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(54) **CONTROL VALVE**

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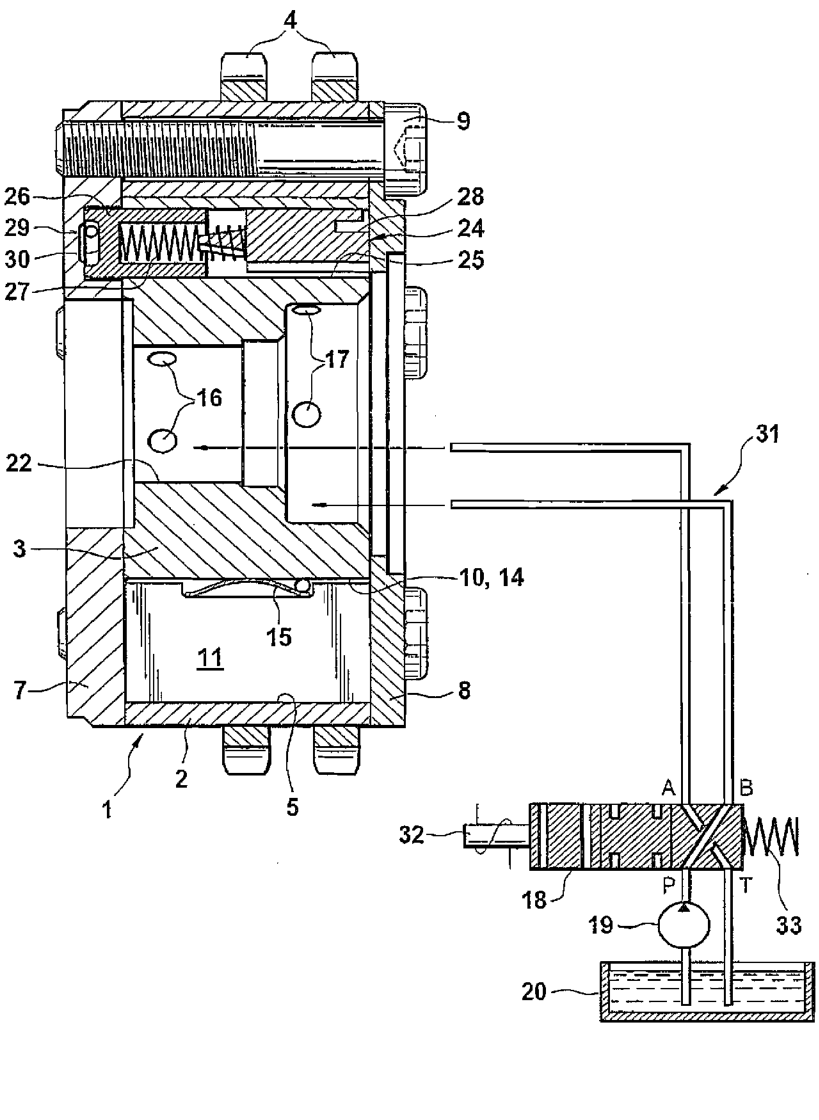
(57) **ABSTRACT**

A control valve (**101**) for the control of a hydraulic device for changing the control times of gas exchange valves of an internal combustion engine is provided, The control valve (**101**) is located in a valve housing (**106**) and an elastic seal element (**124**) is provided at an axial end thereof. The elastic seal element (**124**) secures function by prevention of leakage flow between pressure medium channels (**113**) and the pressure medium channels (**113**) and the drain connector (T). Also provided is an elastic seal ring (**124**) provided as a sealing ring with two conical regions (**129**, **131**).



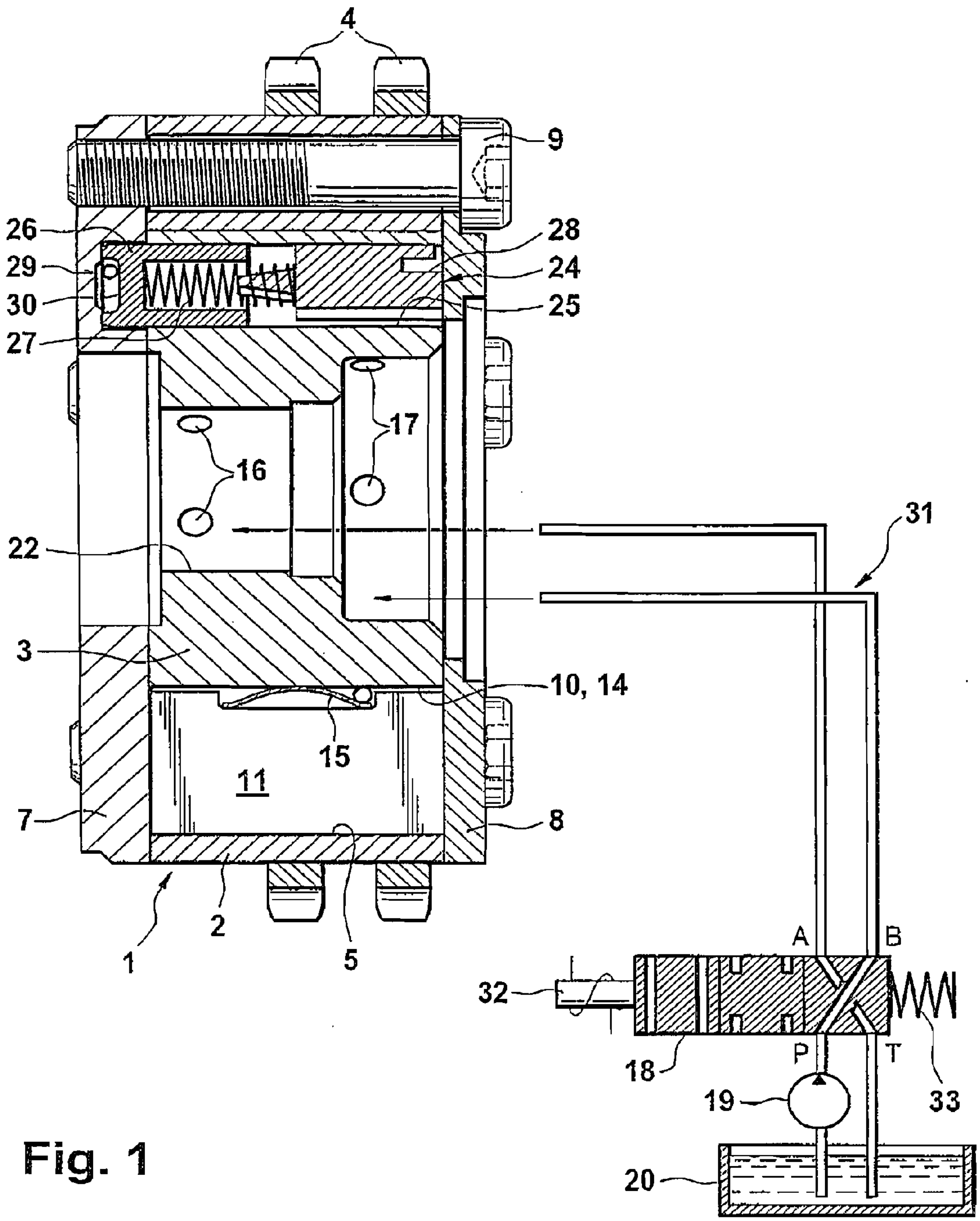


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Fig. 1

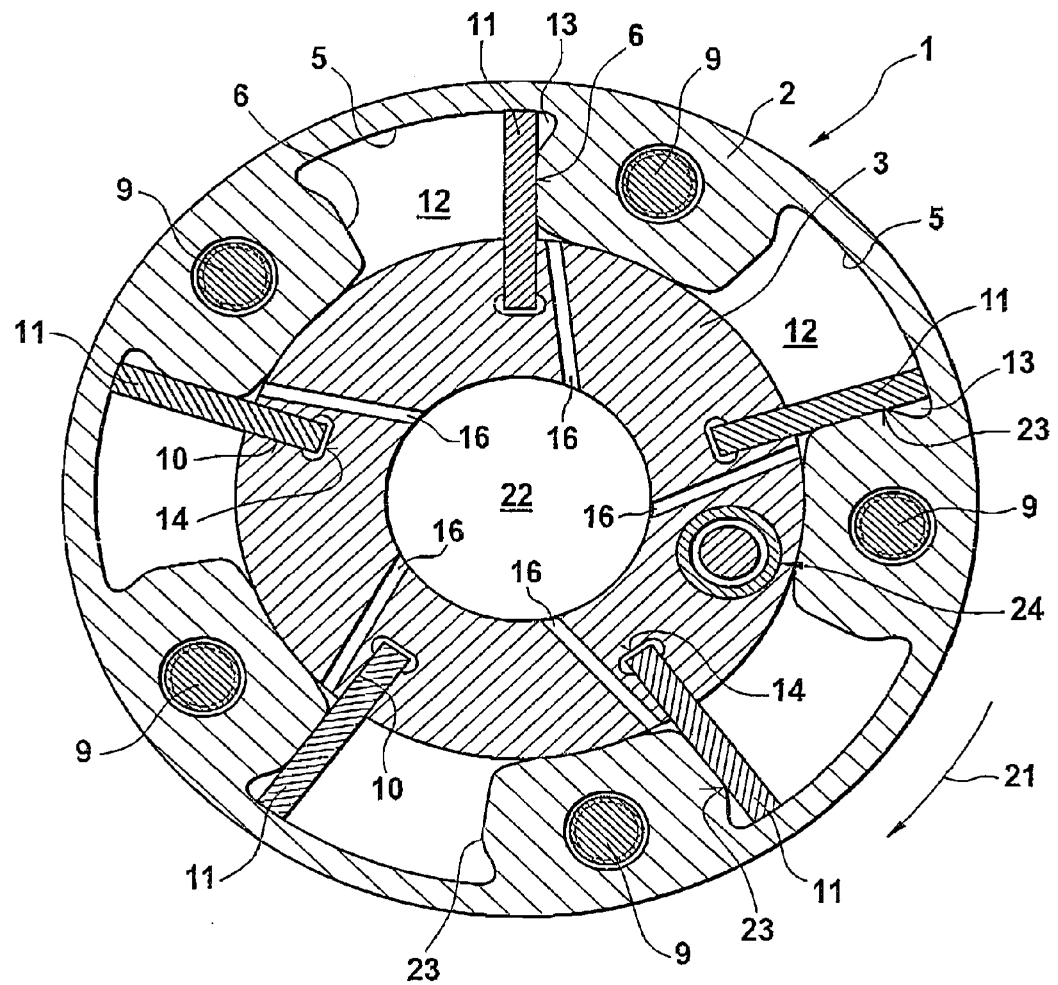
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Fig. 2

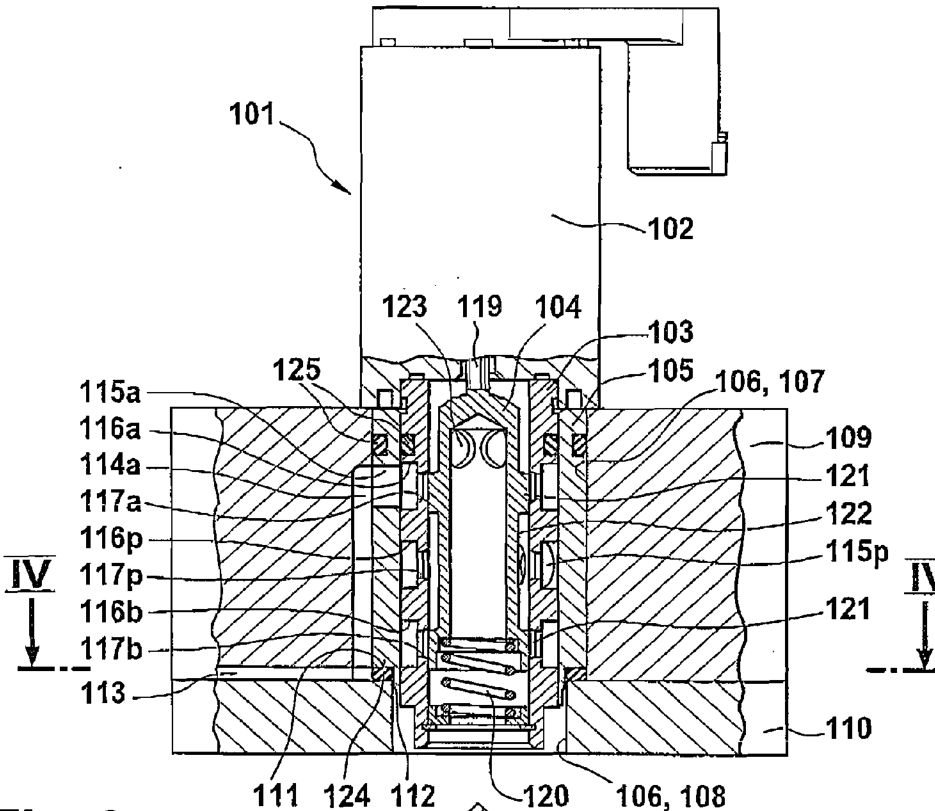
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Fig. 3

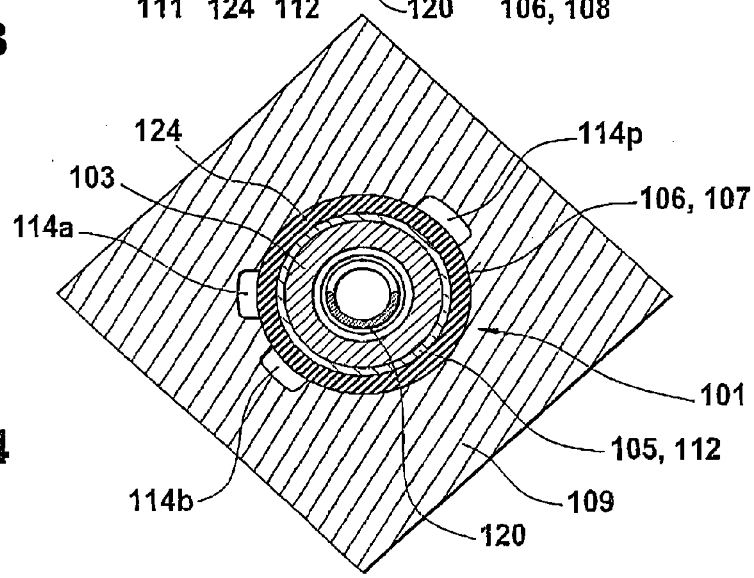
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Fig. 4

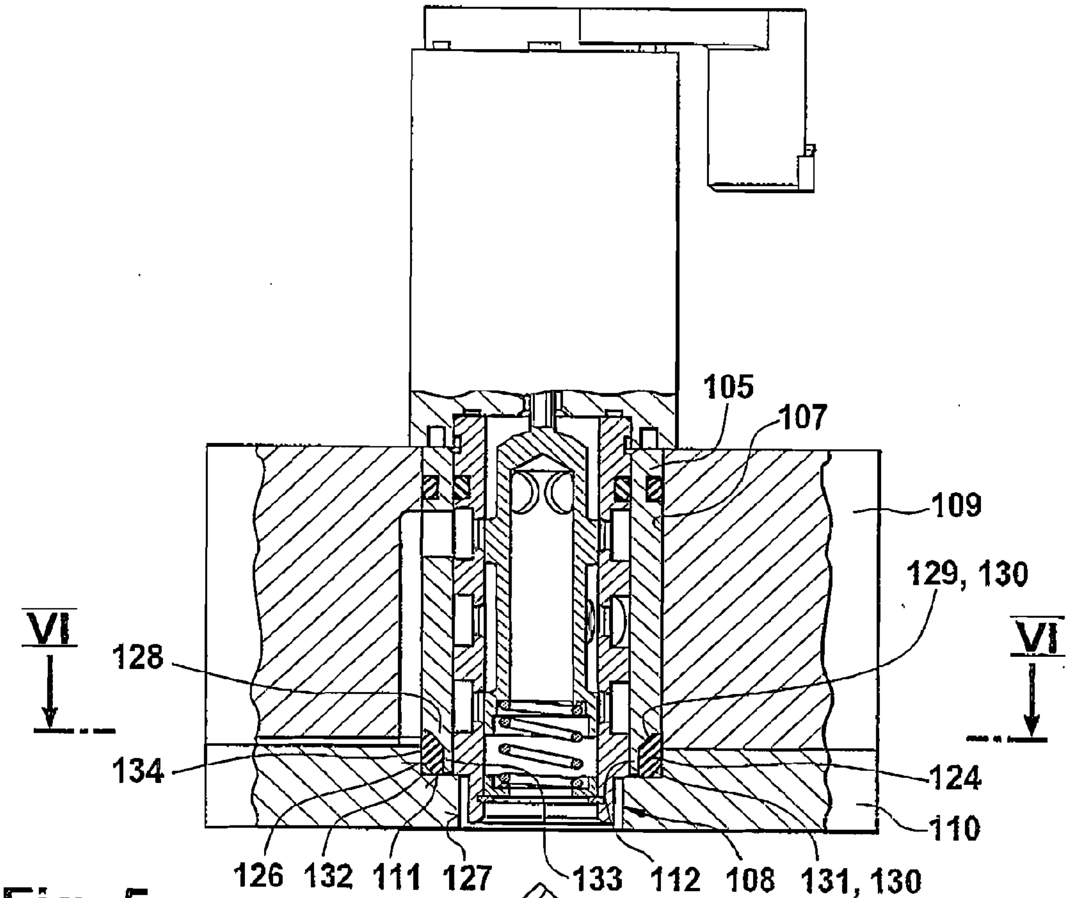
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Fig. 5

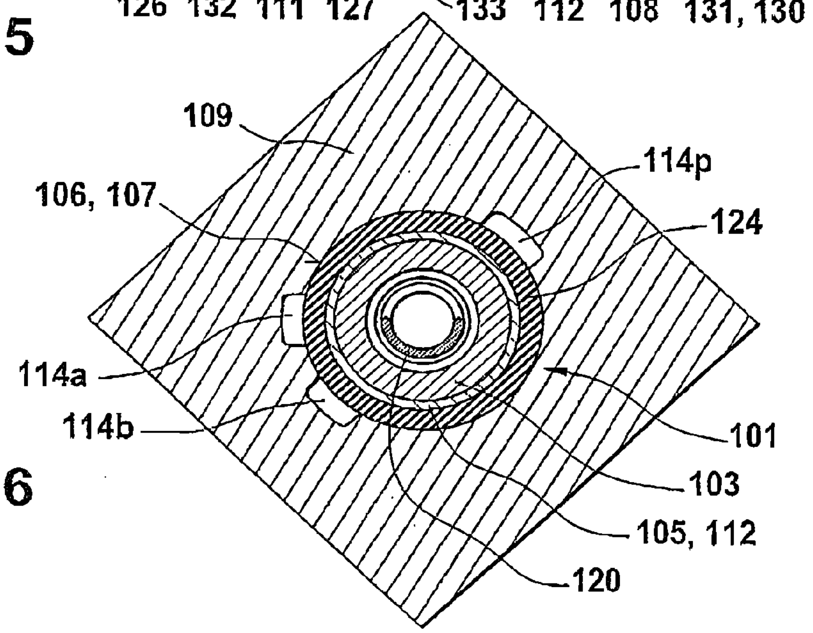
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Fig. 6

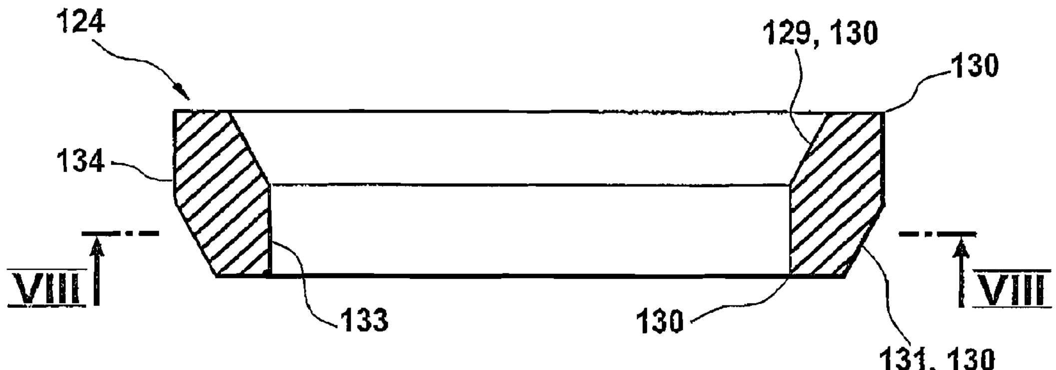

Fig. 7

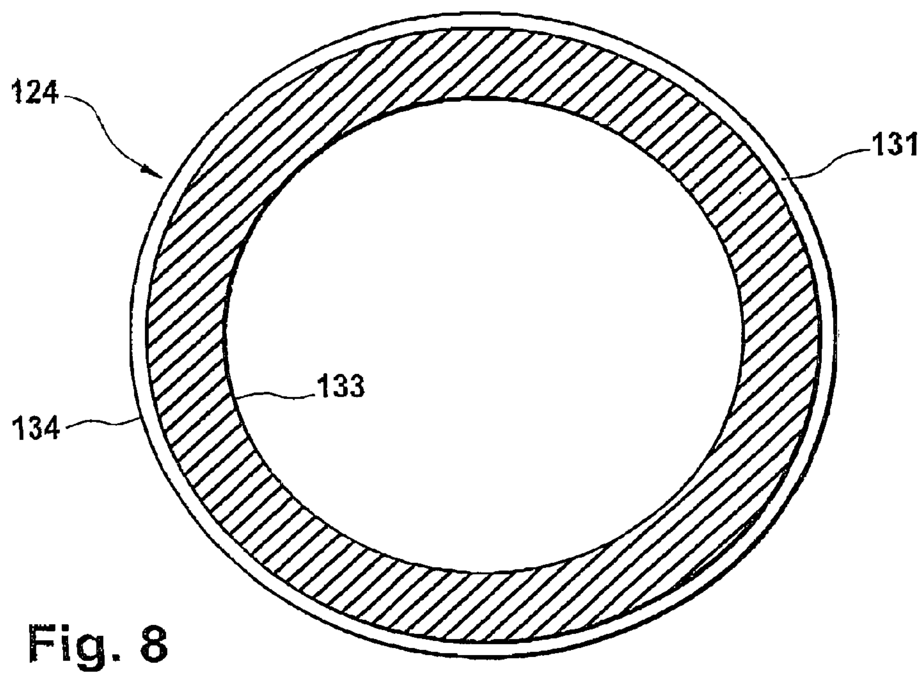

Fig. 8

CONTROL VALVE

BACKGROUND

[0001] The invention relates to a sealing element according to the preamble of Claim **1** and to a control valve for controlling the supply and discharge flow of a pressure medium to and from a device for changing the control times of an internal combustion engine according to the preamble of Claim **4**.

[0002] In internal combustion engines, camshafts are used for actuating the gas-exchange valves. Camshafts are installed in the internal combustion engine, such that cams installed on these camshafts contact cam followers, for example cup tappets, rocker arms, or finger levers. If a camshaft is set in rotation, then the cams roll on the cam followers, which in turn actuate the gas-exchange valves. Thus, both the opening period and also the opening amplitude, as well as the opening and closing times of the gas-exchange valves are set through the position and the shape of the cam.

[0003] Modern engine concepts allow variable valve train designs. On one hand, the valve lift and valve opening period should be made variable up to complete shutdown of individual cylinders. For this purpose, concepts such as switchable cam followers or electrohydraulic or electrical valve actuators are provided. Furthermore, it has been shown to be advantageous to be able to influence the opening and closing times of the gas-exchange valves during the operation of the internal combustion engine. Here it is especially desirable to influence the opening or closing times of the intake or exhaust valves separately, in order, for example, to selectively set a defined valve overlap. By setting the opening or closing times of the gas-exchange valves as a function of the current engine-map range, for example, the current rotational speed or the current load, the specific fuel consumption can be lowered, which has a positive effect on the exhaust-gas behavior and increases the engine efficiency, the maximum torque, and the maximum output.

[0004] The described variability of the gas-exchange valve control times is achieved through a relative change of the phase position of the camshaft relative to the crankshaft. Here, the camshaft is usually in a driven connection with the crankshaft via a chain drive, belt drive, gearwheel drive, or equivalent drive concepts. Between the chain drive, belt drive, or gearwheel drive driven by the crankshaft and the camshaft there is a device for changing the control times of an internal combustion engine, which transmits the torque from the crankshaft to the camshaft. Here, this device is constructed such that during the operation of the internal combustion engine, the phase position between the crankshaft and camshaft is held reliably and, if desired, the camshaft can be rotated within a certain angular range relative to the crankshaft.

[0005] In internal combustion engines with a camshaft for each of the intake and exhaust valves, these can each be equipped with a camshaft adjuster. Therefore, the opening and closing times of the intake and exhaust gas-exchange valves can be shifted in time relative to each other and the valve overlaps are set selectively.

[0006] The seat of modern camshaft adjusters is usually located on the drive-side end of the camshaft. The camshaft adjuster, however, can also be arranged on an intermediate shaft, a non-rotating component, or the crankshaft. It is comprised of a drive wheel, which is driven by the crankshaft at a fixed phase relationship to the crankshaft, a driven part in drive connection with the camshaft, and an adjustment mechanism transmitting the torque from the drive wheel to the driven part. The drive wheel can be constructed in the case of a camshaft adjuster not arranged on the crankshaft as a chain, belt, or gearwheel and is driven by the crankshaft by means of a chain drive, belt drive, or gearwheel drive. The adjustment mechanism can be operated electrically, hydraulically, or pneumatically.

[0007] The so-called axial-piston adjuster and rotary-piston adjuster represent two preferred embodiments of hydraulically adjustable camshaft adjusters.

[0008] For axial piston adjusters, the drive wheel is connected to a piston and this is connected to the driven part via spiral gearing. The piston separates a hollow space formed by the driven part and the drive wheel into two pressure chambers arranged axially relative to each other. Now if one pressure chamber is charged with pressure medium, while the other pressure chamber is connected to a tank, then the piston is displaced in the axial direction. The axial displacement of the piston is converted by the spiral gearing into a relative rotation of the drive wheel relative to the driven part and thus of the camshaft relative to the crankshaft.

[0009] A second embodiment of hydraulic camshaft adjusters is the so-called rotary-piston adjuster. In these adjusters, the drive wheel is locked in rotation with a stator. The stator and a rotor are concentric to each other, wherein the rotor is connected with a non-positive, positive, or form fit, for example, by means of an interference fit, a screw or weld connection with a camshaft, an extension of the camshaft, or an intermediate shaft. In the stator there are several hollow spaces, which extend radially outwards starting from the rotor, spaced apart in the peripheral direction. The hollow spaces are pressure sealed in the axial direction by a side cover. A vane, which is connected to the rotor and which separates each hollow space into two pressure chambers, extends into each of these hollow spaces. Through selective connection of the individual pressure chambers with a pressure medium pump or with a tank, the phase of the camshaft relative to the crankshaft can be set or held.

[0010] For controlling the camshaft adjuster, sensors detect the characteristic data of the engine, for example, the load state and the rotational speed. This data is fed to an electronic control unit, which determines a desired value of the relative phase angle between the camshaft and crankshaft after comparing the data with a characteristic data map of the internal combustion engine. By means of sensors, for example Hall sensors, the actual value of the phase angle and a deviation of the actual value from the desired value are determined. Then the control command is led to a control unit of the control valve, which controls the supply and discharge flow of pressure medium to and from the various pressure chambers and thus controls the adjustment of the phase position of the camshaft.

[0011] To adjust the phase position of the camshaft relative to the crankshaft, in hydraulic camshaft adjusters, one of the two pressure chambers acting against each other in a hollow space is connected to a pressure medium pump and the other is connected to the tank. The supply of pressure medium to one chamber in connection with the discharge of pressure medium from the other chamber displaces the piston separating the pressure chambers in the axial direction, whereby the camshaft is rotated relative to the crankshaft in axial piston adjusters via the spiral gearing. In rotary piston adjusters, the pressure loading of one chamber and the pressure relieving of the other chamber displaces the vane and thus directly rotates the camshaft relative to the crankshaft. To keep the phase position, both pressure chambers are either connected to the pressure medium pump or separated both from the pressure medium pump and also from the tank.

[0012] The control of the pressure medium flows to and from the pressure chambers is realized by means of a control valve, usually a 4/3 proportional valve. A valve housing is provided with a connection for each pressure chamber (work connection), a connection to the pressure medium pump, and at least one connection to a tank. Within the essentially hollow cylindrical valve housing there is an axially displaceable control piston. The control piston can be brought axially into any position between two defined end positions against the spring force of a spring element by means of an adjustment unit, for example, an electromagnetic or hydraulic adjustment unit. The control piston is further provided with ring grooves and control edges, whereby the individual pressure chambers can be connected selectively to the pressure medium pump or to the tank. Likewise a position of the control piston can be provided, in which the pressure medium chambers are separated both from the pressure medium pump and also from the pressure medium tank.

[0013] Such control valves can be constructed as a central valve or as an insert valve. In the case of a central valve, this is arranged within the camshaft or an extension of the camshaft in the area of the camshaft adjuster. In the case of an insert valve, a surrounding construction of the internal combustion engine is provided with a valve receptacle, in which the control valve is inserted. In the casing surface of the valve receptacle, usually constructed as a bore, there are pressure medium lines, which communicate with the pressure medium connections of the control valve. Such a surrounding construction can be, for example, a cylinder head or a cylinder head cover.

[0014] In DE 102 23 431 B4, such a device with a control valve in an insert construction is shown. The device is comprised of a camshaft-fixed driven unit, a drive unit driven by the crankshaft, and two side covers. The drive unit is arranged coaxial to the driven unit and is provided with several recesses spaced apart in the peripheral direction. The recesses are pressure sealed by the drive unit, the driven unit, and the side covers and thus form pressure spaces. A vane extends into each pressure space, wherein each vane is arranged in a vane groove formed on the driven unit. Each vane divides a pressure space into two pressure chambers acting against each other. The pressure chambers communicate via pressure medium lines formed in a camshaft by means of rotary feedthroughs with other pressure medium lines formed in a cylinder head or a cylinder head cover.

[0015] The other pressure medium lines can be connected by means of a control valve, in this case a 4/3 directional control valve, selectively to a pressure medium reservoir or to a pressure medium pump. The control valve is composed of an adjustment unit and a valve body. The valve body is surrounded by an adapter sleeve, wherein this sleeve is arranged in a bore of a cylinder head cover. In the adapter sleeve, three radial openings spaced apart axially and in the peripheral direction relative to each other are formed, which are used as pressure medium connections. A fourth pressure medium connection is formed in the axial direction on the end of the valve body facing away from the adjustment unit. Each radial opening is connected to a pressure medium line via a rising channel. Pressure medium is led via a pressure medium line to the middle radial opening in the axial direction and from there into the interior of the sleeve, wherein the pressure medium flow is guided dependent on the control position of the control valve to one of the two other radial openings. From there the pressure medium is led via another rising line to a pressure medium line, which communicates with one of the rotary feedthroughs and also with a firsts group of pressure chambers.

[0016] In an analogous way, pressure medium is led from a second group of pressure chambers via the rotary feedthrough and pressure medium lines to another rising line, which opens into the third opening. From there the pressure medium is led via the control valve to the axial discharge connection. The rising lines are constructed as grooves constructed in the bore in the cylinder head cover and open to the adapter sleeve. Furthermore, the rising lines are sealed against each other, so that the outer diameter of the adapter sleeve is adapted to the inner diameter of the bore. The pressure medium lines communicating with the rising lines are in this embodiment constructed as grooves formed in the cylinder head cover and open to the cylinder head. To allow discharge of the pressure medium forced from the pressure chambers, the cylinder head is provided with a discharge bore coaxial to the bore formed in the cylinder head cover.

[0017] To prevent leakage between the rising lines and the discharge bore, the inner diameter of the bore and the discharge bore are identical and the adapter sleeve extends at least partially into the adapter bore. The adapter sleeve now forms a sealed contact on the casing surface of the discharge bore, whereby discharge of the pressure medium from the rising lines via the discharge bore into the interior of the cylinder head is prevented. Slight offset of the bores causes damage to the adapter sleeve during assembly, which can lead to loss of the sealing effect between the components.

[0018] To guarantee the sealing function between the rising channels and the discharge bore, an exact coaxial alignment of the bore to the discharge bore and an exact adaptation of the adapter sleeve diameter to the inner diameter of the discharge bore is necessary. This is possible only with very high expense due to the tolerances inevitably appearing in the production process of the individual components.

SUMMARY

[0019] The invention is based on the objective of avoiding these mentioned disadvantages and providing a sealing arrangement for a control valve, which is not susceptible to tolerances appearing in the system. Furthermore, a sealing element is provided, which is used in this sealing arrangement.

[0020] A control valve for controlling the supply and discharge flow of pressure medium to and from a device for changing the control times of an internal combustion engine comprises, among other things, an essentially cylindrical valve housing, on which pressure medium connections are formed, and an axially displaceable control piston arranged within the valve housing. Here, a connection between the different pressure medium connections can be established or separated as a function of the position of the control piston. The valve housing is arranged within a valve receptacle, wherein the insert depth of the valve housing into the valve receptacle is limited by an axial stop constructed in the valve receptacle.

[0021] The objective is met according to the invention in that the axial stop is constructed as a circular or circular ring-shaped wall, which extends radially inwards starting from an inner casing surface of the valve receptacle and that between the valve housing and the axial stop of the valve receptacle there is a sealing element.

[0022] Such a control valve comprises a cylindrical valve housing and a control piston arranged axially displaceable in the valve housing. The valve housing is provided with radial openings, which are used as pressure medium connections. By means of an adjustment unit, the control piston within the valve housing can be brought into any position between two end stops. In this way, the control piston connects or separates various pressure medium connections based on the relative position to the valve housing. The control piston can be in direct contact with the valve housing. Another possibility consists in providing, as shown in DE 102 23 431, a hollow control sleeve between the valve housing and the control piston. The inner diameter of the control sleeve is adapted to the outer diameter of the control piston and the outer diameter of the control sleeve is adapted to the inner diameter of the valve housing. Furthermore, the outer casing surface of the control sleeve is provided with several ring grooves, which communicate on one side with the pressure medium connections and on the other side via radial openings with the interior of the control sleeve. Through axial shifting of the control piston, connections between the ring grooves, and thus the pressure medium connections, and optionally with an axial pressure medium connection, can be established or separated.

[0023] Such control valves are arranged in valve receptacles, in which pressure medium channels are formed, which communicate with the pressure medium connections. The pressure chambers of the camshaft adjuster are connected selectively via the pressure medium channels with a pressure medium pump or a pressure medium reservoir. Such valve receptacles can be formed, for example, in a cylinder head or a cylinder head cover. In this case, one talks of an insert valve. Another possibility is to use the control valve as a central valve. In this case, it is arranged in a valve receptacle in the camshaft and rotates with the camshaft during the operation of the internal combustion engine.

[0024] In both cases, the valve receptacle is constructed as a cylindrical bore. The outer diameter of the valve housing is adapted to the inner diameter of the bore, whereby the pressure medium connections are sealed against each other. Within the bore there is an axial stop for the valve housing. The axial stop can be constructed as a wall limiting the bore. A diameter narrowing of the bore is also conceivable. In this case, the bore is constructed with a stepped cross section, whereby a ring section is constructed, which is used as an axial stop for the valve housing. Furthermore, between the axial stop and the valve housing there is a sealing ring, which prevents leakage currents in the axial direction.

[0025] The radial ring sealing point described in DE 102 23 431 is displaced in the axial direction by this projection, whereby the effects by tolerances in the dimensions of the control valve are not critical.

[0026] In an advantageous improvement of the invention, it is provided that the axial stop-side end of the valve housing is constructed with an area reduced in outer diameter, wherein the sealing element is arranged at least partially in the area reduced in outer diameter. The sealing element is further constructed as a sealing ring with an outer and an inner casing surface.

[0027] The area reduced in outer diameter simplifies the mounting of the sealing element and the control valve in the valve receptacle. The inner diameter of the sealing element constructed as a sealing element is adapted to the outer diameter of the area reduced in outer diameter. The sealing ring is placed in this area on the control valve and is positioned with it together in the valve receptacle. Thus, due to the guidance and centering experienced by the sealing element by means of the control valve, incorrect mounting is prevented and the sealing effect is more process reliable.

[0028] It can be further provided that the sealing element is composed of an elastomer. In the case of a valve housing with an area reduced in outer diameter on the axial stop-side end, the sealing ring contacts the outer casing surface of this area. Furthermore, it is clamped in the axial direction by the valve housing and the axial stop. During the mounting, the sealing ring is pressed by the valve housing against the axial stop. In this way, it deforms elastically, wherein deformation radially inwards is prevented by the valve housing. The elastic deformation thus obtains a "preferred direction," namely radially outwards, against the inner casing surface of the valve receptacle. Therefore, the sealing effect is increased or reached significantly earlier. Another advantage in the use of an elastic sealing ring is to be seen in that axial tolerances can be compensated through its deformability.

[0029] The elastomer can be, for example, a fluoro-rubber or an acrylonitrile butadiene rubber. These materials are very well suited due to their high resistance relative to environmental influences in internal combustion engines, such as high temperatures and contact with motor oil.

[0030] In another realization of the invention, the valve receptacle is assembled from a first and a second bore, wherein the bores are embodied in different surrounding constructions, at least approximately coaxial and adjacent to each other. One example for such an embodiment is the valve receptacle shown in DE 102 23 431. A bore is constructed in a cylinder head and a cylinder head cover. The two bores are arranged such that they are at least approximately coaxial to each other when the cylinder head cover is mounted on the cylinder head.

[0031] In one improvement of the invention, the axial stop can be formed at the boundary of the two surrounding constructions.

[0032] In this embodiment, the inner diameter of the second bore is smaller than that of the first bore. At the boundary between the two bores there is a step. The advantage of this variant lies in the low production costs, because the step is realized by lining up two bores of different inner diameters.

[0033] Alternatively, the axial stop is formed in the second bore in the insertion direction of the control valve. The advantage is provided in that the step-like profile can be constructed such that the sealing element at the boundary of the two surrounding constructions can contact the inner casing surfaces of the bores.

[0034] In this embodiment according to the invention, because the outer casing surface of the valve housing no longer provides the sealing function at the boundary of the surrounding constructions, the inner diameter of the second bore at the boundary between the surrounding constructions can be greater than the inner diameter of the first bore and thus than the outer diameter of the valve housing. Thus, even for a slight offset of the bores relative to each other, non-destructive assembly of the control valve in the valve receptacle is guaranteed.

[0035] It is further provided that the axial stop is arranged and the sealing element is constructed so that the sealing element at the boundary of the two surrounding constructions contacts the valve receptacle. Any possible leakage paths created by edges deviating from the rectangular shape are reliably blocked by the elastic deformation of the sealing element.

[0036] In another advantageous improvement of the invention, the transition area of the valve housing to the diameter-reduced area is at least partially conical. Furthermore, the sealing element at its inner casing surface is provided with a first conical area, wherein this is adapted to the transition area of the valve housing.

[0037] The valve housing is comprised of a first and a second cylindrical area. The first cylindrical area forms a sealed contact on the inner wall of the first bore. The second area involves the area reduced in outer diameter. A conical transition area is formed at the transition from the first to second area. Here the entire diameter reduction can be bridged by means of the conical area. It is also conceivable that starting from the first area, the valve housing extends radially inwards before it transitions into the conical area, which flows into the area reduced in outer diameter. The sealing ring is arranged in this transition area, wherein its contours contacting the valve housing are adapted to the contours of the valve housing, especially the conical area. During the mounting of the control valve in the valve receptacle, the valve housing exerts a force on the sealing ring. Due to the pressure surface that is not parallel to the axial stop, a force is applied to the sealing ring both in the axial and also radial directions. Consequently, a better sealing effect is achieved in the radial direction.

[0038] In an advantageous improvement of the invention, the outer casing surface of the sealing element is provided with a second conical area at the end contacting the axial stop, so that an annular hollow space is produced between the sealing element and the axial stop. If larger axial tolerances have to be compensated, for example, and thus the valve must be positioned farther within the valve receptacle, then the sealing ring can bulge into the hollow space while maintaining its sealing function. Larger production tolerances can be compensated and thus costs can be saved.

[0039] Further proposed is a sealing element in the form of a sealing ring for sealing an axial end of a control valve of a device for changing the control times of gas-exchange valves with an inner casing surface and an outer casing surface. According to the invention, the objective is met in that the inner and the outer casing surfaces are provided with a conical area at each of its ring edges. In this way the two conical areas are formed at ring edges of the sealing ring offset relative to each other in the axial direction. One of the conical areas is provided for contacting a conical area of a component, which is to seal the sealing ring against a second component. This is meant especially for a sealing assembly of a component within a bore, wherein the sealing ring is charged with an axially directed force. The conical contact surface of the component converts the axially directed force into radial and axial force components, whereby the sealing ring deforms in the radial direction and thus increases the sealing effect. Through the conical construction of another ring edge, a ring-shaped hollow space is maintained, in which the sealing ring can bulge under the effect of forces. Due to this hollow space, large axial tolerances can be compensated without negatively affecting the sealing effect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] Additional features of the invention emerge from the following description and from the drawings, in which embodiments of the invention are shown simplified. Shown are:

[0041] FIG. **1** a longitudinal cross-sectional view through a device for changing the control times of an internal combustion engine with pressure medium circuit,

[0042] FIG. **2** a cross sectional view through the device shown in FIG. **1** along the line II-II,

[0043] FIG. **3** a longitudinal cross-sectional view through a control valve mounted in a valve receptacle according to a first sealing concept according to the invention,

[0044] FIG. **4** a cross-sectional view along the line IV-IV from FIG. **3**,

[0045] FIG. **5** a longitudinal cross-sectional view through a control valve mounted in a valve receptacle according to a second sealing concept according to the invention,

[0046] FIG. **6** a cross-sectional view along the line VI-VI from FIG. **5**,

[0047] FIG. **7** a longitudinal cross-sectional view through a sealing ring according to the invention, and

[0048] FIG. **8** a cross-sectional view along line VIII-VIII of FIG. **7**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] FIGS. **1** and **2** show a device **1** for changing the control times of an internal combustion engine. The device **1** essentially comprises a stator **2**, and a rotor **3** arranged concentrically to this stator. A drive wheel **4** is locked in rotation with the stator **2** and constructed as a chain wheel in the illustrated embodiment. Embodiments of the drive wheel **4** as a belt or gearwheel are also conceivable. The stator **2** is supported rotatably on the rotor **3**, wherein five recesses **5** spaced apart in the peripheral direction are provided in the illustrated embodiment on the inner casing surface of the stator **2**. The recesses **5** are limited in the radial direction by the stator **2** and the rotor **3**, in the peripheral direction of two side walls **6** of the stator **2**, and in the axial direction by a first and a second side cover **7**, **8**. Each of the recesses **5** is pressure sealed in this way. The first and the second side covers **7**, **8** are connected to the stator **2** by means of connection elements **9**, for example, screws.

[0050] On the outer casing surface of the rotor **3** there are axial vane grooves **10**, wherein a radially extending vane **11** is arranged in each vane groove **10**. A vane **11** extends into each recess **5** starting from the appropriate vane groove **10**, wherein the vanes **11** contact in the radial direction the stator **2** and in the axial direction the side covers **7**, **8**. Each vane **11** divides a recess **5** into two pressure chambers **12**, **13** working against each other. To guarantee a pressure-sealed contact of the vane **11** on the stator **2**, between the groove bases **14** of the vane grooves **10** and the vanes **11** there are leaf spring elements **15**, which apply a force on the vanes **11** in the radial direction.

[0051] By means of first and second pressure medium lines **16**, **17**, the first and second pressure chambers **12**, **13** are connected via a control valve **18** to a pressure medium pump **19** or a tank **20**. In this way, an adjustment drive is formed, which allows a relative rotation of the stator **2** relative to the rotor **3**. Here, either all of the first pressure chambers **12** are connected to the pressure medium pump **19** and all of the second pressure chambers **13** are connected to the tank **20**, or there is the exact opposite configuration. If the first pressure chambers **12** are connected to the pressure medium pump **19** and the second pressure chambers **13** are connected to the tank **20**, then the first pressure chambers **12** expand at the cost of the second pressure chambers **13**. This produces a shift of the vanes **11** in the peripheral direction, in the direction shown by the arrow **21**. By shifting the vanes **11**, the rotor **3** is rotated relative to the stator **2**.

[0052] The stator **2** is driven by the crankshaft in the shown embodiment by a not-shown chain drive attaching to its drive wheel **4**. The drive of the stator **2**, by a belt or gearwheel drive, is also conceivable. The rotor **3** is connected by a non-positive, positive, or form fit, for example, by means of an interference fit or by a screw connection by means of a central screw, to a not-shown camshaft. From the relative rotation of the rotor **3** relative to the stator **2**, due to the supply or discharge of pressure medium towards or from the pressure chambers **12**, **13**, a phase shift results between the camshaft and crankshaft. Through targeted feeding and discharge of pressure medium into and out of the pressure chambers **12**, **13**, the control times of the gas-exchange valves of the internal combustion engine can be varied selectively.

[0053] The pressure medium lines **16**, **17** are constructed in the shown embodiment as channels within the rotor **3**, which extend from a central bore **22** of the rotor **3** to its outer casing surface. Within the central bore **22** there can be a not-shown central valve, by means of which the pressure chambers **12**, **13** can be connected selectively to the pressure medium pump **19** or to the tank **20**. Another possibility is provided in arranging a pressure medium distributor within the central bore **22**, which connects the pressure medium lines **16**, **17** via pressure medium channels and ring grooves to pressure medium connections A, B, P, T of a control valve **18** attached on the outside.

[0054] The essentially radial side walls **6** of the recesses **5** are provided with formations **23**, which extend in the peripheral direction into the recesses **5**. The formations **23** are used as stops for the vanes **11** and guarantee that the pressure chambers **12**, **13** can be supplied with pressure medium even when the rotor **3** assumes one of its two extreme positions relative to the stator **2**, in which the vanes **11** contact one of the side walls **6**.

[0055] For inadequate supply of pressure medium to the device **1**, for example, during the startup phase of the internal combustion engine, the rotor **3** moves uncontrollably relative to the stator **2** due to the alternating and dragging moments that the camshaft exerts on the rotor. In a first phase, the reactive torque of the camshaft forces the rotor **3** relative to the stator **2** in a peripheral direction that lies opposite the rotational direction of the stator **2** until these contact the side walls **6**. Then the alternating moments exerted by the camshaft on the rotor **3** lead to back and forth oscillations of the rotor **3** and thus of the vanes **11** in the recesses **5** until at least one of the pressure chambers **12**, **13** is filled completely with pressure means. This leads to higher wear and to the development of noise in the device **1**. To prevent these results, a locking element **24** is provided in the device **1**. For this purpose, a pot-shaped piston **26** is arranged in an axial bore **25** of the rotor **3**. A first spring **27** applies a force to this piston in the axial direction. The first spring **27** is supported in the axial direction on one side on a ventilation element **28** and is arranged with its axial end facing away from this ventilation element within the pot-shaped piston **26**. In the first side cover **7** there is a connecting rod **29**, such that the piston **26** can engage this connecting rod in at least one relative position of the rotor to the stator. In this position, the piston **26** is forced into the connecting rod **29** by the first spring **27** if there is inadequate supply of pressure medium to the device **1**. In this state, the rotor **3** is locked in this position relative to the stator **2**. The locking position primarily corresponds to the position that is to be assumed during the startup of the internal combustion engine. Furthermore, means are provided to pull the piston **26** back into the axial bore **25** for an adequate supply of pressure medium to the device **1** and thus to cancel the locking. This is typically implemented with pressure medium, which is led via not-shown pressure medium lines into a recess **30**, which is formed on the cover-side end of the piston **26**. To be able to discharge leakage oil from the spring space of the axial bore **25**, the ventilation element **28** is provided with axial grooves, along which the pressure medium can be led to a bore in the second side cover **8**.

[0056] In FIG. **1**, the pressure medium circuit **31** is also shown. From a tank **20**, a supply connection P of a control valve **18** is supplied with pressure medium by means of a pressure medium pump **19**. Simultaneously, pressure medium is led by the control valve **18** into the tank **20** via a discharge connection T. The control valve **18** further has two work connections A, B, with the first work connection A communicating with the first pressure chambers **12** and the second work connection B communicating with the second pressure chambers **13**. By means of an electromagnetic adjustment device **32**, which acts against the spring force of a second spring **33**, the control valve **18** can be brought into three positions. In a first position of the control valve **18**, which corresponds to a non-powered state of the adjustment device **32**, the first work connection A and thus the first pressure chambers **12** are connected to the discharge connection T. Simultaneously, the supply connection P communicates with the second work connection B and thus with the second pressure chambers **13**. Thus, while pressure medium is discharged from the first pressure chambers **12**, pressure medium are led to the second pressure chambers **13**, whereby the vanes **11** are shifted in the peripheral direction. This produces a change of the phase position between the rotor **3** and the stator **2** and thus between the camshaft and crankshaft.

[0057] In a middle position, both the first work connection A and also the second work connection B are separated both from the supply connection P and also from the discharge connection T. Pressure medium can flow neither to nor from the pressure chambers **12**, **13** and the phase position of the camshaft is held relative to the crankshaft. An alternative possibility is provided by connecting both work connections A, B to the supply connection P, in order to compensate for leakage appearing in the device **1**.

[0058] In a third position of the control valve **18**, the supply connection P is connected to the first work connection A and thus to the first pressure chamber **12**, while the second pressure chamber **13** is connected to the second work connection B to the discharge connection T. Analogous to the first control position of the control valve **18**, the phase position of the camshaft relative to the crankshaft is changed only in the opposite direction.

[0059] FIG. **3** shows a control valve **101** according to the invention, which has an adjustment device **102**, an essentially hollow cylindrical control housing **103**, a similarly essentially hollow cylindrical control piston **104**, and a similarly essentially hollow cylindrical valve housing **105**. The control housing **103** is arranged stationary within the valve housing **105**. Here, the inner diameter of the valve housing **105** is adapted to the outer diameter of the control housing **103**. Furthermore the control piston **104** is displaceable axially within the control housing **103**, wherein the outer diameter of the control piston **104** is adapted to the inner diameter of the control housing **103**.

[0060] The valve housing **105** is arranged within a valve receptacle **106**. The valve receptacle **106** is assembled from two bores **107**, **108**, which are formed in two surrounding constructions **109**, **110**. The first surrounding construction **109** is fixed on the second surrounding construction **110** and the bores **107**, **108** are constructed and arranged such that these are at least approximately coaxial to each other. The inner diameter of the second bore **108** is smaller in this embodiment than the inner diameter of the first bore **107**. Therefore, at the boundary between the first surrounding construction **109** and the second surrounding construction **110** there is a circular ring-shaped axial stop **111**, which limits the insertion depth of the control valve **101**.

[0061] The valve housing **105** is provided on its axial stop-side end with an area **112** reduced in outer diameter, wherein the outer diameter of the area **112** reduced in outer diameter is smaller than the inner diameter of the second bore **108**. Furthermore, in this embodiment the transition to the area **112** reduced in outer diameter has a stepped construction. The valve housing **105** passes through the first bore **107** and extends with its diameter-reduced area **112** at least partially into the second bore **108**. Here, the outer diameter of the valve housing **105** is adapted to the inner diameter of the valve receptacle **106**.

[0062] Three pressure medium channels **113** are formed at the boundary between the first and second surrounding constructions **109**, **110**. The pressure medium channels **113** are constructed in the form of grooves, which are formed either in the surface of the first or second surrounding constructions **109**, **110**. Each of the pressure medium channels **113** opens into a rising groove **114***a*, **114***b*, **114***p*, which are formed in the casing surface of the first bore **107**. The rising grooves **114***a*, **114***b*, **114***p* are offset relative to each other in the peripheral direction of the first bore **107** and extend essentially in the axial direction of the valve housing **105**. Each of the rising grooves **114***a*, **114***b*, **114***p* communicates via corresponding radial openings **115***a*, **115***b*, **115***p*, which are formed in the valve housing **105** and which are used as work connections A, B, and supply connection P, with the interior of the valve housing **105**.

[0063] The outer casing surface of the control housing **103** is provided with three ring grooves **116***a*, **116***b*, **116***p* offset relative to each other axially. Here, the rising grooves **114***a*, **114***b*, **114***p*, the radial openings **115***a*, **115***b*, **115***p*, and the ring grooves **116***a*, **116***b*, **116***p* are arranged so that the first rising groove **114***a* communicates by means of the first radial opening **115***a* exclusively with the first ring groove **116***a*, the second rising groove **114***b* communicates by means of the second radial opening **115***b* exclusively with the second ring groove **116***b*, and the third rising groove **114***p* communicates by means of the third radial opening **116***p* exclusively with the third ring groove **116***p*. Each of the ring grooves **116***a*, **116***b*, **116***p* further communicates by means of openings **117***a*, **117***b*, **117***p* formed in their groove bases with the interior of the control housing **103**.

[0064] The control piston **104** arranged in the interior of the control housing **103** can be displaced within the control housing **103** axially by means of an adjustment device **102** via a push rod **119** against the force of a first spring element **120**. The control piston **104** is provided with two control sections **121**, wherein the outer periphery of the control sections **121** is adapted to the inner periphery of the control housing **103**. The control sections **121** can be made as separate components and mounted on the control piston **104** or constructed in one piece with this piston as shown in FIG. **3**. Outside of the control sections **121** the outer diameter of the control piston **104** has a smaller construction. The control sections **121** are constructed and arranged on the control piston **104** such that a fourth ring groove **122** is formed, which connects the first or second ring groove **116***a*, **116***b* to the third ring groove **116***p* after the adjustment of the control piston **104** relative to the control housing **103**.

[0065] The control piston **104** further has an open construction on its end attaching to the first spring element **120**. Therefore, a connection between the interior of the control piston **104** and the second bore **108** is produced and thus describes a discharge connection T. Fourth openings **123** are formed on the push rod-side end of the control piston **104**, whereby the interior of the control piston **104** is connected hydraulically with the outside of the control piston **104**. The fourth openings **123** are located in the shown embodiment outside of the fourth ring groove **122** in the outer casing surface of the control piston **104**.

[0066] By means of the adjustment device **102**, the control piston **104** can be moved via the push rod **119** within the control housing **103** into any position between two maximum values. Here, the first spring element **120** exerts a restoring force on the control piston **104**. As a control device **102**, for example, hydraulic adjustment devices or, like in the illustrated embodiment, electromagnetic adjustment devices can be used. The electromagnetic adjustment device **102** is comprised of a coil that is arranged in a magnetic field of one or more permanent magnets. A power-supply unit is allocated to the coil, by means of which this coil can be excited with an electric current. Here, several possibilities for exciting the coil are conceivable. One possibility would be, for example, to vary the position of the coil within the magnetic field through variable current intensities, wherein high current intensities would correspond to a large deflection and low current intensities would correspond to a small deflection. Also conceivable is to excite the coil by means of pulsed currents. For example, a rectangular voltage between the values 0V and a constant voltage V_0 can be applied to the electrical poles of the coil. The deflection of the coils and thus the control piston **104** is now defined by the ratio of the time intervals, in which the voltage V_0 or no potential difference is applied to the electrical poles. The greater the voltage-less intervals are, the smaller the deflection of the coil. The longer the time intervals are in which the voltage V_0 is applied, the greater the deflection.

[0067] In the shown embodiment in FIG. **3** and FIG. **4**, a 4/3 direction control valve with four pressure medium connections A, B, P, T is shown, wherein the control piston **104** can be located essentially in three control states. However, the invention is not limited to such a four/three direction control valve, but instead embodiments, in which a 4/4 directional control valve or other valves are used, are by all means also conceivable.

[0068] Below, the function of the 4/3 directional control valve shall be described as an example. By means of one of the pressure medium channels **113**, the third rising groove **114***p* is charged with pressure medium. In each control position of the control valve **101**, the pressure medium is led via the third radial opening **115***p*, the third ring groove **116***p*, and the third openings **117***p* into the fourth ring groove **122**.

[0069] In a first state of the control valve **101**, which corresponds to a non-powered state of the adjustment device **102**, the control piston **104** is shifted by means of the spring force of the first spring element **120** into a maximum deflected position in the direction of the adjustment device **102**. In this control position, the fourth ring groove **122** communicates via the first openings **117***a*, the first ring groove **116***a*, and the first radial opening **115***a* with the first rising groove **114***a*, from where the pressure medium is led to the first pressure chambers **12**.

[0070] In a second control position of the control valve **101**, in which the adjustment device **102** receives maximum power, the control piston **104** is deflected to a maximum extent in the direction of the first spring element **120**. In this case, the fourth ring groove **122** communicates both with the third openings **117***p* and also with the second openings **117***b*. Pressure medium is now led via the second ring groove **116***b*, the second radial opening **115***b*, and the second rising groove **114***b* to the corresponding pressure medium channel **113** and from there to the second pressure chambers **13**.

[0071] In a third state, the control piston **104** is located in a middle position, in which the fourth ring groove **122** communicates only with the third openings **117***p*. In this case, the pressure medium supply to both pressure chambers **12**, **13** is blocked. Alternatively, it is likewise conceivable that, in this middle position, the fourth ring groove **122** communicates with the first, the second, and the third openings **117***a*, **117***b*, **117***p*. In this case pressure medium is led to both pressure chambers **12**, **13**, whereby leakage is compensated and the phase position is held functionally locked between the camshaft and crankshaft.

[0072] In the first and second control position, the control sections **121** completely open or close the appropriate openings **117***a*, **117***b*. Naturally the control piston **104** can also be positioned at any position between these two extreme values, whereby the openings **117***a*, **117***b* are only partially opened or covered. Therefore, the flow resistance and thus the extent of pressure medium supply to the pressure chambers **12**, **13** can be set.

[0073] To prevent pressure medium from being able to flow from the rising grooves **114***a*, **114***b*, **114***p* directly into the second bore **108** and to prevent leakage flows between the rising grooves **114***a*, **114***b*, **114***p*, especially at the boundary between the surrounding constructions **109**, **110**, a sealing element **124** is provided between the valve housing **105** and the axial stop **111**. The sealing element **124** is constructed in the shown embodiment as an elastically deformable sealing ring and preferably from fluoro rubber or acrylonitrile butadiene rubber. Advantageously, the sealing element **124** is arranged on the area **112** of the valve receptacle **105** reduced in outer diameter. During the mounting of the control valve **101** in the valve receptacle **106**, the sealing element **124** is positioned in the area **112** of the valve housing **105** reduced in outer diameter. Then the valve housing **105** is inserted and fixed in the valve receptacle **106**. Through the arrangement on the area **112** reduced in outer diameter, the sealing element **124** is centered and guided during the mounting process, whereby incorrect mounting can be reliably prevented. Through the use of an elastically deformable sealing element **124**, axial tolerances can be compensated.

[0074] The sealing element **124** is pressed **111** by the valve housing **105** in the installed state against the axial stop **111**. Here, it is surrounded by a U shape by the axial stop **111** and the step of the area **112** of the valve housing **105** reduced in outer diameter. Due to the forces, the sealing element **124** deforms elastically and is thus pressed against the inner casing surface of the valve receptacle **106** due to the U-shaped clamping device. In this way, an optimal and early sealing effect is guaranteed in the axial direction.

[0075] Advantageously, the sealing element **124** is arranged such that it contacts the inner casing surface of the valve receptacle **106** at the boundary between the two surrounding constructions **109**, **110**. Therefore, any possible gaps at this boundary are closed and the sealing effect is guaranteed in the peripheral direction.

[0076] Through the construction of the second bore **108** with a small inner diameter in comparison with the first bore **107**, an axial stop **111** is formed, which limits the insertion depth of the control valve **101** in the valve receptacle **106** and acts as a sealing surface in interaction with the sealing element **124**. The control valve **101** engages only with its area **112** reduced in outer diameter into the second bore **108**. Because this area **112** does not take on a sealing function in interaction with the inner casing surface of the second bore **108**, its outer diameter can be smaller than the inner diameter of the second bore **108**, which makes the system not susceptible to tolerances.

[0077] Furthermore, additional seals **125** are provided at the boundary between the control housing **103** and the valve housing **105** or the valve housing **105** and the first bore **107**, which prevent leakage flows in the direction of the adjustment device **102** and thus into the engine space.

[0078] FIGS. **5** and **6** show a second embodiment of the invention. The second embodiment is identical to the first embodiment for the most part, which is shown in FIGS. **3** and **4**. In contrast to the first embodiment, the second bore **108** has a stepped construction. Here, the inner diameter of a first area **126**, which connects directly to the first bore **107**, is larger than the inner diameter of the first bore **107**. Furthermore, the inner diameter of a second area **127** adjacent to the first area **126** is smaller than the inner diameter of the first bore **107**. At the transition from the first area **126** to the second area **127**, an axial stop **111** is formed. The valve housing **105** passes through the first bore **107** of the first surrounding construction **109** and engages in the second surrounding construction **110**. Due to the larger inner diameter of the first area **126** of the second bore **108**, this is possible even for a slight offset of the bores **107**, **108** relative to each other. The transition area **128** of the valve housing **105** to the diameter-reduced area **112** in not stepped in this embodiment as in the first embodiment, but instead at least partially conical. The sealing element **124** is constructed as a sealing ring and arranged in the transition area **128**, wherein the form of the sealing element **124** is adapted to the shape of the transition area **128**, especially its conicity **127**. The inner casing surface **133** of the sealing element **124** thus has a first conical area **129**, wherein the inner diameter continuously decreases starting from the end in the axial direction until it corresponds to the outer diameter of the area **112** reduced in outer diameter.

[0079] On an outer casing surface **134** of the sealing element **124**, a second conical area **131** is formed, wherein this is formed on the ring edge **130** offset in the axial direction relative to the first conical area **129**. The outer diameter of the sealing element **124** increases in the axial direction starting from the end until the maximum outer diameter of the sealing element **124** is reached.

[0080] The axial length of the first area **126**, the area **112** reduced in outer diameter, and the sealing element **124** is constructed so that the sealing element **124** contacts both the first bore **107** and also the second bore **108** in the area of the boundary between the first surrounding construction **109** and the second surrounding construction **110**.

[0081] The conical area formed in the outer casing surface of the valve housing **105** has the effect that the sealing element **124** forms a pressure sealed contact on the casing surface of the first bore **107** and the casing surface of the first area **126** of the second bore **108**. Due to the shape of the sealing element **124**, between the second bore **108** and the sealing element **124** there is a hollow space **132**. This allows the compensation of any axial play during the mounting. In this case, the valve housing **105** can force material of the sealing element **124** into the hollow space **132**, whereby the control valve **101** can be inserted in the axial direction farther into the valve receptacle **106**. This hollow space **132** allows axial tolerances to be compensated to a greater extent than is allowed in the sealing element **124** shown in the first embodiment.

[0082] Obviously, the sealing element **124** of the second embodiment can also be inserted into the valve receptacle **106** of the first embodiment and vice versa. Furthermore, both sealing elements **124** and the control valve **101** can be used in a single stepped bore, which is used as the valve receptacle **106**. Likewise, the sealing element **124** and the control valve **101** are inserted into a bore, which is limited by a circular ring-shaped wall extending in the radial direction.

[0083] FIGS. **7** and **8** show a sealing element **124** according to the invention in the shape of a sealing ring. A ring edge **130** of the inner **133** and the outer casing surface **134** of the sealing element **124** has a conical construction. The conicity is constructed such that the partial cross sectional shape of the sealing element **124** is reached through material removal of two edges of a rectangular surface. That is, the first conical area **129** on the inner casing surface **133** is funnel shaped and the second conical area **131** on the outer casing surface **134** is frustum shaped.

[0084] Furthermore, the sealing element **124** is composed of an elastomer. Here, a fluoro rubber or an acrylonitrile butadiene rubber can be used as the material, for example.

REFERENCE SYMBOLS

[0085] **1** Device
[0086] **2** Stator
[0087] **3** Rotor
[0088] **4** Drive wheel
[0089] **5** Recesses
[0090] **6** Side wall
[0091] **7** First side cover
[0092] **8** Second side cover
[0093] **9** Connection element
[0094] **10** Vane groove
[0095] **11** Vane
[0096] **12** First pressure chamber
[0097] **13** Second pressure chamber
[0098] **14** Groove base
[0099] **15** Leaf spring element
[0100] **16** First pressure medium line
[0101] **17** Second pressure medium line
[0102] **18** Control valve
[0103] **19** Pressure medium pump
[0104] **20** Tank
[0105] **21** Arrow
[0106] **22** Central bore
[0107] **23** Formations
[0108] **24** Locking element
[0109] **25** Axial bore
[0110] **26** Piston
[0111] **27** First spring
[0112] **28** Ventilation element
[0113] **29** Connecting rod
[0114] **30** Recess
[0115] **31** Pressure medium circuit
[0116] **32** Adjustment device
[0117] **33** Second spring
[0118] A First work connection
[0119] B Second work connection
[0120] P Supply connection
[0121] T Discharge connection
[0122] **101** Control valve
[0123] **102** Adjustment device
[0124] **103** Control housing
[0125] **104** Control piston
[0126] **105** Valve housing
[0127] **106** Valve receptacle
[0128] **107** First bore
[0129] **108** Second bore
[0130] **109** First surrounding construction
[0131] **110** Second surrounding construction
[0132] **111** Axial stop
[0133] **112** Area reduced in outer diameter
[0134] **113** Pressure medium channel
[0135] **114*a*** First rising groove
[0136] **114*b*** Second rising groove
[0137] **114*p*** Third rising groove
[0138] **115*a*** First radial opening
[0139] **115*b*** Second radial opening
[0140] **115*p*** Third radial opening
[0141] **116*a*** First ring groove
[0142] **116*b*** Second ring groove
[0143] **116*p*** Third ring groove
[0144] **117*a*** First opening
[0145] **117*b*** Second opening
[0146] **117*p*** Third opening
[0147] **119** Push rod
[0148] **120** First spring element
[0149] **121** Control section
[0150] **122** Fourth ring groove
[0151] **123** Fourth openings
[0152] **124** Sealing element
[0153] **125** Seal
[0154] **126** First area
[0155] **127** Second area
[0156] **128** Transition area
[0157] **129** First conical area
[0158] **130** Ring edge
[0159] **131** Second conical area
[0160] **132** Hollow space
[0161] **133** Inner casing surface
[0162] **134** Outer casing surface

1. Sealing element comprising a sealing ring for sealing an axial end of a control valve of a device for changing control times of gas-exchange valves, including an inner casing surface and an outer casing surface, the inner casing surface and the outer casing surface are provided with a conical area on each of ring edges thereof.

2. Sealing element according to claim **1**, wherein the two conical areas are formed on the ring edges of the sealing element offset relative to each other in an axial direction.

3. Control valve for controlling a supply and discharge of pressure medium to and from a device for changing control times of an internal combustion engine with

an essentially cylindrical valve housing, on which pressure medium connections are formed and

with an axially displaceable control piston arranged within the valve housing,

wherein a connection between the pressure medium connections can be established or separated as a function of a position of the control piston,

wherein the valve housing is arranged within a valve receptacle, and

wherein an insertion depth of the valve housing into the valve receptacle is limited by an axial stop formed in the valve receptacle,

the axial stop is formed as a circular or circular ring-shaped wall,

which extends radially inwards starting from an inner casing surface of the valve receptacle,

and a sealing element is arranged between the valve housing and the axial stop of the valve receptacle.

4. Control valve according to claim **3**, wherein an axial stop-side end of the valve housing is formed with an area reduced in outer diameter, wherein the sealing element is arranged at least partially in the area reduced in outer diameter.

5. Control valve according to claim **3**, wherein the sealing element is constructed as a sealing ring with an outer casing surface and an inner casing surface.

6. Control valve according to claim **3**, wherein the sealing element is comprised of an elastomer.

7. Control valve according to claim **3**, wherein the elastomer is a fluoro rubber or an acrylonitrile butadiene rubber.

8. Control valve according to claim **3**, wherein the valve receptacle is assembled from a first and a second bore, wherein the bores are constructed in different surrounding constructions, arranged at least approximately coaxially and located adjacent to each other.

9. Control valve according to claim **8**, wherein the axial stop is embodied as a boundary of the two surrounding constructions.

10. Control valve according to claim **8**, wherein the axial stop is formed in the second bore in a direction of insertion of the control valve.

11. Control valve according to claim **8**, wherein the axial stop is arranged and the sealing element is constructed so that the sealing element contacts the valve receptacle at a boundary of the two surrounding constructions.

12. Control valve according to claim **4**, wherein a transition area of the valve housing to the diameter-reduced area has an at least partially conical construction and the sealing element is provided on an inner casing surface thereof with a first conical area that is adapted to the transition area of the valve housing.

13. Control valve according to claim **5**, wherein the outer casing surface of the sealing element is provided on an end contacting the axial stop with a second conical area, so that an annular hollow space is produced between the sealing element and the axial stop.

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