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Remarks:

Claim 16 is deemed to be abandoned due to non-payment of the claims fee (Rule 45(3) EPC).

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(54) **Internal combustion engine and relative modular valve cover**

(57) Herein is described an internal combustion engine of the four-stroke type, comprising a block within which one or more cylinders are obtained which respectively house one or more pistons which are mobile with an alternating motion. The block is surmounted by a single head for each cylinder, within which one or more intake ports are obtained for the fuel incoming into the respective cylinders and one or more exhaust ports for exhausting the combustion gases. The opening and closing of the intake and exhaust ports are controlled by respective intake and exhaust valves actuated by at least one camshaft. The camshaft is arranged in the block and its rotating movement is transformed into the alternating rectilinear motion of each valve by means of a corresponding hydraulic tappet. On each single head a single cover for each cylinder is permanently constrained, internally provided with at least two shaped seats capable of completely housing two respective rocker arms during the relative rotating movement around their own pins. In each shaped seat a corresponding circular hole is obtained, wherein the pin for rotating the rocker arm is fixed housed in such shaped seat. On the upper surface of the head one or more centring means are provided, which facilitate the mounting of the cover on the head, ensuring the correct coupling between the spherical head of each rod and a corresponding concave portion obtained in the rocker arm.

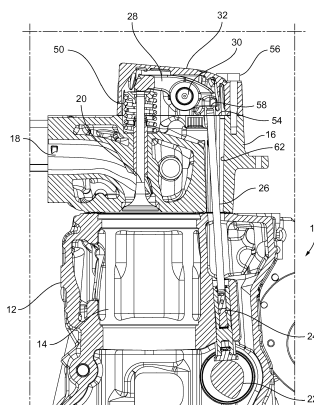


Fig. 2

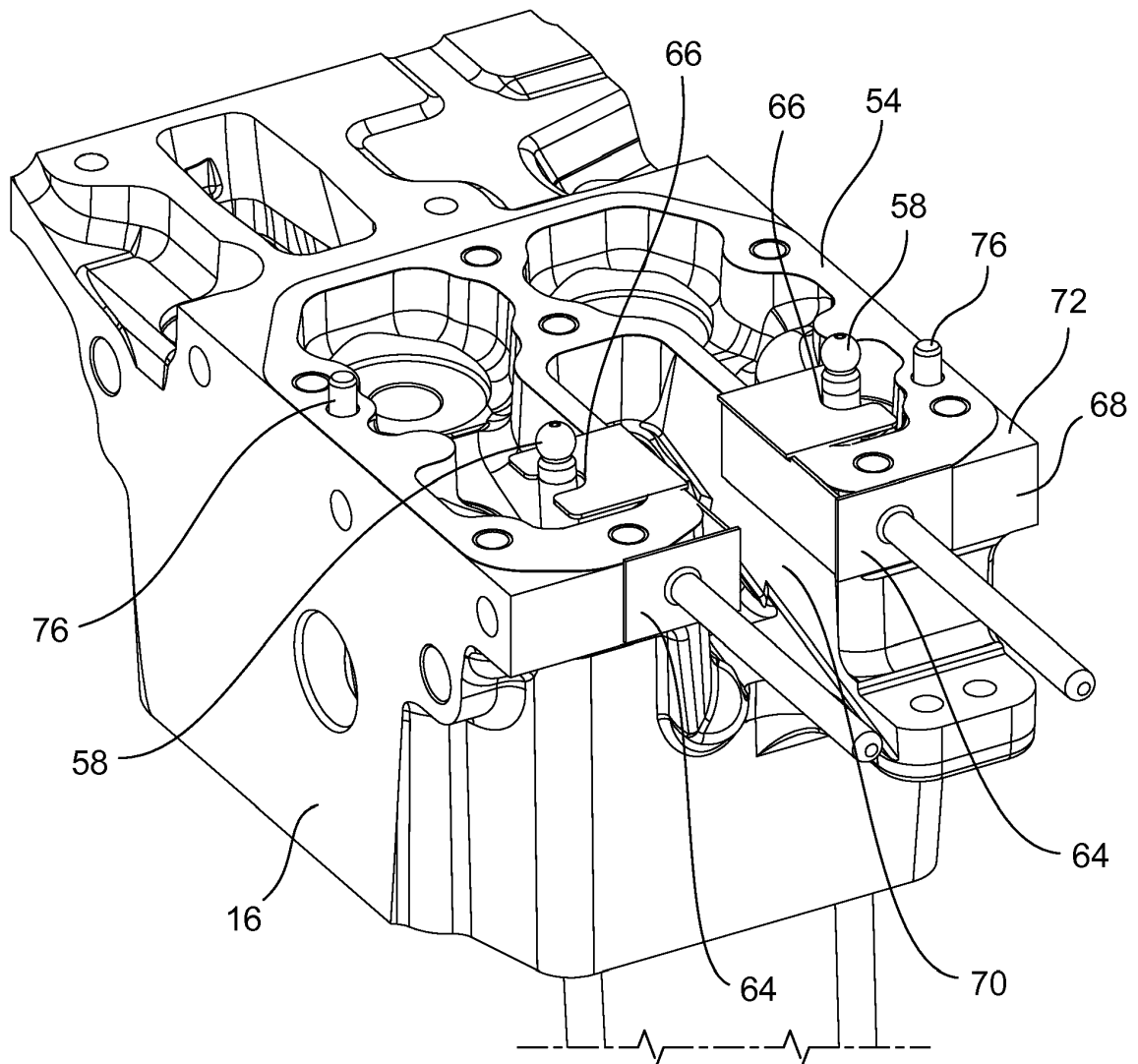


Fig. 7

Description

[0001] The present invention generally refers to an internal combustion engine and, more in particular, to a modular valve cover which can be used on an internal combustion engine with rods and rocker arms distribution and tappets with hydraulic recovery of the clearance.

[0002] As known, the term "distribution" is used to indicate the assembly of the mechanical members provided to control the air/fuel mixture flowing into the cylinder or into the cylinders and the burnt gases flowing from the cylinder or from the cylinders of an internal combustion engine of the four-stroke type.

[0003] In almost all four-stroke internal combustion engines currently being manufactured, the steps of supplying the air/fuel mixture in each cylinder, as well as the ejection of the combustion gases from the cylinder, are carried out by valves of the mushroom type controlled by particular eccentrics, referred to as cams, usually splined on a so-called camshaft. The camshaft is actuated by the drive shaft, with respect to which it rotates at a half angular speed and to which it is connected through a chain or a belt or, more rarely, through a cascade of gears.

[0004] In most of the four-stroke internal combustion engines the distribution mechanism is grouped on the head. In such configuration, the camshaft directly drives the tappets of the valves and it is connected to the driving shaft in one of the aforementioned manners.

[0005] One older design pattern, still commonly used for the fact that it is inexpensive, simple and reliable, instead provides that the distribution occurs indirectly, i.e. with the camshaft housed in the block. According to this distribution system the valves are actuated by interposing a rods and rocker arms mechanism.

[0006] In the attached figure 1 a conventional internal combustion engine provided with the rods and rocker arms distribution system is schematically illustrated, in sectional view. In the engine of figure 1 the rotary movement assigned to the camshaft 100 is transformed into the alternating rectilinear motion through the contact between the cam of the shaft 100 and the plate 102 of the mechanical tappet 104, according to a law of motion defined by the profile of the cam.

[0007] The alternating rectilinear motion of the mechanical tappet 104 generates a rotation of the rocker arm 106 around its own fixing pin 108 by means of a rod 110 arranged in contact with the mechanical tappet 104 and a first "cam side" arm of the rocker arm 106. The rotary movement of the rocker arm 106 is once again transformed into the rectilinear motion of the valve 112 through the second "valve side" arm of the rocker arm 106.

[0008] A spring 114 coupled with the valve 112 generates the due static pre-load in the distribution system and guarantees, during the closing step, the return of the valve 112 in position. A support block 116, required for locking the pin 108 which supports the rocker arm 106,

is fixed using screws into corresponding seats obtained directly in the head of the engine.

[0009] The possible mechanical clearance present in the distribution system, for example due to the design clearances and/or to wear, is adjusted, during the first mounting and during the engine maintenance step, through an adjustment screw 118 integrated in the rocker arm 106. Lastly, a removable cover 120 is arranged to close the entire distribution system and a gasket 122, interposed between the head of the engine and such cover 120, ensures the sealing.

[0010] Another example of a traditional internal combustion engine is described in the document GB-A-388434. Further internal combustion engines according to the prior art are described, for example, in documents US-A-1741677 and FR-A-752332.

[0011] It is known that for each internal combustion engine, regardless of the type of distribution system, there is a need of reducing the overall dimensions, especially vertical-wise, as much as possible so as to ensure an ideal installation of the engine for the provided application. For example, the installation, on board of a vehicle of a compact engine allows to obtain an equally compact design of the engine hood, with clear advantages in terms of visibility for the driver and overall dimensions of the vehicle itself. In addition, in case of installation of the engine on fixed systems, such as for example a generator unit, a compact engine is a forced choice in that, in general, it is desired to reduce the installation spaces and the overall dimensions of the systems as much as possible. At the same time, for each engine it is also required to reduce the layout complexity as much as possible, so as to facilitate the assembly thereof as well as to reduce the overall costs, intended as the sum of the components and assembly costs.

[0012] Thus, an object of the present invention is to provide an internal combustion engine, in particular an internal combustion engine with rods and rocker arms distribution and tappets with hydraulic recovery of the clearance, that is particularly compact in the vertical direction.

[0013] Another object of the present invention is to provide an internal combustion engine in which the construction complexity and assembly of the entire distribution system is reduced with respect to the engines with rods and rocker arms distribution according to the prior art.

[0014] A further object of the present invention is to provide an internal combustion engine in which it is also reduced the number of the components of the entire distribution system with respect to the rods and rocker arms distribution engines according to the prior art.

[0015] These and other objects according to the present invention are attained by providing an internal combustion engine, in particular an internal combustion engine with rods and rocker arms distribution and tappets with hydraulic recovery of clearance, as outlined in claim 1.

[0016] Further characteristics of the invention are out-

lined by the dependent claims, which are an integral part of the present invention.

[0017] In general, the vertical compactness and construction simplification of the internal combustion engine according to the present invention were obtained by designing a valve cover with integrated system for fixing the pins of the rocker arms, to be used in combination with a distribution system according to the rods and rocker arms pattern and tappets with hydraulic recovery of the clearance valves. The use of this integrated valve cover also allowed to compact the injection system (height of the injectors and relative fuelling and cabling pipes) and the exhaust gas aftertreatment system, to the benefit of the final overall dimension of the engine hood.

[0018] Actually, though maintaining the general configuration of the mechanism of the distribution system unvaried, a reduction of the height-wise direction was obtained both by eliminating the adjustment screw, so as to also allow a more compact geometry of the rocker arms and by integrating the fixing seats of the pins of the rocker arms directly in the cover valves, thus eliminating the previous support blocks required for fixing the pins on the head of the engine.

[0019] These modifications were made possible by using hydraulic tappets instead of the mechanical ones. The hydraulic tappets continuously ensure the recovery of the possible mechanical clearance, given that they comprise a hydraulic element which allows a continuous extension or compression of the tappets, thus filling each possible gap. Thus, since it is not required to actuate the regulation of the clearances, neither during the first mounting nor in the engine maintenance step, both the traditional valve cover, necessarily removable, and the adjustment screw were eliminated from the internal combustion engine according to the present invention.

[0020] The characteristics and advantages of an internal combustion engine according to the present invention shall be clearer from the following exemplifying and non-limiting description with reference to the attached schematic drawings wherein:

Figure 1 is a sectional view schematically illustrating a traditional internal combustion engine provided with the rods and rocker arms distribution system; figure 2 is a sectional view schematically illustrating an internal combustion engine according to the present invention; figure 3 is a perspective view, from the inner side, of the valve cover of the internal combustion engine of figure 2; figure 4 is a side elevational view of the valve cover of figure 3; figure 5 is a sectional view along line V-V of figure 4; figure 6 is a sectional view along line VI-VI of figure 4; figure 7 is a perspective view showing, during the mounting operations, a part of the head of the internal combustion engine of figure 2; and figure 8 is a bottom view of an alternative embodi-

ment of the cover valves of the internal combustion engine of figure 2.

[0021] In particular with reference to figures 2 to 8 an internal combustion engine according to the present invention is shown, indicated in its entirety with reference number 10. The engine 10 is of the four-stroke type and it comprises, in a per se known manner, a block 12 within which one or more cylinders 14 are obtained, said cylinders 14 respectively housing one or more pistons which are mobile with an alternating motion.

[0022] The block 12 is surmounted by a single head 16 for each cylinder 14, within which one or more intake ports 18 are obtained for the fuel incoming into the respective cylinders 14 and one or more exhaust ports for exhausting the combustion gases. The opening and closing of the intake and exhaust ports 18 are controlled by respective intake and exhaust valves 20 actuated by at least one camshaft 22.

[0023] The camshaft 22 is arranged in the block 12 and its rotating movement is transformed into the alternating rectilinear motion of each valve 20 by means of a corresponding hydraulic tappet. In detail, the hydraulic tappet comprises, for each valve 20, a hydraulic element 24 for recovering the clearance of such valve 20, operatively connected to a cam of the camshaft 22, a rod 26, fixed on the hydraulic element 24 and mobile with an alternating rectilinear motion partially inside the block 12 and partially inside the head 16, and a rocker arm 28, placed in rotation around its own pin 30 by the alternating rectilinear motion of the rod 26 so as to be able to move - in turn - the valve 20 according to an alternating rectilinear motion.

[0024] According to the invention, on each single head 16 a single cover 32 for each cylinder 14 is permanently constrained, internally provided with at least two shaped seats 34 and 36 capable of completely housing two respective rocker arms 28 during the relative rotating movement around their own pins 30. In addition, in each shaped seat 34, 36 of the cover 32 a corresponding circular hole 38, 40 is obtained in which the pin 30 for rotating the rocker arm 28 is fixed housed in such shaped seat 34, 36.

[0025] The cover 32 has a particularly low height-wise development, given that it is configured for housing the rocker arms 28 only during the relative rotating movement around their own pins 30. Such cover 32 is preferably made of aluminium alloy by means of the diecasting technique. Both the pins 30 and the respective rocker arms 28 are instead preferably made of forged micro-alloyed steel.

[0026] Each circular hole 38, 40 of the cover 32 is preferably a blind hole and it is oriented according to a direction substantially perpendicular with respect to the direction of development of the corresponding shaped seat 34, 36, as illustrated for example in figure 6. Each shaped seat 34, 36 is also provided, at the intersection portion between the shaped seat 34, 36 and the respective cir-

cular hole 38, 40, with a pair of steel shoulder rings 42 which at least partially surround each rocker arm 28 for filling the clearance between such rocker arm 28 and the respective shaped seat 34, 36. The function of the traditional adjustment screw, which serves to adjust the clearance between the valve and the slide of the rocker arm in the engines of the known type, is thus directly performed by the hydraulic element 24 of the tappet. The axial clearance between the rocker arm 28 and the respective shaped seat 34, 36 is instead directly recovered by the shoulder ring 42.

[0027] Between each rocker arm 28 and the respective pin 30 an anti-friction bushing 44 is interposed as shown in figure 5. Each pin 30 is fixed in the respective circular hole 38, 40 by interposing a sealing ring 46 of the O-Ring type, so as to avoid the possible leakage of engine oil from cover 32. In addition, a threaded closing plug 48 of each circular hole 38, 40, is provided which covers the respective pin 30 and further increases the sealing of the cover 32.

[0028] Each valve 20 is provided, in a per se known manner, with a return spring 50 operating by compression. Each shaped seat 34, 36 is thus provided with an enlarged end portion 52 capable of at least partially house such return spring 50 when not compressed by the action of the rocker arm 28. Between the cover 32 and the head 16 it is lastly interposed a gasket 54 for guaranteeing the perfect tightness of the cover 32.

[0029] Besides ensuring lower overall dimensions with respect to the embodiments according to the prior art and eliminating the maintenance of the tappets of the valves 20 during the after-sales stage, the cover 32 according to the present invention also allows to drastically reduce the mounting operations to be carried out in the production line, thus further reducing the costs for assembling the engine 10.

[0030] Indeed, the operator could vertically drop the cover 32, in which the rocker arms 28 and the relative pins 30 were previously pre-assembled on the head 16 of the cylinder through a single operation and exploiting specifically designed dowel pins 76 obtained on the upper surface 72 of the head 16. Once the cover 32 has been approached to the head 16 it would only be required to fasten the fixing screws 56 which constrain such cover 32 to such head 16.

[0031] However, though performed correctly, the aforementioned mounting procedure would not be capable of guaranteeing the correct coupling between the spherical head 58 of the rod 26 and the corresponding concave portion 60 obtained in the rocker arm 28, mainly due to the following reasons:

- absence on the cover 32 (for obvious technical reasons) of suitable openings which can be used for the visual inspection and for manual access with the aim of allowing a correct engagement between each rod 26 and the respective rocker arm 28; and
- misalignment between the spherical head 58 of the

rod 26 and the corresponding concave portion 60 obtained in the rocker arm 28 during the stages of assembling the cover 32.

[0032] Indeed, once the base of the rod 26 has been connected with the underlying hydraulic element 24 for recovering the clearance, due to the force of gravity, the rod 26 rests on the relative channel 62 partially obtained in the head 16 and partially in the block 12 and which is required for recovering the lubrication oil and the blow-by gases. The channel 62, having to ensure the outflow of the engine oil and of the blow-by gases, is characterised by passage sections which are much wider with respect to the nominal diameter of the stem of the rod 26. Thus, the balance position acquired by the rod 26 is considerably far from its nominal operating position, to a point that the coupling, during assembly, between the spherical head 58 of the rod 26 and the corresponding concave portion 60 obtained in the rocker arm 28 is almost impossible.

[0033] In order to be able to correctly perform the procedure of mounting the cover 32, it is thus necessary that each rod 26 is approximately in its nominal operating position. Such object may be attained by using a specific mounting tool which facilitates the work of the operator and ensures the uniqueness of the mounting.

[0034] The mounting tool may for example comprise a plurality of removable masks 64, one for each valve 20 and the relative tappet (figure 7). Each mask 64 may be fixed on the top part of the head 16 before the application of the cover 32. Each mask 64 is provided with a calibrated seat 66, for example U-shaped, with which a respective rod 26 can be held in position. The mounting of the cover 32 may thus be summarised as follows:

1. the operator applies the gasket 54 on the head 16 manually and positions the mounting masks 64;
2. thanks to the dowel pins 76, the operator vertically drops the assembled cover 32 from above, i.e. provided with the rocker arms 28 and the relative pins 30;
3. once the spherical heads 58 of the rods 26 have been correctly engaged with the corresponding concave portions 60 obtained in the rocker arms 28, the operator removes the masks 64 and completes the mounting of the engine 10.

[0035] The mounting masks 64 may be realized according to many variants depending on the configuration of the head 16. In figure 7 it can for example be observed that the positioning of such masks 64 is ensured by one or more machined perpendicular surfaces 68 and 70 of the head 16. In any case, further dowel pins 76 could be inserted on the upper surface 72 of the head 16 to ensure the positioning of the cover 32 and thus modify the layout of the mounting tool.

[0036] However, the mounting tool described up to now, as well as its possible variants require additional

machining costs (machined surfaces on the cylinder head for the positioning or further use of dowel pins), tool costs (providing mounting masks) and assembly costs (additional operations are required by the operator).

[0037] A particular embodiment of the cover 32 according to the present invention is thus capable of avoiding additional operations for the operator and additional assembly costs. As shown in figure 8, the cover 32 may be provided - at the lower part - with a specific gasket 54 having such a shape and development to directly integrate the previously described mounting tool in the design of the gasket 54. Thus, such gasket 54 serves two functions, i.e. that of sealing the surfaces between head 16 of the engine 10 and cover 32 of the valves 20 and that of positioning the rods 26 during the mounting of the cover 32.

[0038] In detail, the correct positioning of the gasket 54 is ensured through a plurality of holes 74 obtained on the lower surface of the cover 32 at relative dowel pins 76 obtained on the upper surface 72 of the head 16 (figure 7). In addition, at each shaped seat 34, 36, one or more walls 78, provided with respective calibrated holes 80 arranged at the upper end of each rod 26 and configured to be traversed by the spherical head 58 of each rod 26, are obtained in the gasket 54.

[0039] Thus, the rods 26, previously assembled in the block 12 of the engine 10, may be manually inserted into the calibrated holes 80 during the positioning of the gasket 54. The rods 26, which would tend to rest on the relative channels 62 under the effect of the force of gravity, shall thus be maintained approximately in their operating position by such calibrated holes 80.

[0040] In this configuration, vertically dropping the cover 32 once the same is assembled, the coupling between the rods 26 and the rocker arms 28 shall be ensured in a unique manner and the rods 26 shall automatically acquire the respective nominal operating position. Lastly, given that both the diameters of the channels 62 in correlation to the required outflow of engine oil and the diameters of the calibrated holes 80 in correlation with the maximum displacement of the rods 26 were defined, each potential interference during the operation of the engine 10 between the rods 26 and the calibrated holes 80 and the channels 62 shall be avoided entirely.

[0041] It has thus been observed that the internal combustion engine according to the present invention attains the previously outlined objects in particular attaining the following technical and economic advantages:

- compactness of the overall design of the engine;
- simplification of the distribution system, due to the elimination of some components traditionally present in the engines with rods and rocker arms distribution system;
- presence of a single assembly containing the rocker arms and the respective pins;
- easy mounting;
- reduction of the costs of the components of the dis-

tribution system, the latter being in a lower number with respect to the rods and rocker arms distribution systems according to the prior art;

- reduction of the distribution system maintenance costs;
- reduction of the costs of manpower in the assembly line, given that only one mounting operation of the assembly containing the rocker arms and the respective pins is provided.

[0042] The internal combustion engine of the present invention thus conceived can be subjected to many modifications and variants, all falling within the same inventive concept; in addition, all details can be replaced by technically equivalent elements. In practice the materials used, as well as the shapes and dimensions, may vary according to the technical requirements.

[0043] The scope of protection of the invention is thus defined by the attached claims.

Claims

1. Internal combustion engine (10) of the four-stroke type, comprising a block (12) within which one or more cylinders (14) are obtained, said cylinders (14) respectively housing one or more pistons which are mobile with an alternating motion, the block (12) being surmounted by a single head (16) for each cylinder (14), within which one or more intake ports (18) are obtained for the fuel incoming into the respective cylinders (14) and one or more exhaust ports for exhausting the combustion gases, the opening and closing of the intake and exhaust ports (18) being controlled by respective intake and exhaust valves (20) actuated by at least one camshaft (22), wherein said camshaft (22) is arranged in the block (12) and its rotating movement is transformed into the alternating rectilinear motion of each valve (20) by means of a corresponding hydraulic tappet which comprises, for each valve (20), a hydraulic recovery element (24) of the clearance of said valve (20), operatively connected to a cam of the camshaft (22), a rod (26), fixed on the hydraulic element (24) and mobile with an alternating rectilinear motion inside a channel (62) partially obtained in the block (12) and partially inside the head (16), and a rocker arm (28), placed in rotation around its own pin (30) by the alternating rectilinear motion of the rod (26) so as to be capable of moving in turn the respective valve (20) according to an alternating rectilinear motion, the internal combustion engine (10) being **characterised in that** on each single head (16) a single cover (32) is permanently constrained for each cylinder (14), said cover (32) being internally provided with at least two shaped seats (34, 36) capable of completely housing two respective rocker arms (28) during the relative rotating movement around their own pins (30), in

each shaped seat (34, 36) there being obtained a corresponding circular hole (38, 40), wherein the rotating pin (30) of the rocker arm (28) housed in said shaped seat (34, 36) is fixed, **and in that** on the upper surface (72) of the head (16) one or more centring means (54, 64, 74, 76, 78, 80) are provided, which facilitate the mounting of the cover (32) on the head (16), ensuring the correct coupling between the spherical head (58) of each rod (26) and a corresponding concave portion (60) obtained in the rocker arm (28).

2. Internal combustion engine (10) according to claim 1, **characterised in that** each circular hole (38, 40) is a blind hole oriented according to a direction substantially perpendicular with respect to the direction of development of the corresponding shaped seat (34, 36).
3. Internal combustion engine (10) according to claim 1 or 2, **characterised in that** each shaped seat (34, 36) is provided, at the intersection portion between said shaped seat (34, 36) and the respective circular hole (38, 40), with a pair of shoulder rings (42) which at least partially surround each rocker arm (28) for filling the clearance between said rocker arm (28) and the respective shaped seat (34, 36).
4. Internal combustion engine (10) according to any one of claims 1 to 3, **characterised in that** between each rocker arm (28) and the respective pin (30) an anti-friction bushing (44) is interposed.
5. Internal combustion engine (10) according to any one of claims 1 to 4, **characterised in that** each pin (30) is fixed in the respective circular hole (38, 40) by interposing a sealing ring (46) of the O-Ring type, so as to avoid the possible leakage of engine oil from the cover (32).
6. Internal combustion engine (10) according to claim 5, **characterised in that** each circular hole (38, 40) is provided with a threaded closing plug (48) which covers the respective pin (30) and further increases the sealing of the cover (32).
7. Internal combustion engine (10) according to any one of claims 1 to 6, **characterised in that** each shaped seat (34, 36) is provided with an enlarged end portion (52) capable of at least partially housing a return spring (50), operating by compression and provided on each valve (20), when said return spring (50) is not compressed by the action of the rocker arm (28).
8. Internal combustion engine (10) according to any one of claims 1 to 7, **characterised in that** between the cover (32) and the head (16) a gasket (54) for

ensuring the sealing of said cover (32) is interposed.

9. Internal combustion engine (10) according to any one of claims 1 to 8, **characterised in that** the cover (32) is permanently constrained above the head (16) through a plurality of fixing screws (56).
10. Internal combustion engine (10) according to any one of claims 1 to 9, **characterised in that** said centring means comprise one or more dowel pins (76) obtained on the upper surface (72) of the head (16), said dowel pins (76) facilitating the mounting of the cover (32) on the head (16) in cooperation with a specific mounting tool (64).
11. Internal combustion engine (10) according to claim 10, **characterised in that** said mounting tool (64) comprises a plurality of removable masks (64), one for each valve (20) and the relative tappet, wherein each mask (64) is fixed on the top part of the head (16) before the application of the cover (32).
12. Internal combustion engine (10) according to claim 11, **characterised in that** each mask (64) is provided with a calibrated U-shaped seat (66) with which a respective rod (26) can be held in position.
13. Internal combustion engine (10) according to claim 11 or 12, **characterised in that** the head (16) is provided with one or more machined perpendicular surfaces (68, 70) which ensure the positioning of said masks (64).
14. Internal combustion engine (10) according to any one of claims 1 to 9, **characterised in that** said centring means comprise one or more holes (74) obtained on the lower surface of the cover (32), said holes (74) being arranged at relative dowel pins (76) obtained on the upper surface (72) of the head (16), and one or more walls (78) obtained on a gasket (54) at each shaped seat (34, 36), said walls (78) being provided with respective calibrated holes (80) arranged at the upper end of each rod (26) and configured to be traversed by the spherical head (58) of each rod (26) to facilitate the mounting of the cover (32) on the head (16).
15. Internal combustion engine (10) according to any one of claims 1 to 9, **characterised in that** said centring means comprise a specific gasket (54) interposed between the cover (32) and the head (16), wherein the correct positioning of said gasket (54) is ensured through a plurality of holes (74) obtained on the lower surface of the cover (32) at relative dowel pins (76) obtained on the upper surface (72) of the head (16), said gasket (54) having such a shape and development to serve both the function of sealing the surfaces between the head (16) and the cover

(32), and the function of positioning the rods (26) during the mounting of the cover (32).

16. Internal combustion engine (10) according to any one of claims 1 to 15, **characterised in that** the cover (32) is made of aluminium alloy by means of the diecasting technique.

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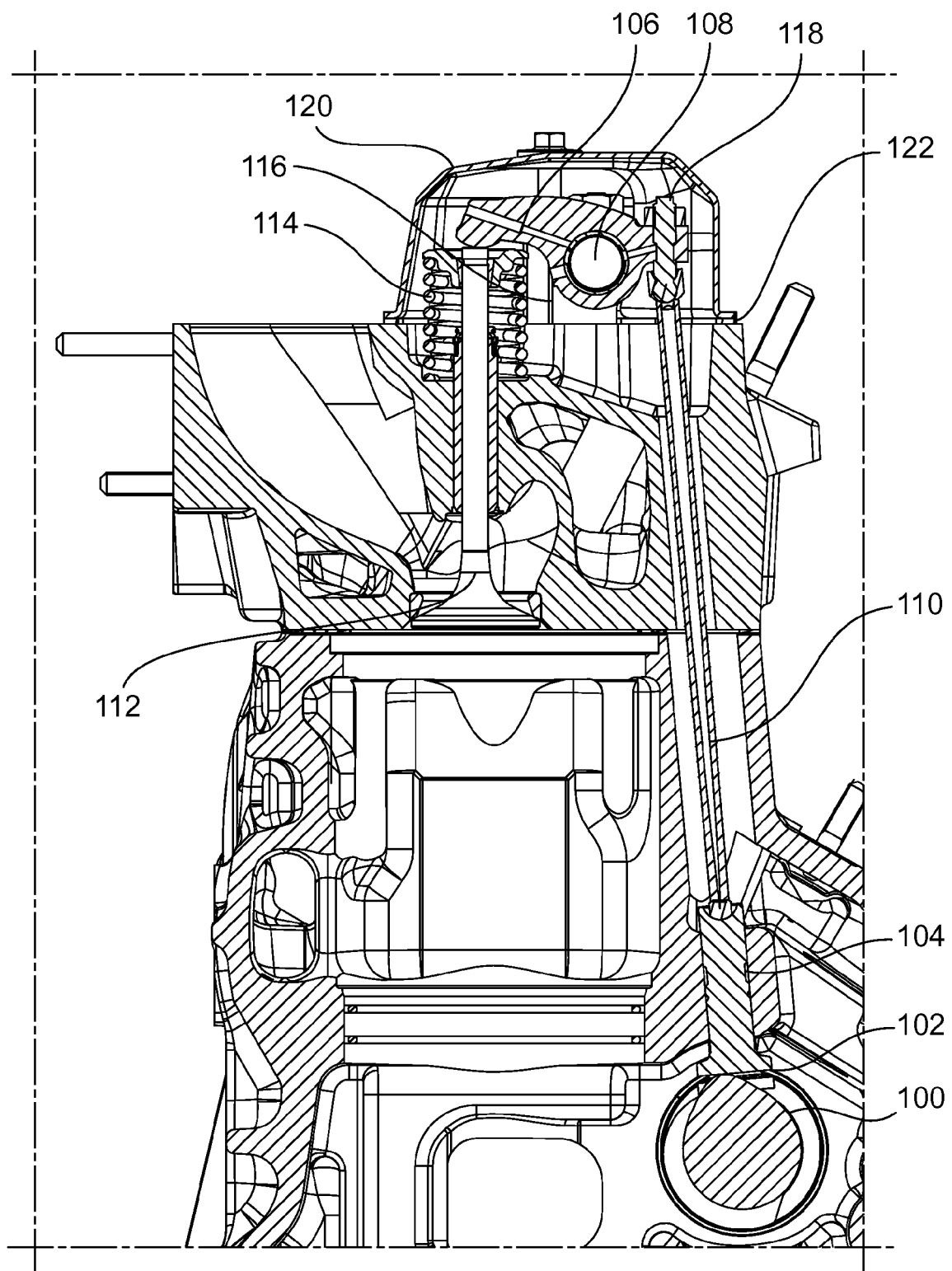


Fig. 1

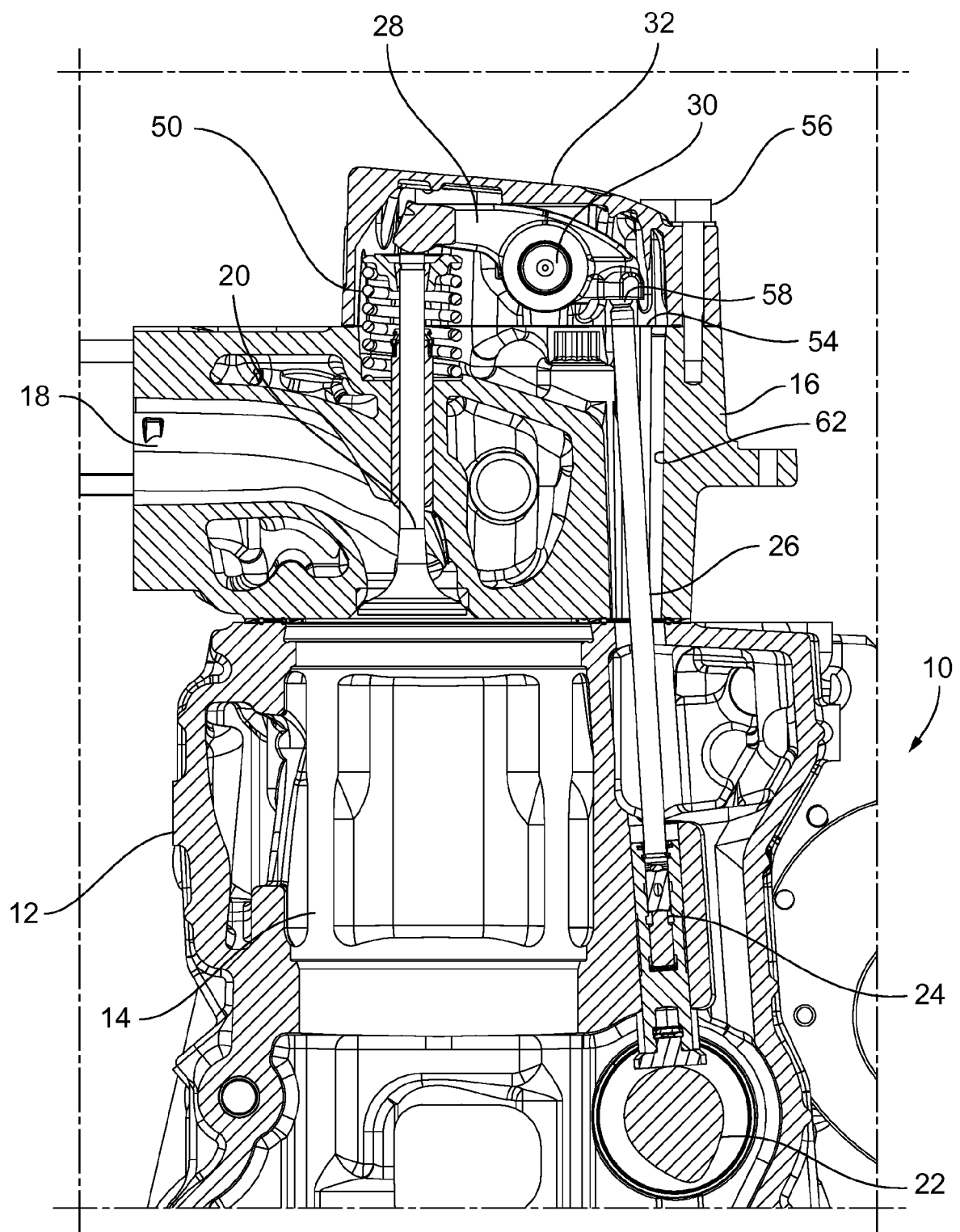


Fig. 2

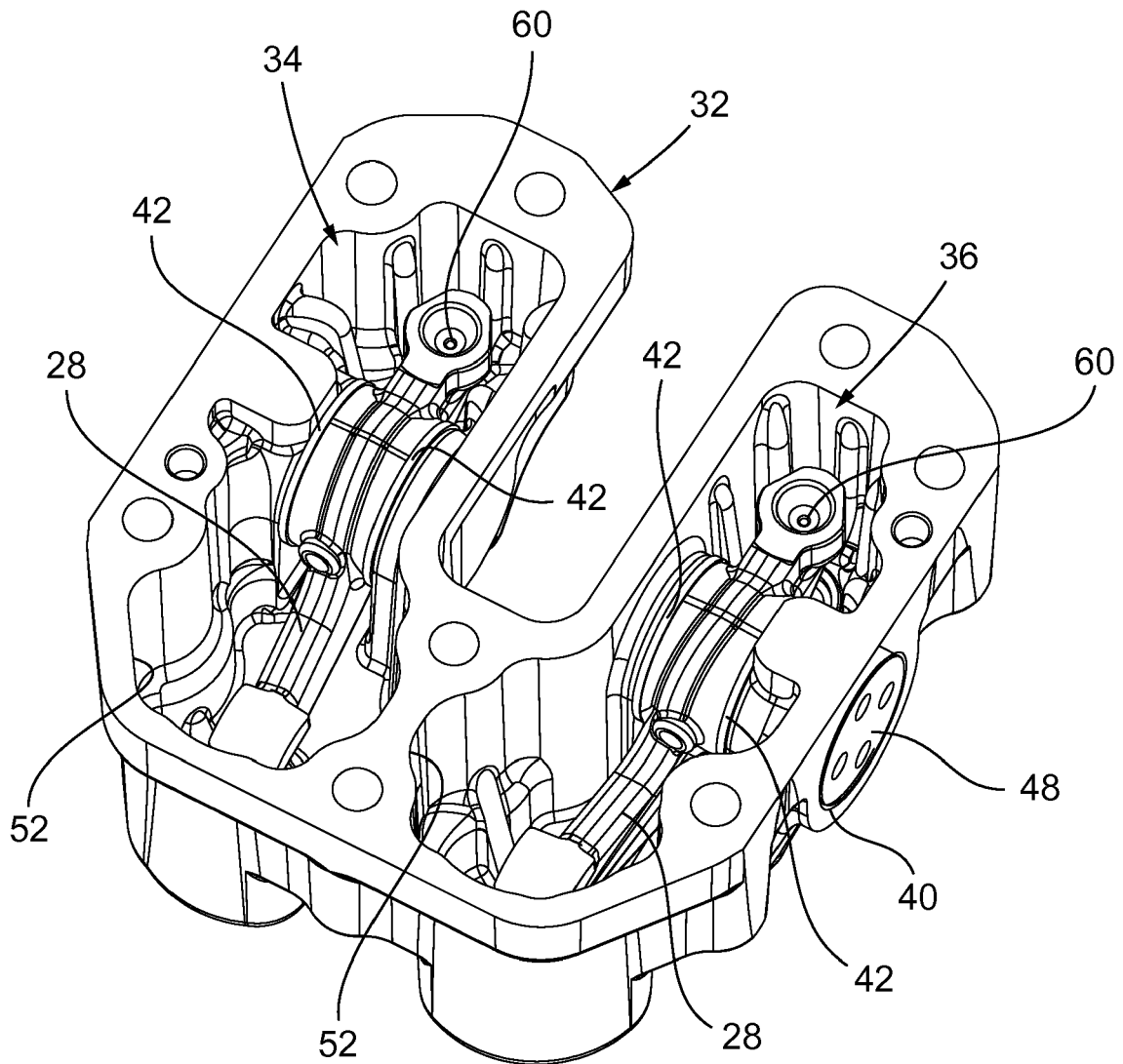


Fig. 3

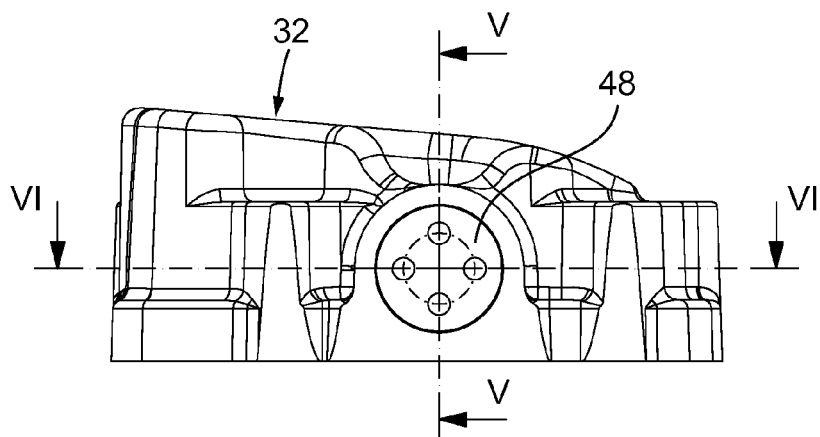


Fig. 4

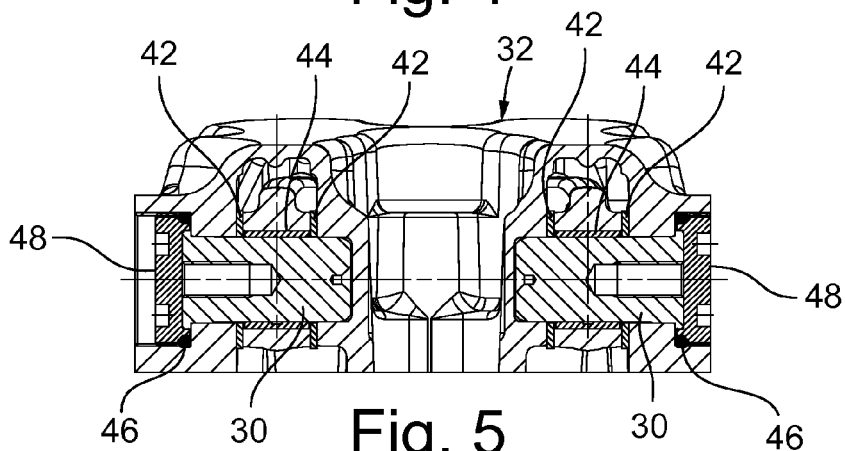


Fig. 5

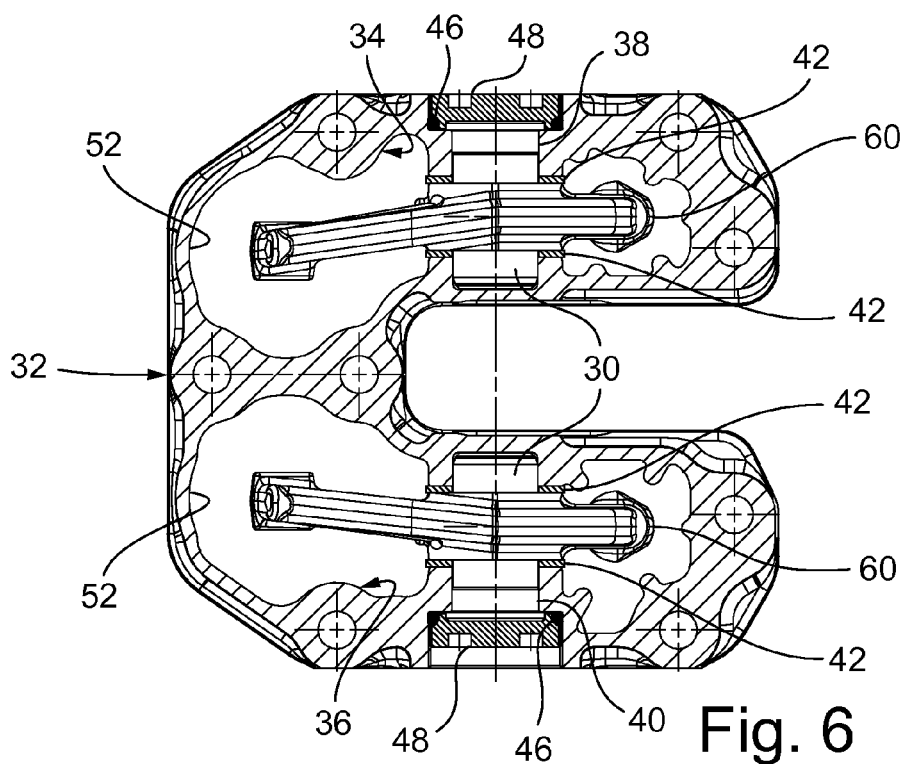


Fig. 6

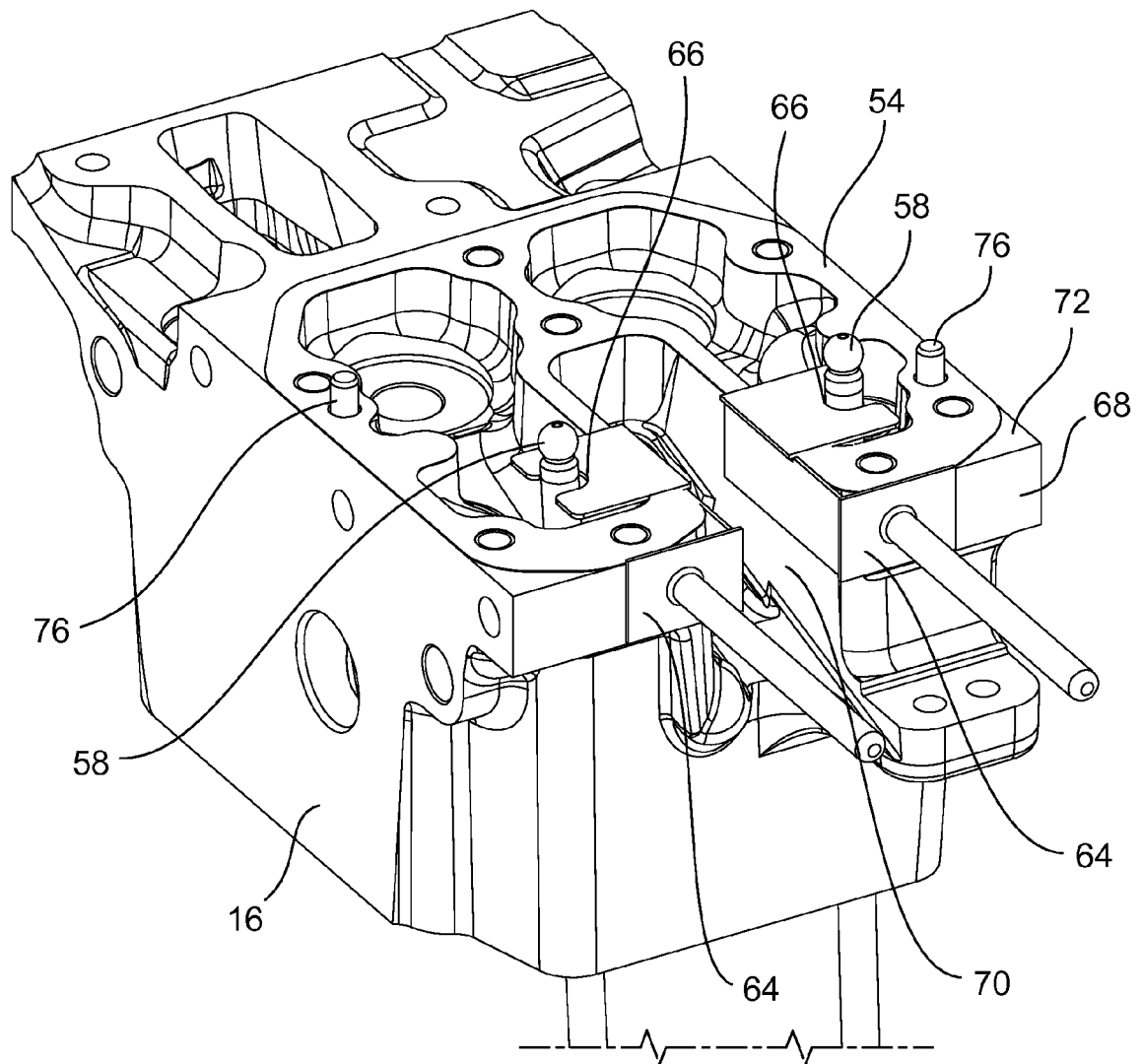


Fig. 7

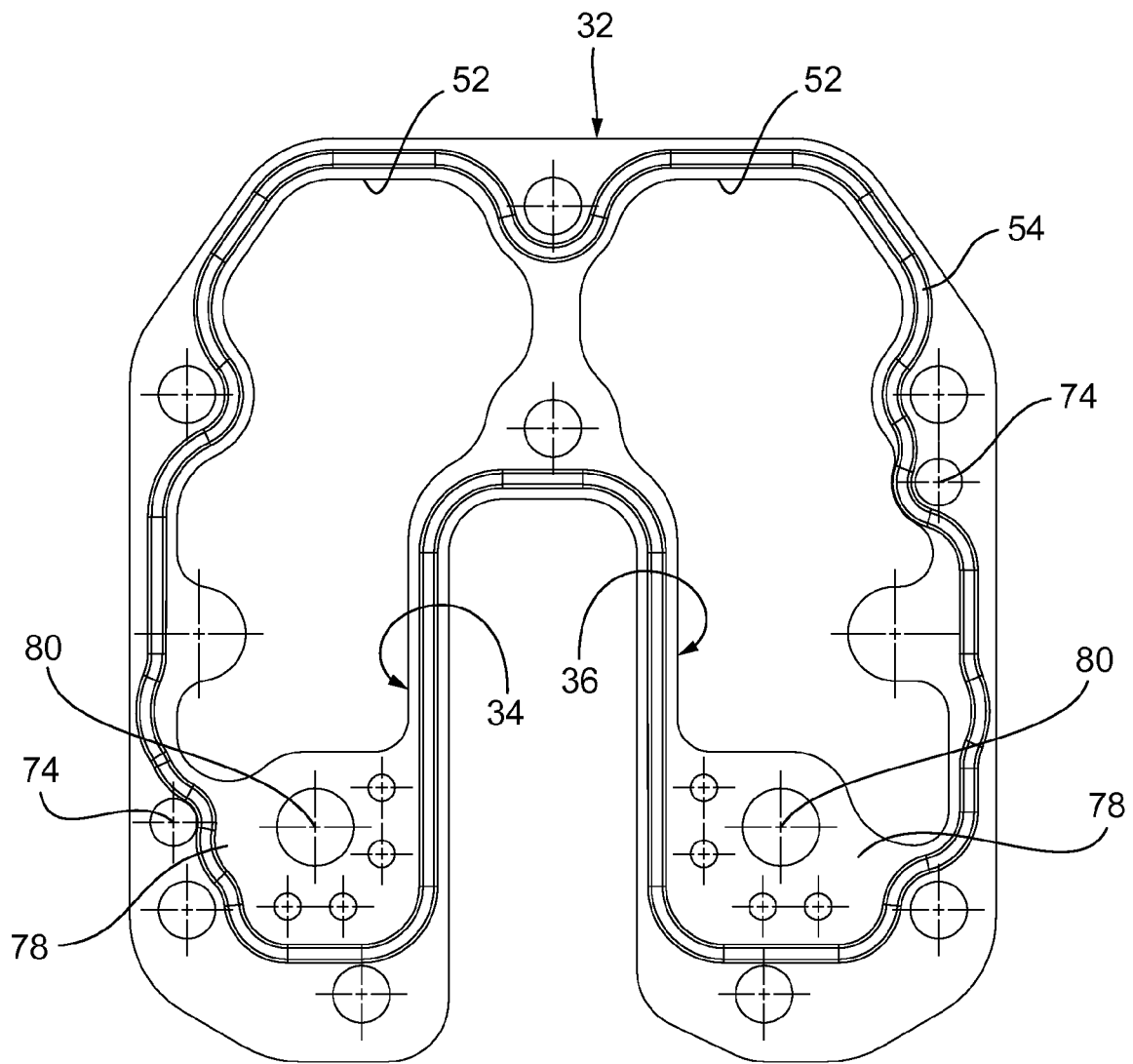


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 14 16 2502

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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