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(54) METHOD FOR PRODUCING AN ADJUSTABLE CAMSHAFT AND ADJUSTABLE CAMSHAFT

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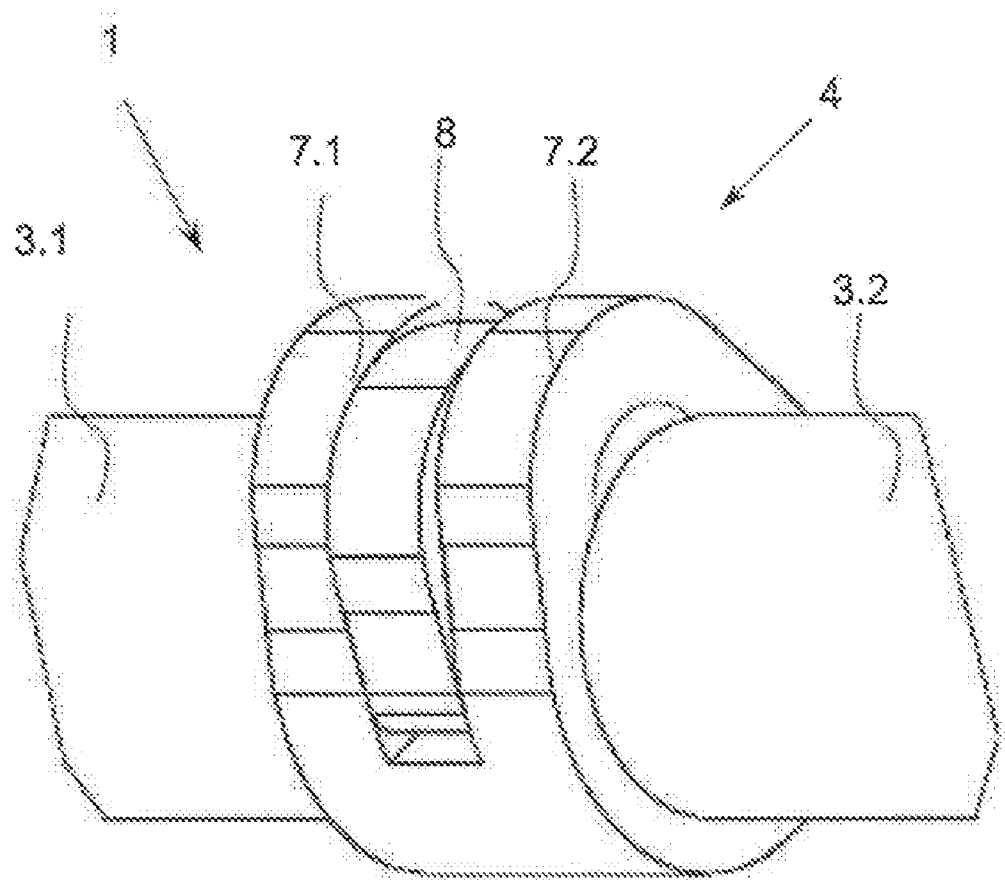
(57) ABSTRACT

An adjustable camshaft, which can be utilized in a motor vehicle, may include at least one fixed cam arranged rotationally fixed on at least one outer shaft segment and at least one adjusting cam arranged rotationally fixed to an inner shaft extending concentrically within the outer shaft segment. A method for producing such an adjustable camshaft may involve arranging an outer shaft segment on an inner shaft, generating a surface modification on a surface of the inner shaft to generate at least one arranging section, arranging a fixed cam on at least one section of the outer shaft segment, and arranging the adjusting cam on the arranging section of the inner shaft.



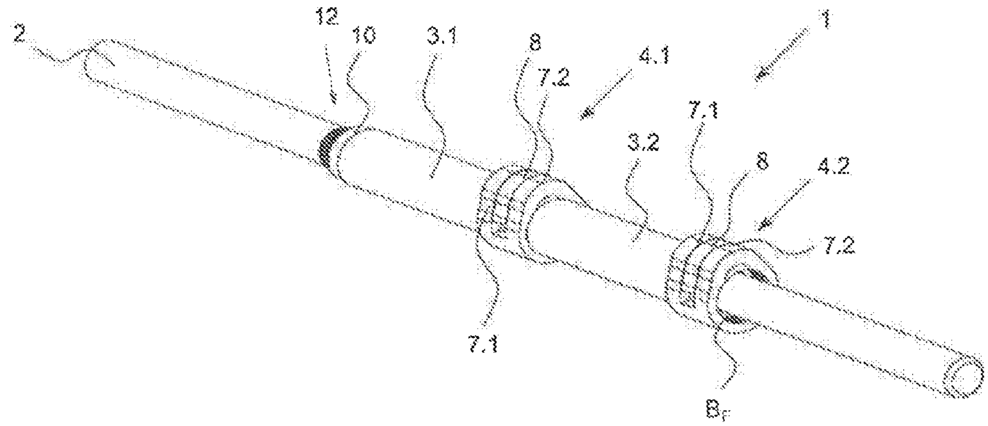


Fig.1

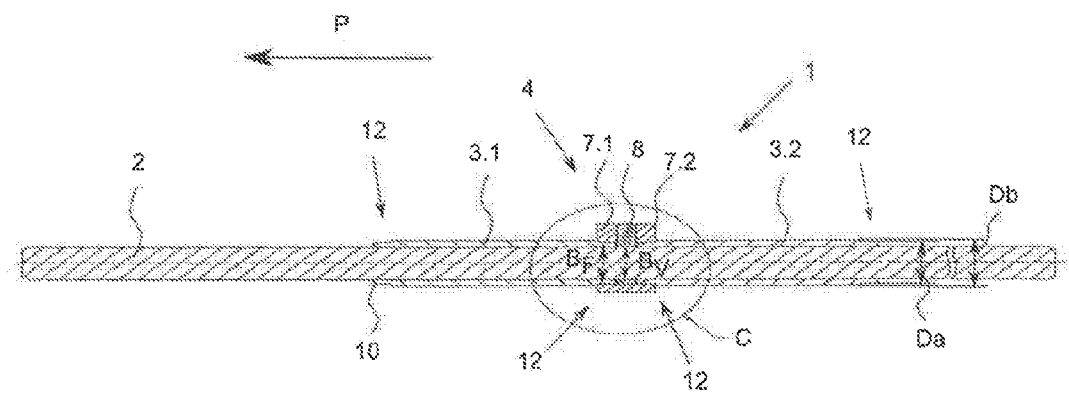


Fig. 2

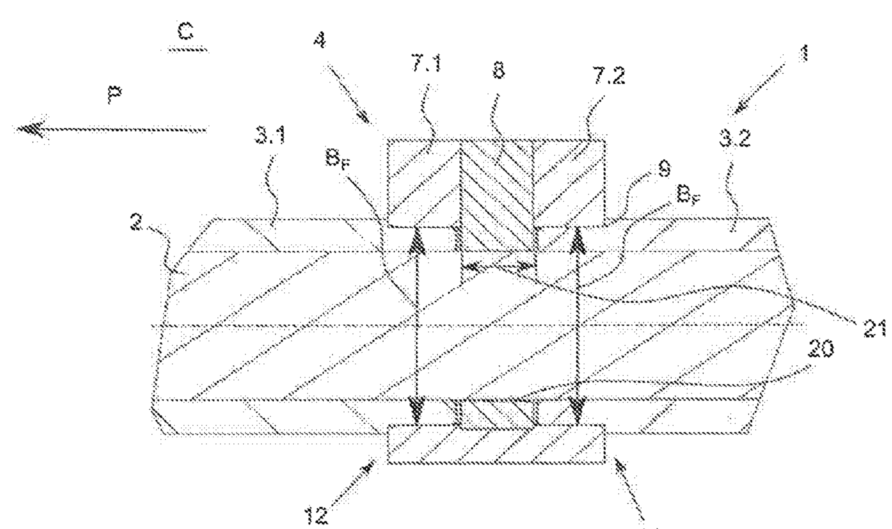


Fig. 3

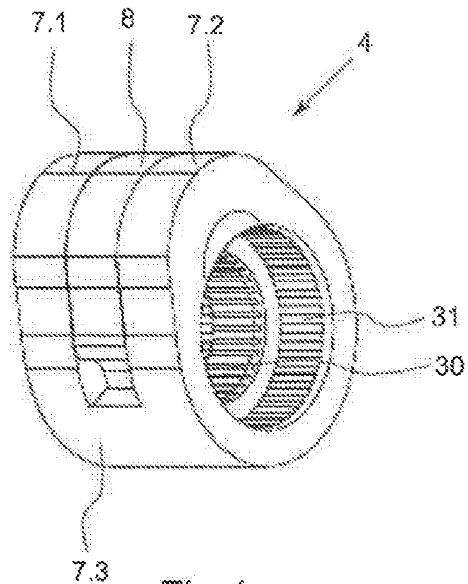


Fig.4

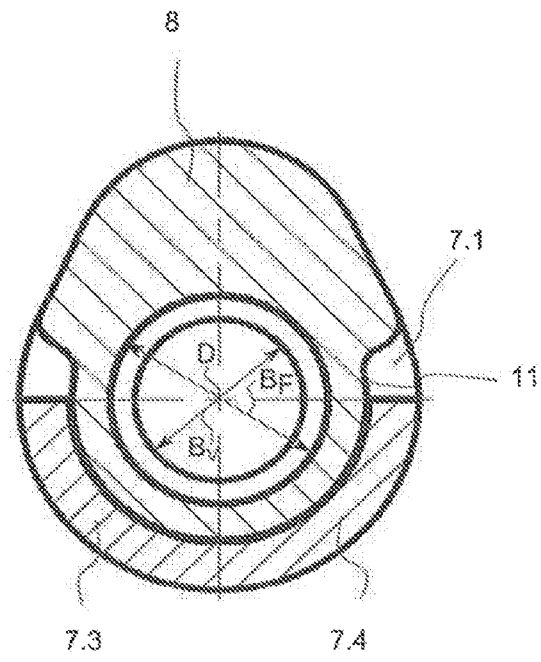


Fig.5

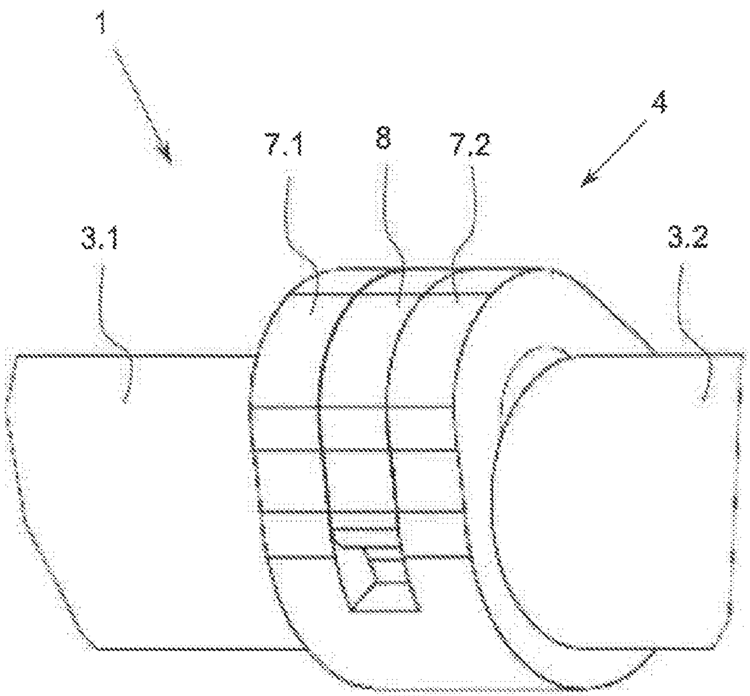


Fig.6

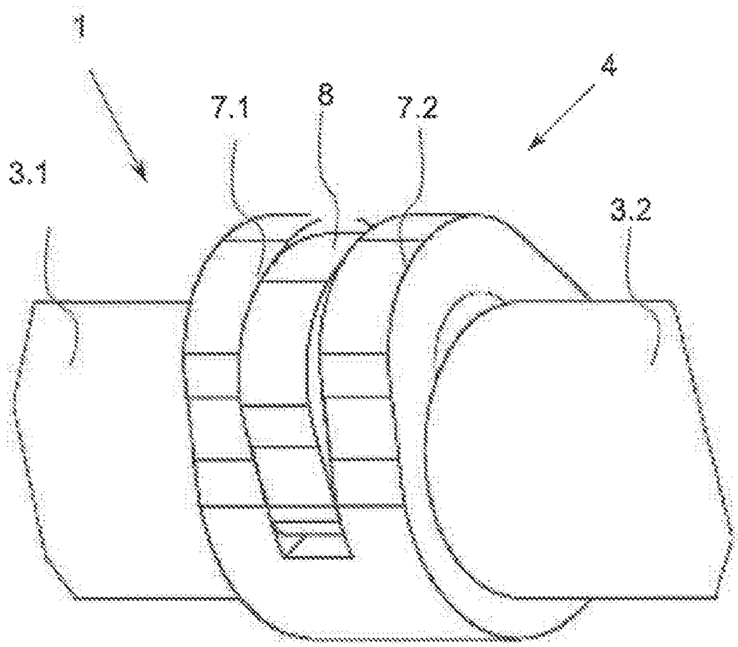


Fig.7

METHOD FOR PRODUCING AN ADJUSTABLE CAMSHAFT AND ADJUSTABLE CAMSHAFT

[0001] The present invention concerns a method for producing an adjustable camshaft of a motor vehicle. Moreover, the invention concerns an adjustable camshaft of a motor vehicle with at least one fixed cam arranged rotationally fixed on at least one outer shaft segment and at least one adjusting cam arranged rotationally fixed to an inner shaft extending concentrically within the outer shaft segment.

[0002] Adjustable camshafts basically find application in valve-controlled internal combustion engines, for example, and serve for the specific influencing of the control timing of the valves of the engine in regard to its development of torque and power, the fuel consumption, and the exhaust gas emission. As is known, adjustable camshafts are designed so that the camshaft comprises an outer shaft and an inner shaft arranged coaxially in this outer shaft. The outer shaft as well as the inner shaft can rotate relative to each other by means of a displacement mechanism, for example. Furthermore, there are cam elements connected to the outer shaft as well as cam elements connected to the inner shaft, while the cam elements of the outer shaft are arranged rotationally fixed on the outer shaft and the cam elements of the inner shaft are arranged rotationally fixed on the inner shaft and movably on the outer shaft, so that when the outer shaft rotates relative to the inner shaft the cam elements connected to the outer shaft are also rotated relative to the cam elements connected to the inner shaft. A rotating of the inner shaft relative to the outer shaft or the outer shaft to the inner shaft is made possible, as is known, by means of a phase shifter, so that a phase shift is advantageously achieved for the valve control timing or the opening duration of the valves can also be varied. In particular, in order to produce a fixed connection between the inner shaft and its corresponding cam elements, the inner shaft cam elements usually have slots in which corresponding connection elements of the inner shaft or connection elements which can be connected to the inner shaft can be inserted. Such connection elements may be, for example pins, bolts, or also screws. In this way, a torque transmission, advantageously should be made possible between the inner shaft and the cam element of the inner shaft.

[0003] For example, the German patent application DE197575404A1 discloses a corresponding camshaft with a connection element designed in the shape of a cylindrical pin. This cylindrical pin is inserted by press fitting into a through bore of the inner shaft and by means of loose fitting into the corresponding cams. For this, it is necessary that the corresponding cams have an outwardly projecting cylindrical region having a bore in which the cylindrical pin is inserted. Clearly, this requires a prior machining of the cam in order to connect it to the connection element of the inner shaft. Such a prior machining of the cam element increases the manufacturing cost, and the manufacturing costs for the production of an adjustable camshaft layout. Various manufacturing tolerances of the individual components, i.e., the slots in the inner shaft region and the slots in the cam region, as well as those for the connection elements, also lead to a variety of defect sources, so that the play might be too much when the cam is mounted on the inner shaft and a play-free transfer of torque from the inner shaft to the cam itself might not be assured.

[0004] Therefore the problem which the present invention proposes to solve is to eliminate at least some of the above-described drawbacks in an adjustable camshaft of a motor vehicle as well as those in a method for producing such an adjustable camshaft of a motor vehicle. In particular, the problem which the present invention proposes to solve is to provide a simple and economical method for the production of an adjustable camshaft, as well as an adjustable camshaft of a motor vehicle which can be produced in a simple and economical manner. Moreover, it should advantageously be possible to place the individual cams quickly, easily, and reliably on the outer shaft or the inner shaft inside a monolithic cowling.

[0005] The above problem is solved according to a first aspect of the present invention by a method for the production of an adjustable camshaft of a motor vehicle with the features of claim **1** and according to a second aspect of the present invention by an adjustable camshaft of a motor vehicle with the features of claim **6**. Further features and details of the invention will emerge from the subclaims, the description and the drawings. Features and details which have been described in connection with the method are also of course considered to be so in connection with the device of the invention, and vice versa, so that mutual reference can and will be done regarding the disclosure of the individual aspects of the invention. Furthermore, the adjustable camshaft according to the invention can be manufactured by means of the method of the invention for the production of an adjustable camshaft.

[0006] The method for producing an adjustable camshaft of a motor vehicle, wherein the camshaft comprises at least one fixed cam arranged rotationally fixed on at least one outer shaft segment and at least one adjusting cam arranged rotationally fixed to an inner shaft extending concentrically within the outer shaft segment, comprises at least the following steps:

- **[0007]** arranging an outer shaft segment on the inner shaft,
- **[0008]** generating a surface modification on a surface of the inner shaft to generate at least one arranging section,
- **[0009]** arranging the fixed cam on at least one section of the outer shaft segment and
- **[0010]** arranging the adjusting cam on the arranging section of the camshaft.

[0011] The adjustable camshaft according to the invention comprises an inner shaft which is adjustable and especially rotatable relative to the outer shaft, being arranged concentrically or coaxially to the outer shaft. Thus, advantageously, the inner shaft lies inside the outer shaft, which is designed for example in the form of a tube and accordingly comprises a through bore, through which the inner shaft extends for at least a portion. Advantageously, the outer shaft comprises at least one outer shaft segment, which is consequently in the form of a segment of the outer shaft and accordingly forms a tube segment not extending entirely along the longitudinal axis of the inner shaft. The adjustable camshaft furthermore comprises at least one fixed cam as well as at least one adjusting cam, the fixed cam being arranged rotationally fixed to the outer shaft and especially to the outer shaft segment, while the adjusting cam is arranged rotationally fixed to the inner shaft. Consequently, upon rotation of the outer shaft relative to the inner shaft, the fixed cam will turn relative to the adjusting cam, so that consequently there will occur a spreading in terms of the angle between adjusting cam and the fixed cam. The adjustable camshaft mentioned here finds application advantageously in the field of automotive engineering, wherein motor vehicles in the context of the invention can mean in particular land, air and water vehicles. Advantageously, the adjustable camshaft can be used in the field of automotive engineering and especially in the field of gasoline and diesel engine technology. The adjustable camshaft serves advantageously to optimize the charge cycle and make possible a variable compression ratio by a variation of the intake valve; and to reduce pollutant and CO_2 emission. Furthermore, it is conceivable for the adjustable camshaft to be used to regulate the variable valve control timing settings between intake and exhaust valve. Advantageously, the adjustable camshaft is used to optimize the mixture formation in injection type engines by increasing the charge mobility in the combustion space based on a specific phase shift of the intake valves, as well as reduce pollution emissions of the cold start phase of the internal combustion engine by cat-heating, for example by an early opening of the exhaust valve. Moreover, it is also conceivable to use such an adjustable camshaft advantageously to control the exhaust gas aftertreatment system such as the particle regeneration filter by an exhaust-side variability, or to control the exhaust gas turbocharging system by a corresponding exhaust-side variability.

[0012] In the context of the invention, the adjustable camshaft advantageously serves to enable the variability in the opening duration of the valve lifting, making possible a continuous opening duration of the entire cam profile, extending over the fixed cam and the adjusting cam, by means of a spreading of the adjusting cam relative to the fixed cam. The valve tapping element, which is a roller cam follower for example, makes contact in the first part of the valve lifting curve with the profile of the cam, while after the transition point the contact changes to the plateau-shaped profile of the adjusting cam. A displacement of such a camshaft and especially the inner shaft relative to the outer shaft is advantageously made possible by means of a phase shifter and especially a dual-phase or a double-phase shifter.

[0013] In order to make possible the construction of such a complex adjustable camshaft of a motor vehicle, an outer shaft segment is advantageously arranged on and in particular shoved onto an inner shaft. Later on in time, it is possible to generate an arranging section on the surface of the inner shaft, the surface of the inner shaft being modified or altered. Subsequent to the surface modification of the surface of the inner shaft for generating an arranging section, according to the invention the fixed cam is arranged on at least one portion of the outer shaft segment and the adjusting cam on the arranging section of the inner shaft.

[0014] In the context of the invention it is furthermore conceivable for the above-mentioned steps to also have a sequence varying in relation to each other. Thus, it is possible for the fixed cam itself to be positioned even before the generating of the surface modification of the inner shaft on at least a portion of the outer shaft segment or to be connected to it or arranged on it. It is furthermore conceivable to generate the surface modification of the inner shaft before the arranging of an outer shaft segment on the inner shaft. Advantageously, it is conceivable for the surface modification of the inner shaft to be used for a frictional and/or form-fitting and/or bonded connection of the adjusting cam to the camshaft, in order to join the adjusting cam especially in the region of the arranging section of the inner shaft to this inner shaft in a rotationally fixed manner, so that upon rotation of the inner shaft relative to the outer shaft the torque can be transmitted to the adjusting cam, so that the latter turns uniformly with the inner shaft about the central axis of rotation of the inner shaft. In the context of the invention, it does not matter whether the outer shaft is rotated relative to the inner shaft or the inner shaft relative to the outer shaft and especially whether the fixed cam is rotated relative to the adjusting cam or the adjusting cam relative to the fixed cam. Advantageously, the outer shaft segment, being in the form of a tube segment or a hollow shaft segment, is shoved onto the inner shaft, which is advantageously configured as a solid shaft, so that the outer shaft segment encloses the inner shaft at least for a portion. Consequently, the inner shaft is arranged centrally, preferably coaxially or concentrically, in the outer shaft.

[0015] In the context of the invention, it is conceivable to generate the surface modification by means of a material elevation. Thus, it is conceivable that the surface of the inner shaft is modified such that it comprises elevations of its own material especially in the arranging section. This advantageously avoids an additional arranging, introducing, or connecting of holding means or materials on the inner shaft and/or the adjusting cam, which are designed to connect the adjusting cam to the inner shaft.

[0016] Advantageously it is conceivable for the material elevation to be generated by means of rolling. In the rolling process, a chipless machining is done with a rolling body, which serves to smooth and strengthen the material surfaces. Advantageously, for example, a rolling tool is pressed with such force against the rotating inner shaft that the material of the inner shaft begins to flow, so that it is displaced accordingly. Advantageously, the rolling process is carried out by means of tools, such as rolling disks, which have a roughened working surface. By means of the rolling process and especially the generating of a material elevation on the surface of the inner shaft in order to generate at least one arranging section and advantageously a plurality of arranging sections on the inner shaft, the outer diameter of the inner shaft is consequently increased at least in the region. If, after generating the arranging section or the material elevation, a cam is shoved onto the inner shaft, advantageously having a through bore through which the inner shaft can extend, there will consequently be at least one frictional connection between the cam and the inner shaft and especially the modified surface of the inner shaft at least in the region of the arranging section having a surface modification. If a surface modification and especially a rolling of the surface of the inner shaft is done before shoving the fixed cam onto the inner shaft and connecting the fixed cam to the outer shaft segment, then it is advantageously conceivable for the fixed cam itself to have a through bore, being larger in diameter than the diameter of the through bore of the adjusting cam, in order to consequently be shoved across the surface modification of the surface of the inner shaft without creating for example a frictional connection between the fixed cam and the inner shaft. However, it would also be conceivable for the fixed cam and the adjusting cam to have substantially comparable through bore diameters, in which case it would be necessary for the fixed cam to be at least shoved onto the inner shaft prior to generating the surface modification of the inner shaft and furthermore advantageously to be arranged on the outer shaft segment. In the context of the invention, it is advantageously possible for the fixed cam to be joined force-fitted to the outer shaft segment and especially to a distal end of the outer shaft segment. However, it is also conceivable for the arrangement of the fixed cam with the outer shaft segment to be done by a form fitting and/or a bonded connection. Advantageously, the fixed cam will be shoved across at least one portion of the outer shaft segment, the fixed cam advantageously having a through bore diameter which corresponds substantially to the outer diameter of the outer shaft segment, in order to create advantageously a press fit connection between the outer shaft segment and the fixed cam. However, it is also conceivable for the outer shaft segment to have an insertion region, which can be designed in the form of an insert bevel, a shoulder, or a recess or the like. This insertion region advantageously serves to connect the fixed cam via this insertion region in a rotationally fixed manner to the outer shaft segment. Advantageously, the insertion region, especially a portion of this insertion region, furthermore itself also serves as a limiting region in order to prevent a further or inadvertent excessive shoving of the fixed cam on the outer shaft segment.

[0017] Advantageously, the adjustable camshaft comprises at least two fixed cams, each connected to an outer shaft segment, and an adjusting cam arranged between the fixed cams and connected in a rotationally fixed manner to the inner shaft. Consequently, a cam pack having a cam profile itself consists of more than one fixed cam and one adjusting cam, namely, advantageously of at least two fixed cams and one adjusting cam, which is arranged between the two fixed cams. Consequently, it is conceivable for a further fixed cam to be arranged adjacent to the adjusting cam and for a further outer shaft segment to be arranged adjacent to the further fixed cam on the inner shaft, the further fixed cam being arranged on the further outer shaft segment and being connected to it in particular in a rotationally fixed manner. The construction or assembly of the adjustable camshaft is accordingly done in modular fashion, in particular thanks to the advantageous modular design of the outer shaft, which consists of at least one outer shaft module and advantageously of one, two or more outer shaft segments.

[0018] Advantageously, the fixed cam or the two fixed cams of a cam pack are connected at least by force-fit or by form fit or by bonding to the outer shaft segment. However, it is also conceivable for the fixed cam to be joined force-fitted and by form fit and by bonding to the outer shaft segment. The same holds for the connection between the adjusting cam and the inner shaft segment, which can likewise be joined at least force-fitted or by form fit or by bonding to the inner segment. Advantageously, however, the adjusting cam is connected force-fitted via the material elevation to the inner shaft. Advantageously, a frictional connection between the connection cam and the outer shaft segment as well as the adjusting cam and the inner shaft enables an easy and economical fabrication and assembly of an adjustable camshaft for motor vehicles.

[0019] Furthermore, there is claimed an adjustable camshaft of a motor vehicle, which comprises at least one fixed cam arranged rotationally fixed on an outer shaft segment and at least one adjusting cam arranged rotationally fixed to an inner shaft extending concentrically within the outer shaft segment, wherein the adjusting cam is at least force-fitted connected to an arranging section of the inner shaft extending for at least a portion along the inner shaft, wherein the arranging section comprises a surface modification of the surface of the inner shaft. As already mentioned above, the outer shaft segment is advantageously designed in the form of a tube segment with a shell surface and a through bore, through which the camshaft extends for at least a portion. The inner shaft is advantageously a cylindrical rod-shaped element, especially advantageously a solid shaft, which extends for at least a portion through the through bore of the outer shaft segment. In the adjustable camshaft, the adjusting cams can be arranged able to rotate or move relative to the fixed cams in order to alter a cam profile of a cam pack from at least one fixed cam and at least one adjusting cam. The adjusting cam as well as the fixed cam advantageously each comprises a through bore, through which at least a portion of the inner shaft extends. Advantageously, the fixed cam comprises a through bore dimensioned such that at least the outer shaft segment can also extend for a portion through this through bore or can at least extend for a portion into the through bore. Advantageously, it is conceivable for the adjusting cam to be placed between two fixed cams, which are designed as single fixed cam elements or as a combined fixed cam element in a double anvil design. By the term double anvil design is meant in the context of the invention a design of the fixed cams in which the fixed cams have a common base region, through which the through bore extends, while the cam lifting region of the fixed cams is designed in particular at a spacing from each other. Consequently, between these two fixed cams joined together in the base region there is provided a recess, inside which the adjusting cam is introduced. The fixed cam or the fixed cams and the adjusting cam advantageously lie concentric to each other, so that upon a rotation of the fixed cams to the adjusting cam or of the adjusting cam to the fixed cams there occurs a rotation of the cams about an identical axis. Advantageously, the fixed cams and the adjusting cam form a combined cam profile, which can be varied based on the relative rotary movement between the fixed cams and the adjusting cam. Especially advantageously, the adjusting cam and especially the adjusting cam contour makes contact with a tapping element interacting accordingly with the respective cam contour, such as a cam follower for the transfer of the rotary movement of the camshaft into a translatory movement for the control of the valves, insofar as the adjusting cam is turned relative to the fixed cams and the cam contour of the adjusting cam is consequently displaced relative to the cam contour of the fixed cam or the fixed cams or takes up a changed position.

[0020] Advantageously, the surface modification of the surface of the inner shaft is a material elevation, which is generated for example by means of the rolling method. Thus, it is conceivable for the adjusting cam to be joined to the inner shaft by means of a pressing on and especially by means of a frictional connection in the arranging section, so that upon rotation of the inner shaft a rotation of the adjusting cam also occurs.

[0021] In the context of the invention, it is possible for the camshaft to comprise at least two outer shaft segments, on each of which a fixed cam is arranged in a rotationally fixed manner. Consequently, the adjusting cam is advantageously enclosed by the two fixed cams and accordingly by outer shaft segments connected to the fixed cams. Such a modular design, especially for the outer shaft by means of the use of individual outer shaft segments as well as the design of the cam pack, advantageously comprising at least one fixed cam and at least one adjusting cam and especially advantageously at least two fixed cams and one adjusting cam arranged between the fixed cams, advantageously enables an easy fabrication of the adjustable camshaft.

[0022] In the context of the invention, it is furthermore conceivable for the outer shaft segment to have at least one distal shell surface region whose outer diameter is smaller in dimension for at least a portion than an outer diameter of the remaining shell surface. Thus, advantageously, the outer shaft segment comprises an insertion region at least at one of the distal ends and advantageously at both distal ends in the region of the shell surface. This insertion region serves advantageously for shoving the fixed cam at least for a portion onto the outer shaft segment and advantageously onto a portion. The insertion region is designed advantageously in the form of a substantially continually decreasing or increasing insert bevel, a diameter constriction, a recess, a shoulder, or a comparable geometrical form by means of which an outer diameter of smaller dimension is formed in the insertion region at least for a portion, than in the remaining outer shaft segment. It is moreover conceivable for the length of these insertion regions or this insertion region, looking in the longitudinal direction of the outer shaft segment, to correspond substantially to the width of the fixed cam, so that the fixed cam can be arranged advantageously entirely, but at least almost entirely on this insertion region and be joined by it to the outer shaft segment advantageously in a rotationally fixed manner.

[0023] In the context of the invention, it is advantageously conceivable for the adjusting cam and the fixed cam to be arranged concentric to each other and for the through bore of the fixed cam to be larger in dimension than the through bore of the adjusting cam. This is especially advantageous when an assembly of the entire cam pack, advantageously consisting of at least one fixed cam and one adjusting cam, is shoved onto the inner shaft after the placement of the material elevation on this inner shaft. Advantageously, the through bore of the adjusting cam is roughly the same in dimension as the outer diameter or the circumferential diameter of the inner shaft. On the other hand, the through bore of the fixed cam is larger in dimension than the outer diameter or the circumferential diameter of the inner shaft and especially advantageously larger than the outer diameter of the material elevation or rolling, in order to enable a rolling of the fixed cam across the material elevation of the inner shaft during the assembly process. Advantageously, the through bore of the fixed cam is at most identical to the outer diameter or the circumferential diameter of the outer shaft segment, in order to enable a secure arrangement of the fixed cam on the outer shaft segment, especially by means of a press fit, advantageously by generating a frictional connection. Thanks to the use of a frictional connections between the fixed cam and the outer shaft segment as well as between the adjusting cam and the inner shaft, an easy and economical as well as a reliable fabrication and a durable use of the adjustable camshaft is possible.

[0024] All the benefits already described for the method of production of an adjustable camshaft according to the first aspect of the invention are present for the described adjustable camshaft.

[0025] Embodiments of an adjustable camshaft according to the invention shall be explained more closely below by means of drawings. There are shown, each time schematically:

[0026] FIG. **1** in a perspective view, one embodiment of an adjustable camshaft,

[0027] FIG. **2** in a cross sectional side view, one embodiment of an adjustable camshaft according to the invention,

[0028] FIG. **3** in a cross sectional side view, an enlargement of cutout C, as shown in FIG. **2**,

[0029] FIG. **4** in a perspective view, one embodiment of a cam pack of an adjustable camshaft according to the invention,

[0030] FIG. **5** in a cross sectional side view, one embodiment of a cam pack of a camshaft according to the invention,

[0031] FIG. **6** in a perspective view, a cutout from one embodiment of a camshaft according to the invention, showing a cam pack in a first arranging and

[0032] FIG. **7** in a perspective view the cutout shown in FIG. **7** for the camshaft according to the invention, in a second arranging of the cam pack.

[0033] Elements with the same function and mode of working are each time provided with the same reference numbers in FIGS. **1** to **7**.

[0034] FIG. **1** shows in a perspective view one embodiment of an adjustable camshaft **1** according to the invention. The camshaft **1** comprises an inner shaft **2** as well as two outer shaft segments **3.1** and **3.2**. Each outer shaft segment **3.1**, **3.2** comprises at least one insertion region **10**, being formed on a distal shell surface region **12**. The fixed cams **7.1**, **7.2**, as shown in the exemplary embodiment of FIG. **1**, are part of a cam pack **4.1**, **4.2**, it being conceivable for the camshaft **1** to have a plurality of such cam packs **4.1**, **4.2**. Each cam pack **4.1**, **4.2** comprises a first fixed cam **7.1** and a second fixed cam **7.2**, while between the two fixed cams, **7.1**, **7.2** is arranged an adjusting cam. Advantageously, the inner shaft **2** extends through the through bore of the fixed cam B_F, shown in FIG. **1**, as well as through a through bore of the adjusting cam **8**, not shown here, and through a corresponding through bore of the outer shaft segments **3.1** and **3.2**, not shown here. The arrangement of the fixed cams **7.1**, **7.2** and the adjusting cam **8** will be explained in particular in FIGS. **2** and **3**.

[0035] FIGS. **2** and **3** show in a side view a cross sectional representation of one embodiment of the adjustable camshaft **1** according to the invention, FIG. **3** showing a magnified representation of the region C shown in FIG. **2**. The section shown in FIG. **2** and of one embodiment of a camshaft **1** according to the invention comprises at least one cam pack **4**, having a first fixed cam **7.1** and a second fixed cam **7.2** as well as an adjusting cam **8** arranged between the fixed cams **7.1** and **7.2**. As can be seen from FIGS. **2** and **3**, the through bore B_F of the fixed cams **7.1** and **7.2** comprises a larger diameter than the through bore B_V of the adjusting cam **8**. In this way, it is advantageously possible to shove the cam pack **4** over the inner shaft **2** in a previously assembled condition during the assembly process for the adjustable camshaft **1**, that is, a condition consisting of the two fixed cams **7.1** and **7.2** as well as the adjusting cam **8**, while it would be conceivable for the inner shaft **2** to have already undergone a surface modification **20** and in particular a material elevation in the form of a rolling process. Based on the different diameters B_V, B_F of the bores of the fixed cams **7.1**, **7.2** and adjusting cam **8**, it is consequently assured that, especially when shoving the cam pack **4** onto the inner shaft **2**, the first fixed cam **7.1** in particular is moved across the surface modification **20** and especially the material elevation **20** of the inner shaft **2**, while during further movement of the cam pack **4** along the inner shaft **2** especially in the represented arrow direction P a contacting occurs between the surface of the through bore B_V of the adjusting cam **8** and the material elevation **20** or the surface modification **20** of the inner shaft **2**. This advantageously makes possible a frictional connection between the adjusting cam **8** and the inner shaft **2**. It is conceivable that, after the mounting of the cam pack **4** on the inner shaft **2** and an arranging of the adjusting cam **8** at the arranging section **21** of the inner shaft **2**, having the surface modification **20**, advantageously a first outer shaft segment **3**.**1** and a second outer shaft segment **3**.**2** is shoved onto the inner shaft **2**. It would also be conceivable for the first outer shaft segment **3**.**1** or **3**.**2**, depending on the mounting direction, to have already been shoved onto the inner shaft **2** even before the placement of the cam pack **4**.

[0036] As shown in FIGS. **2** and **3**, the two outer shaft segments **3**.**1** and **3**.**2** advantageously have an insertion region **10** at both distal ends **12** and especially at the distal shell surface regions **12**. This insertion region can be designed, for example, in the form of a shoulder, an insert bevel, a recess or slot, or a comparable form geometrically changing the shell surface. Advantageously, the outer diameter and especially the circumferential diameter of the outer shaft segments **3**.**1** and **3**.**2** comprises a smaller diameter in the region of the insertion regions **10**, as indicated by the reference Da, than in the remaining region of the outer shaft segment, as indicated by the reference Db. The shape and size or geometrical configuration of the insertion regions **10** will not be limited to a particular geometrical shape in the context of the invention. Instead, it should be noted that the insertion regions **10** are designed such as to advantageously ensure a frictional connection between the fixed cams **7**.**1** and **7**.**2** and the respective outer shaft segments **3**.**1** and **3**.**2**. Advantageously, the insertion region **10** of the respective outer shaft segment **3**.**1** or **3**.**2** also serves to prevent too far a placement or shoving of the cam pack **4** or the fixed cam **7**.**1** or **7**.**2** of the cam pack **4** onto the outer shaft segment **3**.**1** or **3**.**2**.

[0037] In the context of the invention, it would also be conceivable to first shove or mount the outer shaft segment **3**.**1** or **3**.**2** onto the inner shaft **2**, before a rolling of the inner shaft **2** and especially a surface treatment of the inner shaft **2** to generate a surface modification **20** takes place. Accordingly, it would be conceivable in the method for creating the camshaft according to the invention to first shove a first outer shaft segment **3**.**1** onto an inner shaft **2**, which is accommodated for example in a chuck on an automatic cam placing machine. After this, the rolling of the inner shaft **2** could occur, in order to create a material elevation **20** on the surface of the inner shaft **2**. In a further step, it would be conceivable to mount the cam pack **4**, preferably with adjusting cam **8** threaded or arranged between the fixed cam **7**.**1**, on the inner shaft **2**, so that a frictional connection is produced between the first fixed cam **7**.**1** and the first outer shaft segment **3**.**1** as well as the adjusting cam **8** and the surface modification **20** or the material elevation **20** of the inner shaft **2**. In a further, following step, it would be conceivable for a second outer shaft segment **3**.**2** to be shoved onto the inner shaft **2** and this far enough into the region of the cam pack **4** onto the inner shaft **2** so that in particular the insertion region **10** is force-fitted connected to the second fixed cam **7**.**2** of the cam pack **4**. It is conceivable for a spacing to be present between the outer shaft segments **3**.**1** and **3**.**2** and the adjusting cam **8** in order to prevent a contacting of the outer shaft segments **3**.**1** or **3**.**2** with the adjusting cam **8**. Advantageously, this will prevent friction during movement between outer shaft or outer shaft segments **3**.**1**, **3**.**2** and inner shaft **2** and especially between fixed cams **7**.**1** and **7**.**2** and adjusting cam **8**. Too far a shoving of the fixed cam **7**.**1**, **7**.**2** onto the outer shaft segments **3**.**1**, **3**.**2** is advantageously prevented by a limiting element **9**, such as is shown for example in FIG. **3**. This limiting element **9** is advantageously part of the insertion region **10** and comprises a wall which extends substantially—at least for a portion—in the radial direction.

[0038] FIG. **4** shows in perspective view an embodiment of a cam pack **4**, being an element of the adjustable camshaft **1** according to the invention. The cam pack **4** comprises a first fixed cam **7**.**1** and a second fixed cam **7**.**2**, enclosing the adjusting cam **8**. The adjusting cam **8** advantageously comprises an identical cam contour to the fixed cams **7**.**1** and **7**.**2** and is mounted concentrically to the fixed cams **7**.**1** and **7**.**2**, so that upon movement of the adjusting cam **8** relative to the fixed cams **7**.**1** and **7**.**2** a rotation of the cams **7**.**1**, **7**.**2**, **8** about a common axis of rotation D, as shown in particular in FIG. **4**, can occur. Advantageously, the adjusting cam **8** is designed to be movable relative to the fixed cams **7**.**1** and **7**.**2**. As shown in FIG. **4**, the through bore B_F of the fixed cam **7**.**1** or **7**.**2** as well as the through bore B_V of the adjusting cam **8** each comprises—at least for a portion—a structured surface **30** or **31**, which can be designed identical to each other or also different from each other. Based on this structured surface **30**, **31**, a frictional connection is optimized between the fixed cams **7**.**1**, **7**.**2** and the surfaces of the outer shaft segments **3**.**1** and **3**.**2** as well as between the adjusting cam **8** and the surface of the inner shaft **2**, as shown for example in FIGS. **1** to **3**. The fixed cams **7**.**1** and **7**.**2** are advantageously joined together in their base region **7**.**3** and consequently form a fixed cam consisting of two cam profiles. Such an arrangement of fixed cams with respect to each other is also called a double anvil in the context of the invention. Consequently, a recess is formed between the cam contours of the individual fixed cams **7**.**1** and **7**.**2**, which are spaced apart from each other, in which the adjusting cam **8** is encompassed. However, it would also be conceivable to arrange only one adjusting cam **8** and one fixed cam **7**.**1** or **7**.**2**. Advantageously, in this case, at least the fixed cam **7**.**1** or **7**.**2** and/or the adjusting cam **8** could be press-fitted on a sleeve (not shown here), and this sleeve is or can be operatively connected at least to one outer shaft segment **3**.**1** or **3**.**2** or to the inner shaft **2**, advantageously making use of a frictional connection.

[0039] FIG. **5** shows schematically in a side view a cross sectional representation of one embodiment of a cam pack **4**. The cam pack **4** shown in FIG. **5** advantageously comprises a first fixed cam **7**.**1** and a second fixed cam **7**.**2**, not shown here, between which is arranged an adjusting cam **8**. As is also shown in particular in FIG. **5**, the adjusting cam **8** comprises a through bore B_V, which is smaller in dimension than the through bore B_F of the fixed cam **7**.**1** or **7**.**2**. The fixed cam **7**.**1** or **7**.**2** or the fixed cam element designed as a double anvil can be moved about an axis of rotation D identical to the adjusting cam **8**, so that consequently the fixed cams **7**.**1**, **7**.**2** and the adjusting cam **8** are arranged concentrically or coaxially to each other with respect to their axis of rotation D. Furthermore, the adjusting cam **8** comprises a clearance **11**, inside which runs the transition region **7**.**4** of the base region **7**.**3** of the double-anvil fixed cam.

Based on the clearance **11** of the adjusting cam **8**, a rotation of the adjusting cam **8** relative to the fixed cam **7.1** or **7.2** is possible. Advantageously, this clearance **11** also serves for mounting the inner shaft **2** in at least one of the outer shaft segments **3.1**, **3.2**.

[0040] The movement or rotary movement of the adjusting cam **8** relative to the fixed cams **7.1** and **7.2** and especially the movement of the cam pack **4** is shown advantageously in FIGS. **6** and **7**. Thus, FIG. **6** shows schematically in a perspective view a cutout of an embodiment of a camshaft **1** according to the invention with a cam pack **4** in a first arranging, in which the adjusting cam **8** comprises undergone no rotary movement relative to the fixed cam **7.1** or **7.2**. Consequently, the cam pack **4** comprises a flat cam contour. Upon rotary movement of the inner shaft **2** relative to the outer shaft or the outer shaft segments **3.1** or **3.2**, a rotary movement of the adjusting cam **8** relative to the fixed cam **7.1** or **7.2** consequently occurs. In this way, the cam pack **4** experiences a spreading of the adjusting cam **8** relative to the fixed cams **7.1** and **7.2**, as shown especially in FIG. **7**. Based on the spreading, the cam profile of the entire cam pack **4** is consequently changed, by which a tapping element controls the setting or adjusting of intake and/or exhaust valves.

[0041] Advantageously, the method according to the invention for the production of an adjustable camshaft as well as an adjustable camshaft of a motor vehicle according to the invention advantageously produced with the method of the invention will enable a production or fabrication and assembly of an adjustable camshaft in an easier and more economical manner. Thus, advantageously, it is no longer required to arrange a connection element, such as a pin, for connecting the inner shaft to the adjusting cam. Furthermore, it should be mentioned advantageously that the method according to the invention makes possible a production or assembly of the adjustable camshaft in a single layout, the individual elements, namely the inner shaft as well as the outer shaft segments, the cam pack with the fixed cams and the adjusting cam being able to be mounted in a common layout. This advantageously prevents the time-consuming and costly transport of intermediate workpieces and avoids damage to semi-assembled or preassembled camshafts. Furthermore, it is advantageous that ground cams and especially ground fixed cams and ground adjusting cams can be installed by means of the method according to the invention.

LIST OF REFERENCE NUMBERS

[0042] **1** Camshaft
[0043] **2** Inner shaft
[0044] **3.1** First outer shaft segment
[0045] **3.2** Second outer shaft segment
[0046] **4.1** First cam pack
[0047] **4.2** Second cam pack
[0048] **4** Cam pack
[0049] **7.1** First fixed cam
[0050] **7.2** Second fixed cam
[0051] **7.3** Base region
[0052] **7.4** Transition region
[0053] **8** Adjusting cam
[0054] **9** Limiting element
[0055] **10** Insertion region
[0056] **11** Clearance
[0057] **12** Distal end/distal shell surface region
[0058] **20** Surface modification/material elevation
[0059] **21** Arranging section
[0060] **30** Structured surface of the fixed cam
[0061] **31** Structured surface of the adjusting cam
[0062] B_F Through bore of the fixed cam
[0063] B_V Through bore of the adjusting cam
[0064] D Axis of rotation
[0065] Da Outer diameter of distal shell surface region
[0066] Db Outer diameter of the remaining shell surface
[0067] P Arrow direction

1.-**10**. (canceled)

11. A method for producing an adjustable camshaft of a motor vehicle, wherein the adjustable camshaft comprises a fixed cam disposed rotationally-fixed on an outer shaft segment and an adjusting cam disposed rotationally-fixed to an inner shaft extending concentrically within the outer shaft segment, the method comprising:
- positioning the outer shaft segment on the inner shaft;
- generating a surface modification on a surface of the inner shaft to generate an arranging section;
- positioning the fixed cam on a section of the outer shaft segment; and
- positioning the adjusting cam on the arranging section of the inner shaft.

12. The method of claim **11** wherein the generation of the surface modification occurs by way of a material elevation.

13. The method of claim **12** wherein the material elevation is generated by means of rolling.

14. The method of claim **11** wherein the fixed cam is a first fixed cam and the outer shaft segment is a first outer shaft segment, the method further comprising:
- positioning a second fixed cam adjacent to the adjusting cam; and
- positioning a second outer shaft segment on the inner shaft adjacent to the second fixed cam, wherein the second fixed cam is disposed on the second outer shaft segment.

15. The method of claim **11** further comprising connecting the fixed cam to the outer shaft segment in at least one of a force-fitted manner, a form-fitted manner, or a firmly bonded manner.

16. An adjustable camshaft of a motor vehicle, the adjustable camshaft comprising:
- a fixed cam disposed rotationally-fixed on an outer shaft segment; and
- an adjusting cam disposed rotationally-fixed to an inner shaft extending concentrically within the outer shaft segment, wherein the adjusting cam is at least force-fit connected to an arranging section of the inner shaft extending along a portion of the inner shaft, wherein the arranging section comprises a surface modification of a surface of the inner shaft.

17. The adjustable camshaft of claim **16** wherein the fixed cam is a first fixed cam, wherein the adjusting cam is disposed between the first fixed cam and a second fixed cam, wherein the first and second fixed cams are configured as single fixed cam elements or as a combined fixed cam element in a double-anvil design.

18. The adjustable camshaft of claim **16** wherein the outer shaft segment is a first outer shaft segment and the fixed cam is a first fixed cam, the adjustable camshaft further comprising a second outer shaft segment and a second fixed cam, wherein the second fixed cam is disposed rotationally-fixed on the second outer shaft segment.

19. The adjustable camshaft of claim **16** wherein the outer shaft segment comprises a distal shell surface region with an outer diameter that is smaller in dimension for at least a portion than an outer diameter of a remaining shell surface.

20. The adjustable camshaft of claim **16** wherein the adjusting cam and the fixed cam are disposed concentrically, wherein a through bore of the fixed cam is larger in dimension than a through bore of the adjusting cam.

21. An adjustable camshaft of a motor vehicle, the adjustable camshaft comprising:

an inner shaft;

an adjusting cam disposed on the inner shaft in a rotatably-fixed manner;

a first outer shaft segment through which the inner shaft extends, wherein an end of the first outer shaft segment is adjacent to the adjusting cam; and

a first fixed cam disposed on the first outer shaft segment in a rotatably-fixed manner, with the first fixed cam being adjacent to the adjusting cam.

22. The adjustable camshaft of claim **21** further comprising:

a second outer shaft segment through which the inner shaft extends, wherein an end of the second outer shaft segment is adjacent to the adjusting cam such that the adjusting cam is disposed between the first and second outer shaft segments; and

a second fixed cam disposed on the second outer shaft segment in a rotatably-fixed manner, with the second fixed cam being adjacent to the adjusting cam.

23. The adjustable camshaft of claim **22** wherein the first and second fixed cams are coupled together.

24. The adjustable camshaft of claim **23** wherein the adjusting cam is rotatably secured to the first and second fixed cams.

25. The adjustable camshaft of claim **21** wherein a diameter of a through bore of the first fixed cam is larger than a diameter of a through bore of the adjusting cam.

26. The adjustable camshaft of claim **21** wherein the adjusting cam is disposed on a material elevation of a surface of the inner shaft.

27. The adjustable camshaft of claim **21** wherein a thickness of the first outer shaft segment is reduced at a region of the first outer shaft segment that supports the first fixed cam.

28. The adjustable camshaft of claim **21** wherein a space exists between the first outer shaft segment and the adjusting cam.

29. The adjustable camshaft of claim **21** further comprising a limiting element disposed between the first outer shaft segment and the adjusting cam.

30. The adjustable camshaft of claim **22** wherein the adjusting cam and the first fixed cam are disposed concentrically.

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