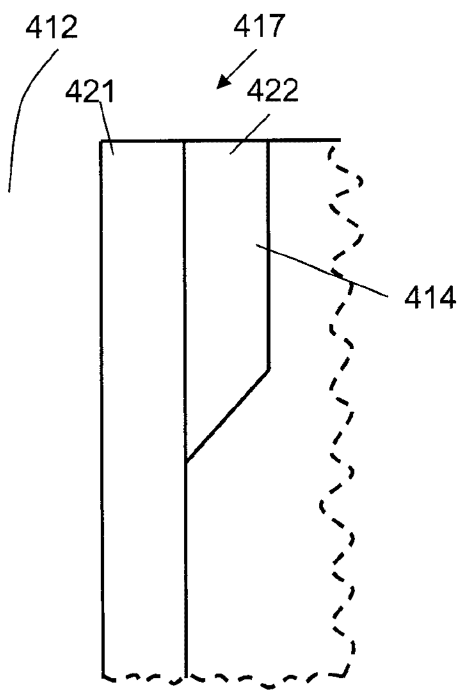

Fig. 5

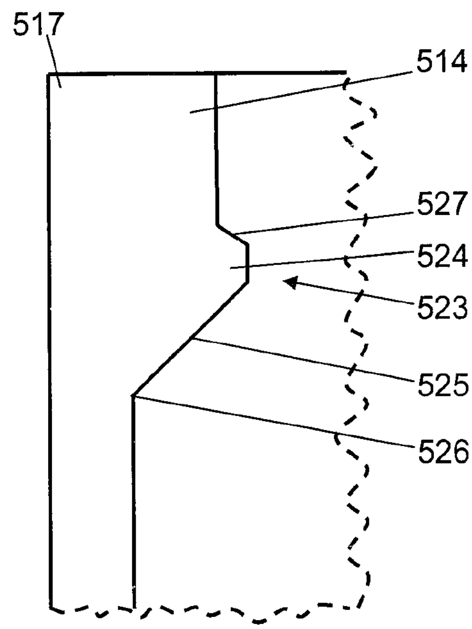

Fig. 6

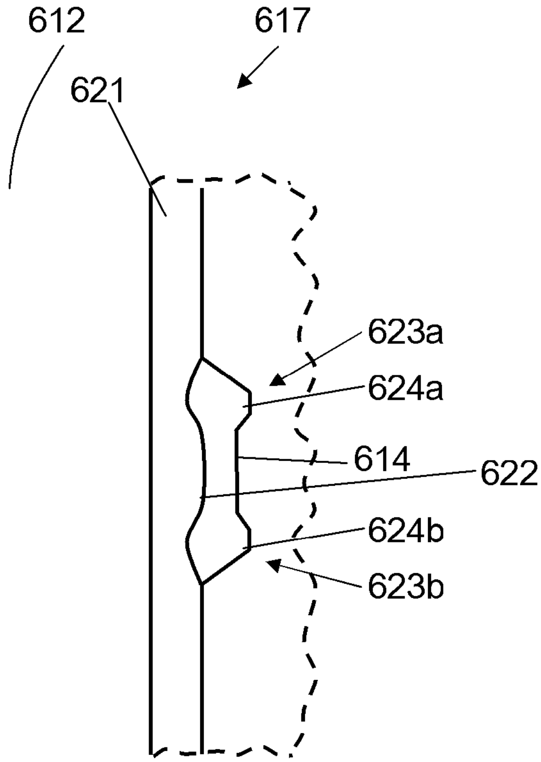

Fig. 7

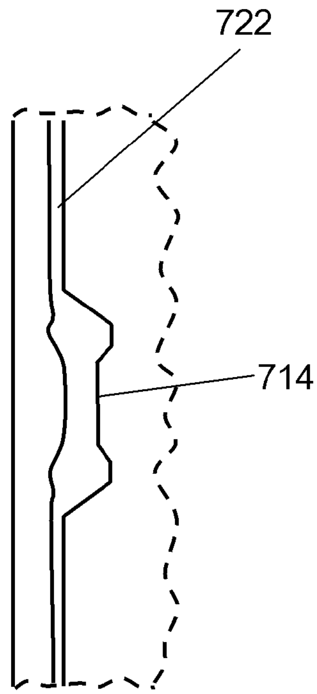

Fig. 8

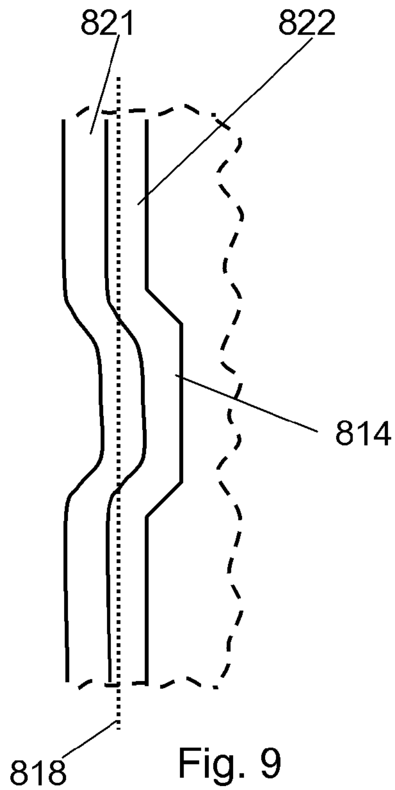

Fig. 9

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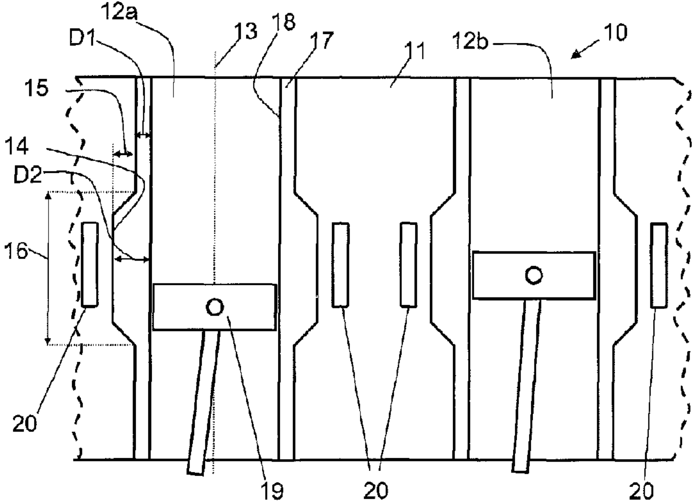
12a
D1
13
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17
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12b
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15
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D2
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19
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