

(19)



(11)

**EP 1 264 979 B1**

(12)

**EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention  
of the grant of the patent:  
**28.02.2007 Bulletin 2007/09**

(51) Int Cl.:  
**F02F 3/00 (2006.01)**

(21) Application number: **02253880.5**

(22) Date of filing: **31.05.2002**

(54) **Piston unit for combustion engine**

Kolben für ein Brennkraftmaschine

Piston pour un moteur à combustion interne

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR**

(30) Priority: **04.06.2001 FI 20011165**

(43) Date of publication of application:  
**11.12.2002 Bulletin 2002/50**

(73) Proprietor: **Wärtsilä Finland Oy  
65380 Vaasa (FI)**

(72) Inventors:  
• **Nurmi, Hannu  
65380 Vaasa (FI)**

• **Rösgren, Carl-Erik  
65480 Vikby (FI)**

(74) Representative: **Hanson, William Bennett et al  
Bromhead Johnson  
19 Buckingham Street  
London WC2N 6EF (GB)**

(56) References cited:  
**DE-A- 3 110 292 US-A- 4 253 430  
US-A- 4 419 925 US-A- 4 887 518  
US-A- 5 499 572**

**EP 1 264 979 B1**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

## Description

**[0001]** This invention relates to a piston assembly for a combustion engine in accordance with the preamble of claim 1. Piston assemblies according to the preamble of claim 1 are disclosed in US-A-441925 and US-A-4887518.

**[0002]** From the prior art it is known for a piston of a combustion engine to have a number of separate sections, for instance the upper section may be a separate part connected, for example, by screws to the piston body. There are several known approaches to the sealing of the joint between such sections. However, the known constructions are typically such that the piston rings, or at least the oil rings, are located above such joints, i.e. in the upper section of the piston.

**[0003]** Sealing the upper section of a so-called hot combustion piston is particularly problematic since the upper section is typically made of material different from the rest of the piston. DE-A-3110292 discloses one known method of sealing the upper section of a ceramic piston by utilizing a comb structure. The problem with this kind of an approach is, among other things, how to hold the ceramic piece in place.

**[0004]** In US-A-4253430 sealing by separate sealing rings is suggested instead. However this approach also is not totally without problems since the mounting of the rings at the assembly stage requires particular accuracy, and considering the thermal expansion makes the approach less feasible.

**[0005]** An object of the present invention is to provide a new piston assembly for an internal combustion engine, where the problems according to the prior art are minimised. A particular object of the invention is to provide a so-called hot combustion piston assembly having piston rings located below the upper section of the piston, and where the upper section and the rest of the piston are engaged with one another tightly and firmly. In this specification a so-called hot combustion piston refers to a piston in which the surface abutting onto the combustion chamber is made of a material having a reduced heat conductivity.

**[0006]** According to the present invention there is provided a piston assembly for an internal combustion engine according to claim 1.

**[0007]** The sealing arrangement is at least partly based on the influence of the difference between the mounting and working temperatures of the upper section and the piston skirt, preferably on the different thermal expansion properties of the upper section and the piston skirt.

**[0008]** The performance can be enhanced by selecting the materials of the upper section and the piston skirt so that their thermal expansion properties differ from one another, whereby the sealing arrangement comprises counter surfaces provided in the upper section and the piston skirt, which surfaces are arranged with respect to each other so that their mutual distance is minimised at the working temperature of the surfaces.

**[0009]** The invention relates especially to a piston assembly in which grooves of the piston rings have such a location that the joining point of the upper section and the skirt has to operate under compression pressure when the piston assembly is in operation.

**[0010]** The sealing arrangement between the upper section and the skirt of the piston conveniently comprises several surface sections, the surfaces of the upper section and the skirt being substantially parallel, whereby at mounting temperature the surfaces are spaced at a first distance from each other, and the direction of the normal of which surface sections is at the surface section approximately parallel with the main thermal expansion direction, whereby at working temperature the surfaces are spaced at a second distance from one another, and the second distance is shorter than the first distance. Preferably the second distance is substantially such that the surfaces are attached to one another.

**[0011]** The sealing arrangement is preferably provided so that it consists of alternating grooves and protrusions in the upper section and the skirt forming the counter surfaces in such a way that the protrusion of one counter surface is always facing the groove of the other counter surface.

**[0012]** According to one embodiment the counter surfaces form a screw thread in the direction of the longitudinal axis of the piston. Preferably, the counter surfaces form a trapezoidal thread in the direction of the longitudinal axis of the piston. In some cases the counter surfaces can also comprise a sealing surface deviating from the direction of the longitudinal axis of the piston.

**[0013]** The sealing arrangement according to the invention suitably comprises several counter surfaces operationally in succession and arranged in relation to each other so that their mutual distance is reduced at the working temperature of the surfaces and that a pressure balancing chamber is formed between two successive, tightly arranged counter surface pairs.

**[0014]** When applying the invention the skirt section of the piston is made of such material that its thermal expansion coefficient is from  $10 \times 10^{-6}/K$  to  $13 \times 10^{-6}/K$  and the thermal expansion coefficient of the upper section material is typically from  $13 \times 10^{-6}/K$  to  $17 \times 10^{-6}/K$ .

**[0015]** An embodiment of the invention will now be described, by way of example only, with particular reference to the accompanying drawings, in which:

Fig. 1 shows schematically a piston assembly, according to the present invention, for an internal combustion engine;

Fig. 2 is an enlargement of part of Figure 1, depicted at II, showing the sealing surface between the upper section and the skirt of the piston assembly;

Fig. 3 is an enlargement of part of Figure 1, depicted at III, showing the sealing surface between the upper section and the skirt of the piston assembly;

Fig. 4 shows a sealing surface between upper and skirt sections of the piston assembly according to the invention at mounting temperature; and

Fig. 5 shows a sealing surface according to Fig. 4 at working temperature.

**[0016]** In Fig. 1 the reference number 1 generally designates a piston assembly for an internal combustion engine comprising an upper section 2 abutting onto the combustion chamber of the combustion engine cylinder and a piston skirt 3 in connection with the upper section. Fig. 1 is greatly simplified and in practice the piston assembly comprises several kinds of additional arrangements which are not shown herewith.

**[0017]** The piston assembly 1 comprises grooves 4 for piston rings. In the piston assembly 1 according to the invention the grooves 4 of the piston rings have such a location that the joining point of the upper section 2 and the skirt 3 has to operate under working pressure when the piston assembly is in operation. This is due to the fact that the material of the upper section is typically such that the piston rings cannot be provided therein.

**[0018]** In order to provide sufficient tightness the mating surfaces between the upper section 2 and the skirt 3 of the piston assembly comprises sealing arrangements 1.2, 1.3, which will be described below. Here the sealing arrangement comprises both an arrangement parallel with the longitudinal axis of the piston and an arrangement deviating from the longitudinal axis. The sealing arrangements 1.2, 1.3 are provided by utilising the influence of the difference between the mounting and working temperatures of the piston assembly. An advantageous sealing effect can be achieved by selecting the upper section and skirt materials so that by any structure of the sealing arrangements 1.2, 1.3, respectively, the reaching of the working temperature makes the counter surfaces included in the sealing arrangement between the upper section 2 and the skirt 3 move with respect to one another, due to different thermal expansion, so that sufficient tightness is achieved or the tightness is considerably improved. The sealing effect can be achieved or it can be improved also by considering the fact that the upper section 2 of the piston is, in operating conditions, at a higher temperature than the rest of the piston assembly.

**[0019]** Fig. 2 shows in more detail the sealing arrangement 1.2 adapted to the cylindrical mating surface and which is generally parallel with the longitudinal axis of the piston. The counter surfaces comprise several grooves and protrusions 5 so that the protrusion of one surface is always facing the groove of the other surface. Here, the sealing arrangement 1.2 between the upper section 2 and the skirt 3 of the piston comprises several surface sections 2a, 3b, 2b, 3a, where the surfaces of the upper section and the skirt are substantially parallel. This kind of a mating surface is preferably arranged to form a screw thread in the direction of the longitudinal axis of the piston assembly. The thread is preferably a

trapezoid type of thread where the thread top is substantially planar. This particular form provides good tightness, whereby it is especially advantageous to apply a thread like this to the present invention. The grooves on the counter surfaces are preferably somewhat larger than the protrusions, whereby the sealing arrangement includes successive pressure balancing chambers between the surfaces 2b - 3a located between the tight surface contacts 2a - 3b. Thus the sealing arrangement according to the invention comprises several operationally successive surface sections 2a - 3b in each other's immediate vicinity as well as pressure balancing chambers between two such surface sections. Operational successiveness refers to the fact that as a certain pressure difference prevails over the sealing arrangement, the gases tend to flow along a particular flow path towards the low pressure.

**[0020]** Fig. 3 shows in more detail the sealing arrangement 1.3 provided in the piston assembly in the direction substantially normal or perpendicular to its longitudinal axis. Thus the grooves and protrusions are concentric with each other. Also in this embodiment the grooves of the counter surfaces are preferably somewhat larger than the protrusions, whereby successive chambers 2b - 3a located between the tight surface contacts 2a - 3b are provided in the sealing arrangement, while the surface sections move with respect to one another as a result of changes and/or differences of temperature.

**[0021]** Figs. 4 and 5 show the influence of the thermal expansion differences of the materials and changes of temperature in the sealing arrangement according to the invention. Fig. 4 shows a sealing surface according to the invention at mounting temperature. The construction and the material of the sections 2, 3 are such that a desired clearance 6 is provided on the sealing surface between such counter surfaces 2b, 3a that, depending on the application, will approach one another in operation. This situation is shown in Fig. 5. In operating conditions the sections 2 and 3 move with respect to each other due to the change in temperature, typically the raising thereof, so that the surface 2b approaches the surface 3a, whereby the clearance 6 is reduced to clearance 6a. Simultaneously, the surface 2a draws away from the surface 3b and the clearance 6b increases.

**[0022]** The same effect can be utilized also in a sealing arrangement in the direction of the normal of the piston assembly or even in another direction.

**[0023]** In Fig. 4 the surfaces 2b, 3a are spaced at a first distance 6 from one another in mounting conditions. The direction of the normal of these surfaces is approximately parallel with the primary thermal expansion direction at the surface, whereby in operating conditions the surfaces 2b, 3a are spaced at a significantly shorter distance 5.5 from one another.

**[0024]** The invention is not limited to the above-described applications, but several other modifications are conceivable in the scope of the appended claims.

## Claims

1. A piston assembly (1) for an internal combustion engine comprising an upper section (2) movable within the combustion chamber of the cylinder, a piston skirt (3) in connection with the upper section, **characterized by** a sealing arrangement (1.2, 1.3) utilising heat expansion for sealing the joint between the upper section and the skirt, the sealing arrangement (1.2, 1.3) between the upper section and the skirt being arranged to operate under working pressure, and in that the sealing arrangement between the upper section and the skirt of the piston comprises several surface sections, where the surfaces of the upper section and the skirt are substantially parallel, whereby at mounting temperature the surfaces are located at a first distance from one another and the direction of the normal of which surface sections is approximately parallel with the main thermal expansion direction -at the surface section, whereby at working temperature the surfaces are spaced at a second distance from one another, and that the second distance is shorter than the first distance. 5 10 15 20
2. A piston assembly according to claim 1, **characterised in that** the materials selected for the upper section and the piston skirt, respectively, have different thermal expansion properties, and **in that** the sealing arrangement comprises counter surfaces provided in the upper section (2) and the piston skirt (3), which surfaces are arranged with respect to one another so that their mutual distance is minimized at the working temperature of the surfaces. 25 30
3. A piston assembly according to claim 1, **characterised in that** the second distance is substantially such that the surfaces are attached to one another. 35
4. A piston assembly according to any of the preceding claims, **characterised in that** the sealing arrangement consists of alternating grooves and protrusions in the upper section and the skirt forming the counter surfaces in such a way that the protrusion of one counter surface is always facing the groove of the other counter surface. 40 45
5. A piston assembly according to claim 4, **characterised in that** the counter surfaces form a thread in the direction of the longitudinal axis of the piston. 50
6. A piston assembly according to claim 5, **characterised in that** the counter surfaces form a thread having a trapezoidal section in the direction of the longitudinal axis of the piston. 55
7. A piston assembly according to claim 4, **characterised in that** the counter surfaces form a sealing surface deviating from the direction of the longitudinal

axis of the piston.

8. A piston assembly (1) according to any of the preceding claims comprising grooves (4) for piston rings, **characterised in that** the grooves (4) of the piston rings have such a location that the joining point of the upper section and the skirt has to operate under compression pressure when the piston assembly is in operation.
9. A piston assembly (1) according to any of the preceding claims, **characterised in that** the sealing arrangement comprises several counter surfaces provided operationally in succession, which are arranged with respect to one another so that their mutual distance is reduced at the working temperature of the surfaces, and that a pressure balancing chamber is formed between two successive, tightly arranged counter surface pairs (2a - 3b).
10. An internal combustion engine provided with a piston assembly according to any one of the previous claims.

## Patentansprüche

1. Kolbenanordnung (1) für eine Brennkraftmaschine mit einem oberen Abschnitt (2), der in der Brennkammer des Zylinders beweglich ist, und einem Kolbenhemd (3) in Verbindung mit dem oberen Abschnitt, **gekennzeichnet durch** eine Dichtungsanordnung (1.2, 1.3), die Wärmeausdehnung zum Abdichten der Verbindung zwischen dem oberen Abschnitt und dem Hemd verwendet, wobei die Dichtungsanordnung (1.2, 1.3) zwischen dem oberen Abschnitt und dem Hemd zum Betrieb unter Arbeitsdruck ausgeführt ist, und **dadurch**, dass die Dichtungsanordnung zwischen dem oberen Abschnitt und dem Hemd des Kolbens mehrere Flächenabschnitte umfasst, wobei die Flächen des oberen Abschnitts und des Hemds im Wesentlichen parallel zueinander sind, wobei sich die Flächen bei Montagetemperatur in einem ersten Abstand voneinander befinden und die Richtung der Normalen dieser Flächenabschnitte ungefähr parallel zur Hauptwärmeausdehnungsrichtung am Flächenabschnitt verläuft, wobei die Flächen bei Arbeitstemperatur in einem zweiten Abstand voneinander beabstandet sind, und dass der zweite Abstand kürzer als der erste Abstand ist.
2. Kolbenanordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** die für den oberen Abschnitt und das Kolbenhemd ausgewählten Materialien jeweils verschiedene Wärmeausdehnungseigenschaften aufweisen und dass die Dichtungsanordnung Gegenflächen umfasst, die im oberen Ab-

schnitt (2) und im Kolbenhemd (3) vorgesehen sind, wobei diese Flächen bezüglich einander so angeordnet sind, dass ihr gegenseitiger Abstand bei Arbeitstemperatur auf ein Minimum reduziert ist.

3. Kolbenanordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** der zweite Abstand im Wesentlichen so ist, dass die Flächen aneinander angefügt sind.
4. Kolbenanordnung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Dichtungsanordnung aus abwechselnden Nuten und Vorsprüngen im oberen Abschnitt besteht und wobei das Hemd die Gegenflächen so bildet, dass der Vorsprung einer Gegenfläche immer zur Nut der anderen Gegenfläche weist.
5. Kolbenanordnung nach Anspruch 4, **dadurch gekennzeichnet, dass** die Gegenflächen ein Gewinde in Richtung der Längsachse des Kolbens bilden.
6. Kolbenanordnung nach Anspruch 5, **dadurch gekennzeichnet, dass** die Gegenflächen ein Gewinde mit einem trapezförmigen Abschnitt in Richtung der Längsachse des Kolbens bilden.
7. Kolbenanordnung nach Anspruch 4, **dadurch gekennzeichnet, dass** die Gegenflächen eine Dichtungsfläche bilden, die von der Richtung der Längsachse des Kolbens abweicht.
8. Kolbenanordnung (1) nach einem der vorhergehenden Ansprüche mit Nuten (4) für Kolbenringe, **dadurch gekennzeichnet, dass** sich die Nuten (4) der Kolbenringe in einer solchen Position befinden, dass die Verbindungsstelle des oberen Abschnitts und des Hemds unter Kompressionsdruck funktionieren muss, wenn die Kolbenanordnung in Betrieb ist.
9. Kolbenanordnung (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Dichtungsanordnung mehrere Gegenflächen umfasst, die betrieblich aufeinander folgend vorgesehen sind und bezüglich einander so angeordnet sind, dass ihr gegenseitiger Abstand bei Arbeitstemperatur der Flächen verringert wird, und dass eine Druckausgleichskammer zwischen zwei aufeinander folgenden, dicht angeordneten Gegenflächenpaaren (2a - 3b) ausgebildet ist.
10. Brennkraftmaschine, die mit einer Kolbenanordnung nach einem der vorhergehenden Ansprüche versehen ist.

## Revendications

1. Ensemble piston (1) pour un moteur à combustion interne comprenant une section supérieure (2) déplaçable dans la chambre de combustion du cylindre, une jupe de piston (3) connectée à la section supérieure, **caractérisé par** un agencement de scellement (1.2, 1.3) utilisant la dilatation thermique pour sceller le joint entre la section supérieure et la jupe, l'agencement de scellement (1.2, 1.3) entre la section supérieure et la jupe étant prévu pour fonctionner avec une pression de travail, et **caractérisé en ce que** l'agencement de scellement entre la section supérieure et la jupe du piston comprend plusieurs sections de surface, les surfaces de la section supérieure et de la jupe étant substantiellement parallèles, les surfaces étant situées à une première distance l'une de l'autre lorsque la température augmente et la direction de la normale auxdites sections de surface étant approximativement parallèle à la direction principale de dilatation thermique au niveau de la section de surface, les surfaces étant espacées l'une de l'autre d'une deuxième distance à la température de travail, et **en ce que** la deuxième distance est plus courte que la première distance.
2. Ensemble piston selon la revendication 1, **caractérisé en ce que** les matériaux sélectionnés pour la section supérieure et la jupe de piston, respectivement, ont des propriétés de dilatation thermique différentes et **en ce que** l'agencement de scellement comprend des contre-surfaces prévues dans la section supérieure (2) et la jupe de piston (3), lesquelles surfaces sont agencées l'une par rapport à l'autre de telle sorte que leur distance mutuelle soit minimisée à la température de travail des surfaces.
3. Ensemble piston selon la revendication 1, **caractérisé en ce que** la deuxième distance est substantiellement telle que les surfaces soient attachées l'une à l'autre.
4. Ensemble piston selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'agencement de scellement comprend une alternance de gorges et de crêtes dans la section supérieure et la jupe formant les contre-surfaces de telle sorte que la crête d'une contre-surface soit toujours en regard de la gorge de l'autre contre-surface.
5. Ensemble piston selon la revendication 4, **caractérisé en ce que** les contre-surfaces forment un filetage dans la direction de l'axe longitudinal du piston.
6. Ensemble piston selon la revendication 5, **caractérisé en ce que** les contre-surfaces forment un filetage ayant une section trapézoïdale dans la direction de l'axe longitudinal du piston.

7. Ensemble piston selon la revendication 4, **caracté-  
risé en ce que** les contre-surfaces forment une sur-  
face de scellement déviant de la direction de l'axe  
longitudinal du piston.
- 5
8. Ensemble piston (1) selon l'une quelconque des re-  
vendications précédentes, comprenant des gorges  
(4) pour des segments de piston, **caractérisé en ce  
que** les gorges (4) des segments de piston sont po-  
sitionnées de telle sorte que le point d'assemblage  
de la section supérieure et de la jupe doive fonction-  
ner à une pression de compression lorsque l'ensem-  
ble piston fonctionne.
- 10
9. Ensemble piston (1) selon l'une quelconque des re-  
vendications précédentes, **caractérisé en ce que**  
l'agencement de scellement comprend plusieurs  
contre-surfaces prévues en succession fonctionnel-  
le, qui sont agencées les unes par rapport aux autres  
de telle sorte que leur distance mutuelle soit réduite  
à la température de travail des surfaces, et qu'une  
chambre d'équilibrage de la pression soit formée en-  
tre deux paires de contre-surfaces successives  
agencées étroitement (2a-3b).
- 15  
20  
25
10. Moteur à combustion interne pourvu d'un ensemble  
piston selon l'une quelconque des revendications  
précédentes.

30

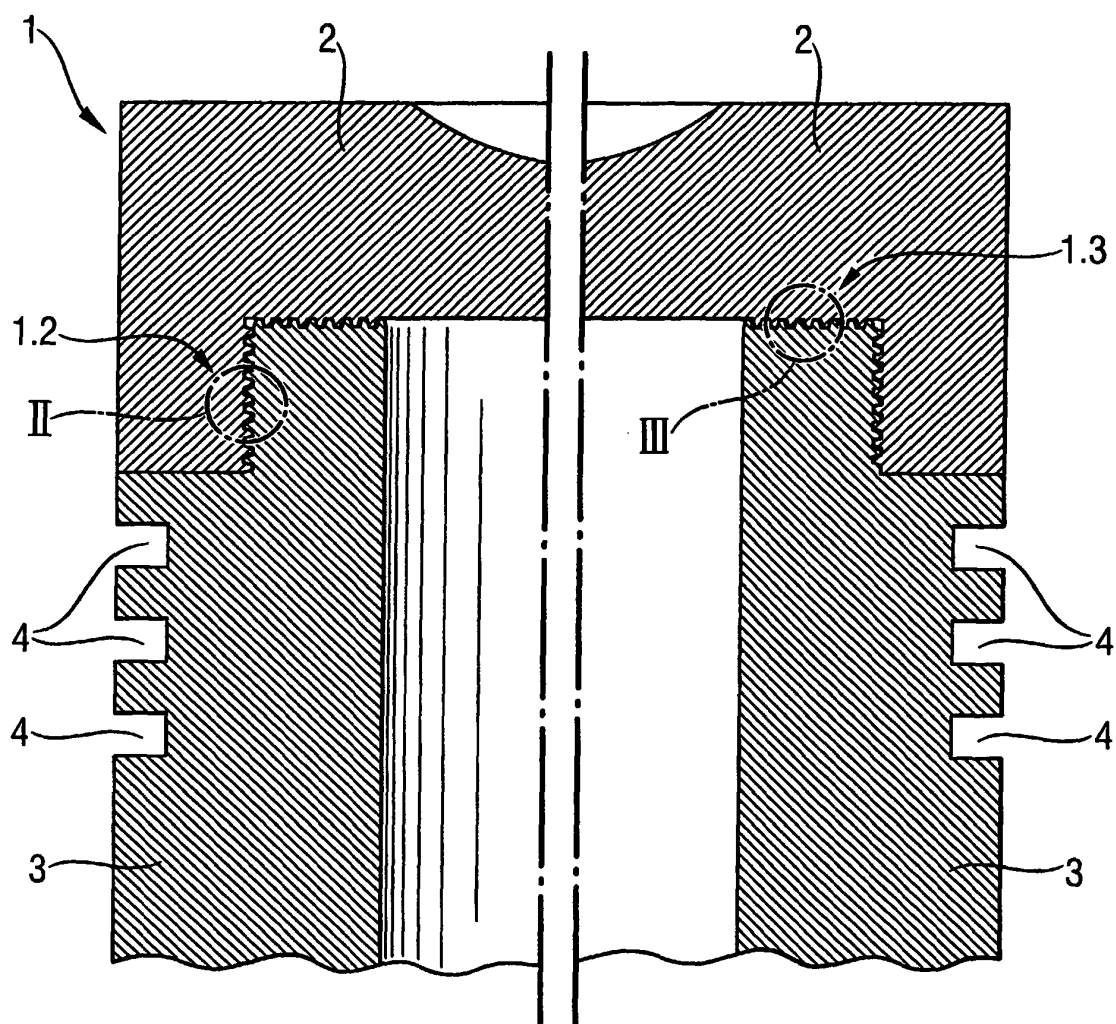
35

40

45

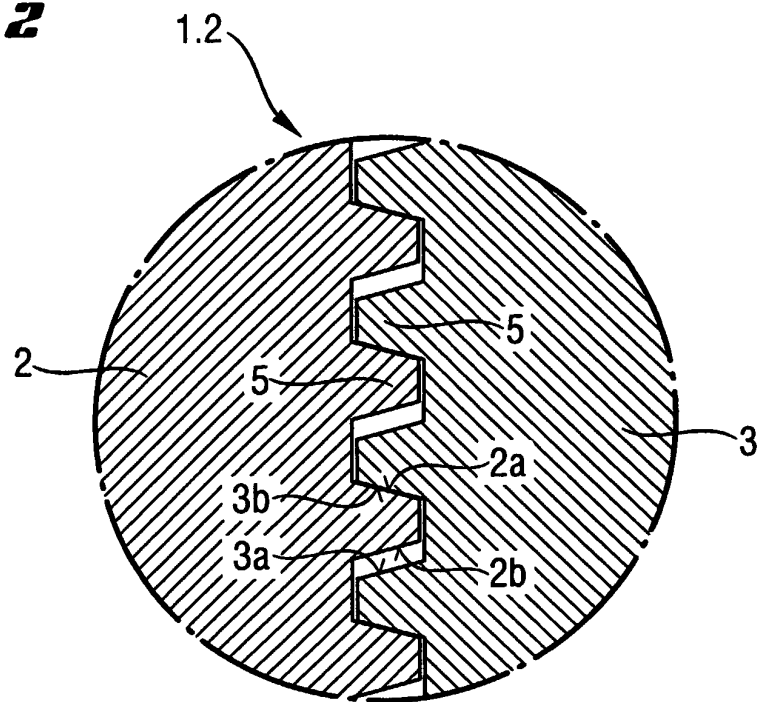
50

55

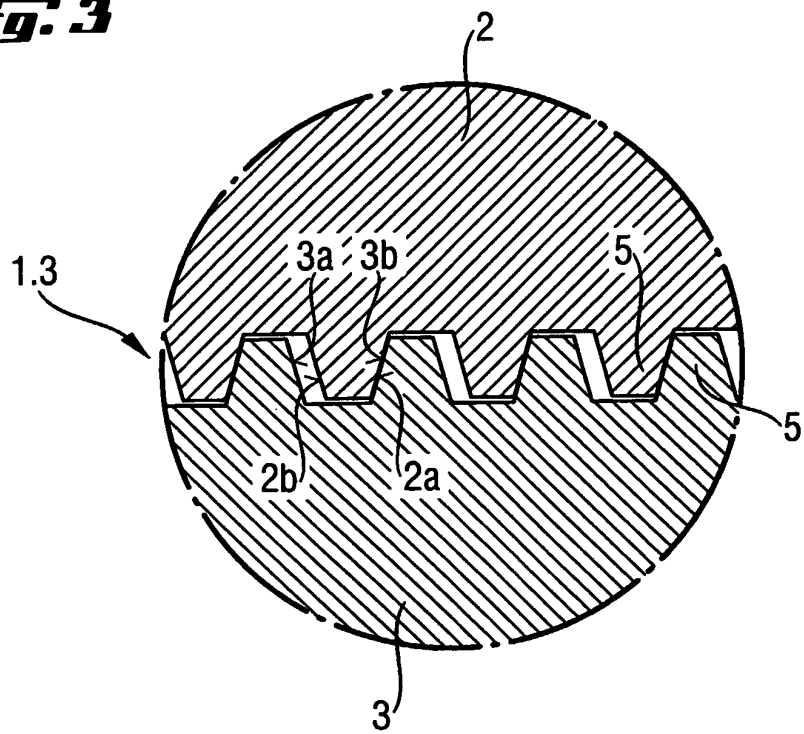


***Fig. 1***

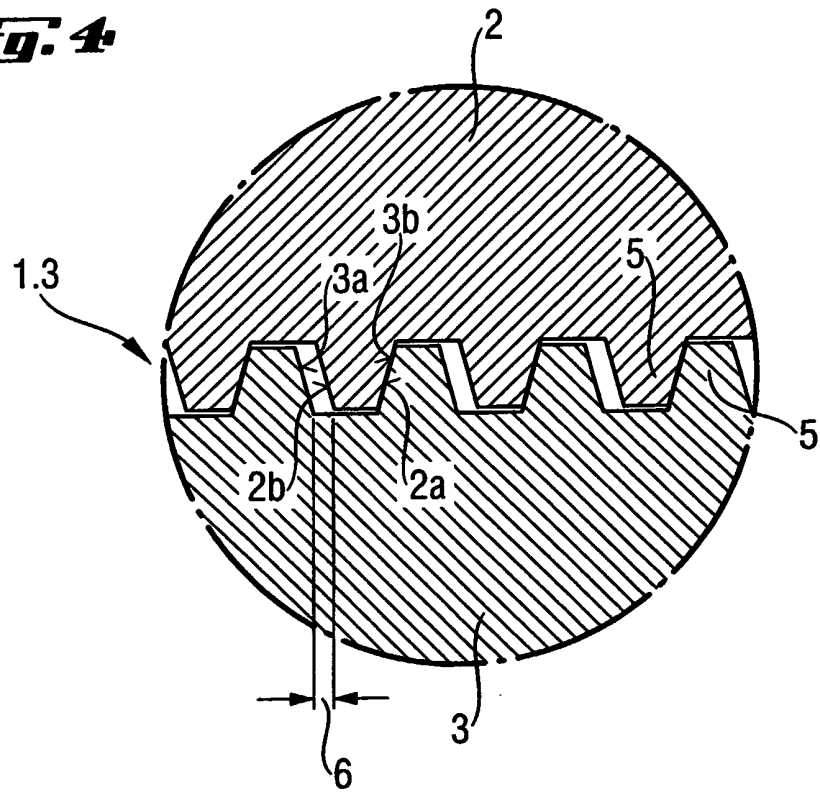
**Fig. 2**



**Fig. 3**



**Fig. 4**



**Fig. 5**

