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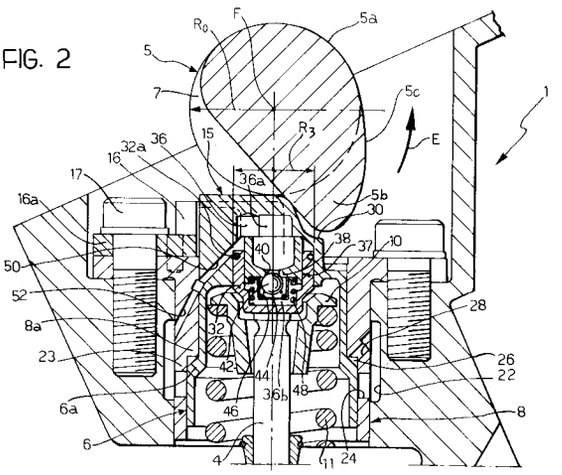
(54) A valve control device for an internal combustion engine having a tappet clearance compensation device.

(57) A control device for a valve of an internal combustion engine comprises a valve (3) associated with resilient biasing means (11) biasing it towards its closure position and valve control means (5) for urging the valve (3) towards its open position. A hydraulic brake device (23) for slowing the movement of the valve (3) in the latter part of its closing stroke includes an annular chamber (36) defined between the tappet (6) and a bush (8) coaxially outside the tappet (6) in communication with a source (20, 22) of oil under pressure. A tappet clearance compensation device (30), interposed between the tappet (6) and the valve (3), which can be connected to the pressurised oil source (20, 22) of the hydraulic brake device (23) includes a pair of auxiliary ducts (50, 52) formed respectively in the body of the tappet (6) and in the bush (8), which permit the automatic compensation device (30) and the hydraulic brake device (23) to be connected together when the valve (3) is in the closure position.

FIG. 2



EP 0 681 092 A1

The present invention relates to a control device for a valve of an internal combustion engine, comprising:

- a valve displaceable between a duct closure position and a duct open position, this valve being associated with resilient biasing means urging it towards its closure position,
- valve control means for displacing the valve towards its open position, including a rotary cam operable to engage an active surface of a tappet interposed between the cam and the valve, at least during the displacement of the valve towards its open position,
- a hydraulic brake device for slowing the movement of the valve during the last part of its closure stroke, including an annular chamber defined between the tappet and a bush coaxially of and external to the tappet, this chamber being in communication with a source of oil under pressure and having a volume which is variable as a consequence of the displacement of the tappet with respect to the bush, and
- a tappet clearance compensation device interposed between the tappet and the valve.

Such a valve control device forms the subject of European Patent Application No. EP-A-0 574 867 which is to be considered as part of the present description.

In the above-indicated known device the tappet clearance compensation device is constituted by a spacer pad of calibrated dimensions, interposed between the tappet and the valve. To adjust the tappet clearance, that is to say the relative position between cam and tappet, it is necessary to replace the spacer pad. Since such a system is subject to wear over time, which modifies the tappet clearance, it is necessary to perform periodic inspections for the purpose of checking if the tappet clearance is maintained within a predetermined range of values.

Hydraulic devices which allow automatic adjustment of the tappet clearance in an internal combustion engine are known from US Patents US-A-4 367 701 and US-A-4 373 477.

The principal object of the present invention is that of providing a valve control device for an internal combustion engine of more efficient type than previously known systems by the use of an automatic hydraulic tappet clearance compensation device.

This object is achieved according to the invention in that the tappet clearance compensation device is of self adjusting hydraulic type and can be connected to the pressurised oil source of the hydraulic brake device by means of a first auxiliary duct formed in the body of the tappet and by a second auxiliary duct formed in the said bush, these auxiliary ducts being intended to assume a mutually aligned position in which the automatic compensation device and the hydraulic brake device are connected together, when the valve is in the said closure position, and positions out-of-alignment with one another, in which the automatic compensation device is isolated from the hydraulic brake device, when the valve is in a position other than the closure position.

By virtue of these characteristics the device according to the invention allows automatic adjustment of the tappet clearance compensation by utilising a single source of pressurised oil for supplying both the hydraulic brake device and the automatic tappet clearance compensation device, in this way making available a large volume for effectively damping shock waves which propagate in the pressurised oil circuit in consequence of different phases of operation of the hydraulic brake device.

Further characteristics and advantages of the present invention will become more clearly apparent from the following detailed description, made with reference to the attached drawings, provided purely by way of non-limitative example, in which:

Figure 1 is a sectioned side view of a valve control device according to the invention;

Figure 2 is a view on an enlarged scale of a detail indicated with the arrow II in Figure 1;

Figure 3 is a view similar to Figure 2 at a different point in the operation of the device;

Figure 4 is a perspective view of some of the elements of Figure 3;

Figures 5 and 6 are partially sectioned front elevation views in the direction of the arrow V of Figure 4 in two different instants in the operation of the device; and

Figure 7 is a schematic side view in the direction of the arrow VII-VII of Figure 1, which illustrates a cylinder head of an internal combustion engine provided with the control device of the invention.

With reference to the drawings, the reference numeral 1 indicates a cylinder head of an internal combustion engine (only partially illustrated in the drawings).

The reference numeral 2 indicates an induction duct associated with one of the cylinders, the outlet opening of which is controlled by a valve 3 which in its closure position is disposed in contact with a seat 3a. The valve 3 has a stem 4 displaceable axially along an axis D to control opening and closure of the duct 2.

The stem 4 is guided by a sleeve 4a of type known per se, associated with the cylinder head 1. The displacement of the valve 3 is controlled cyclically by a cam 5 mounted on the internal combustion engine's camshaft, rotating in a direc-

tion indicated by the arrow E about the axis F of the camshaft.

Between the cam 5 and the end of the valve stem 4 closest to the cam 5 there is interposed a tappet 6 the body of which is substantially cup-shaped. The tappet 6 is mounted axially slidably within a bush 8 coaxially of the axis D, connected rigidly to the cylinder head 1.

A spring cap (disc) member 10 of type known per se is axially fixed to the valve stem 4 and is engaged by a coil spring 11 concentric with the stem 4, the function of which is to maintain the valve 3 urged towards its closure position of the duct 2.

The tappet 6 includes a head 14 adjacent the cam 5, which has an active surface 15 cooperable with the cam profile 5. This active surface 15 comprises a first flat portion 15a substantially orthogonal to the axis D and a second, curved portion 15b joined to the portion 15a and having a constant radius of curvature in such a way as to present a convex zone towards the cam 5.

The head 14, fixed to the tappet 6, is locked against relative rotation with respect to the bush 8 by means of a pair of guide shoulders 16 which have a shape corresponding to the shape of the adjacent edge of the head 14 and are formed on an element 16a rigidly connected to the cylinder head 1 by means of a screw 17 which also permits fixing of the bush 8 to the cylinder head 1.

The cam 5 comprises an asymmetric cylindrical member the base of which is defined by a curved line which comprises a portion 5a having a cam base circle of radius R_0 and a cam lobe 5b projecting from the base circle, serving as a thrust head for the tappet 6. The curved line defines the profile of the cam 5 which is asymmetric with respect to a plane passing through the axis of rotation F and the apex of the lobe 5b, in such a way that the cam 5 has a "less steep" profile portion 5c and an opposite "steeper" profile portion 5d, where the term "steepness" means the variation of the radial coordinate with respect to the axis F for a given increment of the angular coordinate.

Because of the different "steepness" of the profile portions 5a and 5b, during the valve opening phase, that is to say in the phase which takes the valve 3 from the zero height to the maximum height, the angular displacement of the cam 5 is greater than the angular displacement of the cam necessary to take the valve to its closure position. In this way, when the speed of the camshaft which is well known to be proportional to the speed of the engine, exceeds a predetermined threshold value, for example corresponding to a speed of rotation of the engine of about 2500 revolutions per minute, the active profile 15 of the tappet 6 loses contact with the "steeper" profile portion 5d of the cam 5, thus achieving an operation of the "ballistic" type. In these conditions the law of closure of the valve 3 is determined solely by the mass of the movable components, the thrust of the spring 11 and the inertial and damping actions to which the valve 3 is subject. For speeds of the camshaft less than the predetermined threshold value the active profile 15 of the tappet 6 is always in contact with the profile of the cam 5.

Each bush 8 is surrounded by a respective peripheral chamber 22 supplied by the pressurised oil utilised for lubrication of the engine.

Between the tappet 6 and the bush 8 is defined an annular chamber 26 forming part of a hydraulic brake device 23 the volume of which is variable in dependence on the position of the tappet 6 with respect to the bush 8. In particular, the chamber 26 extends radially between the tappet 6 and the bush 8 and is delimited in the axial direction by a portion 6a of greater diameter than the tappet 6 and, on the opposite side, by a portion 8a of smaller diameter than the bush 8. The chamber 26 therefore has a base area in the form of a circular ring concentric with the axis D and is delimited internally by a circumference of radius R_1 and externally by a circumference of radius R_2.

Each bush 8 has radial holes 24 for connecting the peripheral chamber 22 to the annular chamber 26, having a relatively short length with respect to their diameter, or rather which achieve thin wall opening conditions in such a way that the flow of fluid through them produces a damping effect causing a hydraulic brake action to slow the stroke of the valve in the last part of its closure phase so as to avoid sharp contact between the tappet 6 and the cam profile 5 during "ballistic" operation.

In the bush 8 there are further formed exit apertures 28 close to the smaller diameter portion 8a, which extend between the chamber 22 and the chamber 26, the diameter of the holes 28 being significantly less than the diameter of the apertures 24 in such a way as to cause a more energetic damping action during the final phase of the closure of the valve 3, when the cylindrical outer wall of the tappet 6 closes the holes 24.

The tappet 6 further includes a hydraulic device for automatically adjusting the tappet clearance compensation. This device, generally indicated with the reference numeral 30, includes a cup-shaped member 32 mounted slidably along the axis D in a corresponding seat in the tappet 6 and substantially sealed in such a way that the bottom of the member 32 is disposed directly in contact with the end of the valve stem 4 closest to the cam 5. A circlip 32a prevents accidental separation of the member 32 from the seat defined in the tappet 6.

The member 32 defines, with the inner wall of the cylinder head 14, a substantially cylindrical cavity 36 in which oil is present. To the interior of the member 32 is mounted, also slidably and substantially sealed, a sleeve 37 which has a dividing partition 38, orientated transversely with respect to the axis D, which allows the cavity 36 to be separated into an upper chamber 36a and a lower chamber 36b (with reference to the drawings). A compression coil spring 48 is interposed between the partition 38 and the bottom of the cup-shaped member 32.

The partition 38 is provided with a central through hole 40 on the lower edge of which engages a ball 42 of a non-return valve. The ball 42 is urged towards a position in which it closes the hole 40 by a conical coil spring 46 which rests on the bottom of a perforated cage 44 in such a way as to prevent the passage of the oil present in the chamber 36b towards the chamber 36a in normal conditions. When the ball 42 is moved away from the edge of the hole 40 overcoming the biasing action of the spring 46, the chamber 36a and the chamber 36b are put into communication with one another, thereby permitting the transfer of oil from one to the other.

In the body of the tappet 6 is formed a first auxiliary duct 50 which at one end is open to the exterior of the tappet and, at the opposite end, opens into the chamber 36a. In the bush 8 there is formed a second auxiliary duct 52 passing therethrough, one end of which opens into the peripheral chamber 22, whilst the opposite end faces towards the tappet 6. The ducts 50 and 52 can be disposed in a mutually aligned condition, illustrated in Figures 1 and 2, in which they put the peripheral chamber 22 into communication with the chamber 36 when the valve 3 is in its closure position closing the duct 2. When the valve 3 is in a different position from the closure position the ducts 50 and 52 are in positions which are not aligned with one another (Figure 3) in such a way that the chamber 36a is isolated from the chamber 22.

When a clearance between the tappet 6 and the cam 5 arises the spring 48 automatically compensates for this clearance by separating the bottom of the member 32 from the partition 38 of the sleeve 37 and therefore from the head of the tappet 6 by a distance equal to the clearance which has arisen in the system. In these conditions a depression is caused within the chamber 36b which causes opening of the non-return valve against the action of the spring 46 causing the passage of oil under pressure from the chamber 36a to the chamber 36b until achieving an equilibrium condition in which the clearance is completely nullified and the ball 42 is returned into the position covering the hole 40 thereby closing the non-return valve.

The base area of the cavity 36, which corresponds to the area over which the pressure of the oil present in the peripheral chamber 22 is exerted when the ducts 50 and 52 are aligned with one another, corresponds to the area of a circular surface of radius R_3, which is at least equal to but preferably greater than the base area of the annular chamber 26 defined by the difference between the areas of the circular surfaces defined by the radii R_2 and R_1. Consequently the force exerted on the device 30 by the pressure of the oil present in the chamber 22, when the ducts 50 and 52 are aligned, which tends to separate the member 32 and the tappet 6 in the absence of engagement between the active surface 15 of the tappet and the profile of the cam 5, will be slightly predominant over the force due to the pressure of the oil which acts on the base surface of the chamber 26, in such a way that, thanks also to the spring 48, when the valve 3 is in the closure position of the duct 2 adjustment of the clearance of the tappet takes place without causing any variation in the volume of the chamber 26.

During operation of the system in the "ballistic" mode, when the active surface 15 of the tappet 6 loses contact with the "steeper" profile portion 5d of the cam 5 and therefore the ducts 50 and 52 are in the out-of-alignment configuration, the absence of abutment between the tappet 6 and the cam 5 could cause unwanted extension of the spring 48, as a result of which the bottom of the cup-shaped member 32 could move to a position which is too greatly spaced from the active surface 15 of the tappet 6 thereby preventing the correct closure of the valve 3 on the seat 3a. The force due to the pressure present in the chamber 26, together with the inertial forces and the friction to which the tappet 6 is subjected, cause a resultant force which opposes the thrust exerted by the spring 48. In particular, the resilient characteristic of the spring 48 is chosen in dependence on the force acting in the chamber 26 defined by the product of the base area of the chamber 26 and the pressure of the oil present in it, in such a way that this resultant force is of a magnitude which predominates over the resilient force of the spring 48. In this way, in the absence of any tappet clearance to be compensated, unwanted extension of the spring 48 during the "ballistic" operation of the system is prevented.

Moreover, in order to prevent the compensation device 30 from extending too much under the resilient action of the thrust of the spring 48 at the end of the closure stroke of the valve 3, the cam 5 includes a pair of cylindrical abutment surfaces 7 the radius of which is equal to the radius of the base circle R_0 of the cam, disposed alongside and

on opposite sides of the asymmetric cylindrical member of the cam 5.

Figure 7 shows the cylinder head 1 which has a plurality of valves 4 with respective tappets 6 and bushes 8, each of which is surrounded by a respective peripheral chamber 22. The chambers 22 are supplied with pressurised engine lubrication oil via a common channel 20. A plurality of cylindrical reservoirs 55 (only one of which is visible in Figure 7) are connected by service channels 54 to the channel 20 and each contains an elastically deformable cylindrical member 56 of type known per se. The volume which each of the members 56 occupies within the respective reservoir 55 is variable as a function of the change of the oil pressure in the channels 20 and 54.

In operation of the engine, during closure of the duct 2 by the valve 3, the hydraulic brake device 23 performs its action slowing the valve 3 during the final phase of its rising stroke. In these conditions, and in a cyclic manner, the oil flows out from the chambers 26 in the contraction phase, through the respective apertures 24 and 28, accumulates in the reservoirs 55 to be returned to the chambers 26 during their subsequent phase of expansion which takes place simultaneously with opening of the valves 3. The flow of oil exchanged between the chambers 26 and the reservoirs 55, caused by the cyclic expansions and contractions of the chambers 26, generates shock waves which propagate in the oil through the channels 20.

The volume of the reservoirs 55 and the channels 20 and 54 together with the additional volume defined by the ducts 50 and 52 is sufficiently great to minimise the effects of these shock waves and to render them negligible. Moreover, when the tappet clearance compensation devices 30 are connected to the peripheral chambers 22 by the ducts 50 and 52, these shock waves are effectively damped along the ducts 50 and 52 in such a way as not to propagate into the interior of the chambers 36a.

Thanks to the invention it is possible to utilise the same pressurised oil circuit already intended to operate the hydraulic brake device 23 to supply oil under pressure to the cavity 36 of the device 30 so that the tappet clearance compensation can take place correctly even when, as a result of inevitable escapes of oil through the imperfect seals between the bush 37 and the cup-shaped member 32 and between the member 32 and its seat in the tappet 6, the volume of oil contained in the chamber 36b diminishes.

Claims

1. A device for controlling the valve of an internal combustion engine, comprising:

- a valve (3) displaceable between a duct (2) closure position and a duct (2) open position, this valve (3) being associated with resilient biasing means (11) urging it towards its closure position,
- valve control means for displacing the valve (3) towards its open position including a rotary cam (5) operable to engage an active surface (15) of a tappet (6) interposed between the cam (5) and the valve (3) at least during the displacement of the valve towards its open position,
- a hydraulic brake device for slowing the movement of the valve (3) in the last part of its closure stroke, including an annular chamber (26) defined between the tappet (6) and a bush (8) coaxially of and external to the tappet (6), this chamber (26) being in communication with a source (22) of oil under pressure and having a volume which is variable as a consequence of the relative displacement of the tappet (6) with respect to the bush (8), and
- a tappet clearance compensation device (30) interposed between the tappet (6) and the valve (3),

characterised in that the tappet clearance compensation device (30) is of self-adjusting hydraulic type and can be connected to the pressurised oil source (22) of the hydraulic brake device by means of a first auxiliary duct (50) formed in the body of the tappet (6) and by a second auxiliary duct (52) formed in the said bush (8), these auxiliary ducts (50, 52) being intended to assume a mutually aligned position in which the automatic compensation device (30) and the hydraulic brake device (23) are connected together when the valve is in the said closure position, and positions out-of-alignment with one another, in which the automatic compensation device (30) is isolated from the hydraulic brake device (23) when the valve (3) is in a position other than the closure position.

2. A device according to Claim 1, characterised in that between the tappet (6) and the valve (3) is interposed a cup-shaped member (32) slidable with respect to the tappet (6) along the axial direction (D) of movement of the valve (3), this cup-shaped member (32) defining with the tappet (6) a cavity (36) in which is present a movable dividing partition (38) disposed transversely with respect to the said axial direction (D) to subdivide this cavity (36) into a first chamber (36a) into which the said auxiliary duct (50) opens and a second chamber (36b)

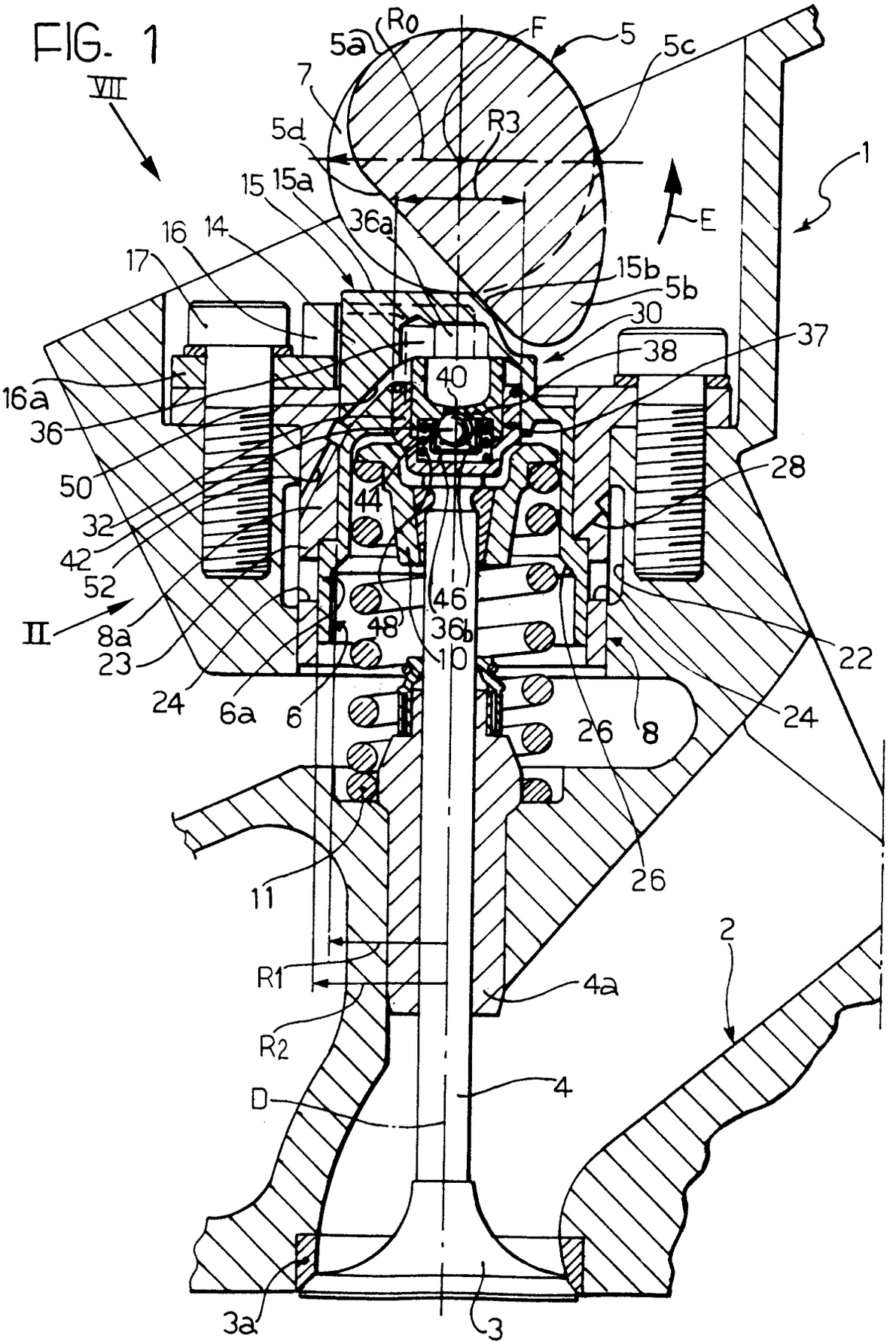
in which resilient thrust means (48) interposed between the partition (38) and the cup-shaped member (32) are provided, the partition (38) including a non-return valve (40, 42, 46) for impeding the passage of fluid present in the second chamber (36b) towards the first chamber (36a).

3. A device according to Claim 1 or Claim 2, characterised in that the cross-sectional area of the said cavity (36), with respect to the said axial direction (D), is equal to or greater than the cross-sectional area of the said annular chamber (26).

4. A device according to Claim 2 or Claim 3, characterised in that the elastic characteristic of the elastic thrust means (48) is such that the resultant forces which act on the tappet (6) when its active surface (15) is spaced from the cam (5), determined by the pressure in the annular chamber (26) and by inertial and friction forces to which the tappet (6) is subject, are predominant over the thrust force exerted by the elastic thrust means (48).

5. A device according to any of Claims from 2 to 4, characterised in that the cam (5) with asymmetric profile comprises a cylindrical member the base of which is defined by a curved line which has a base portion (5a) delimited by a base circle (R_0) of the cam (5) and from which extends a cam lobe (5b) of asymmetric form, and a pair of cylindrical surfaces (7) externally delimited by a radius equal to the radius of the base circle (R_0) of the cam (5), these cylindrical surfaces lying alongside and on opposite sides of the said cylindrical member.

FIG. 1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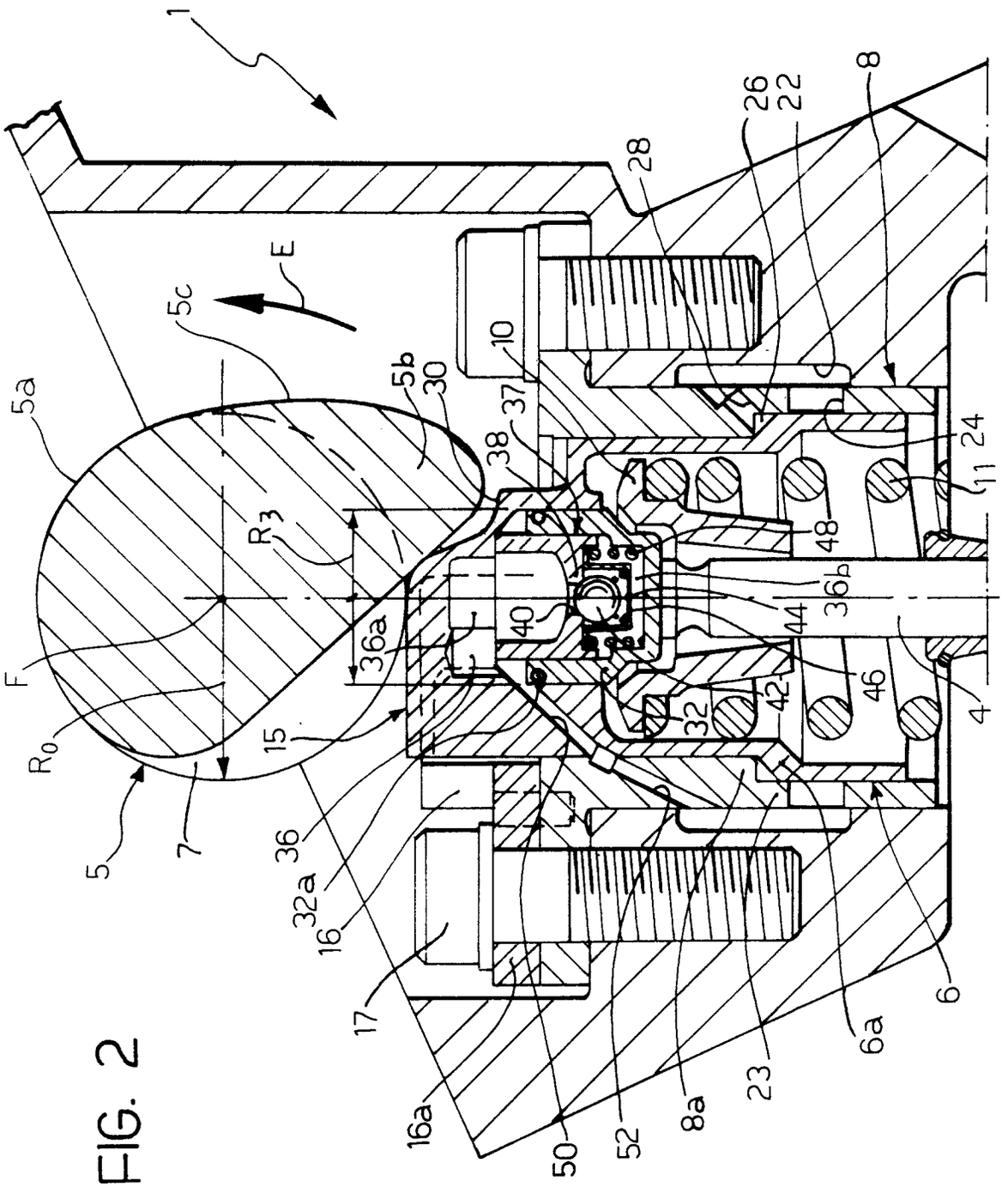
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FIG. 2

FIG. 3

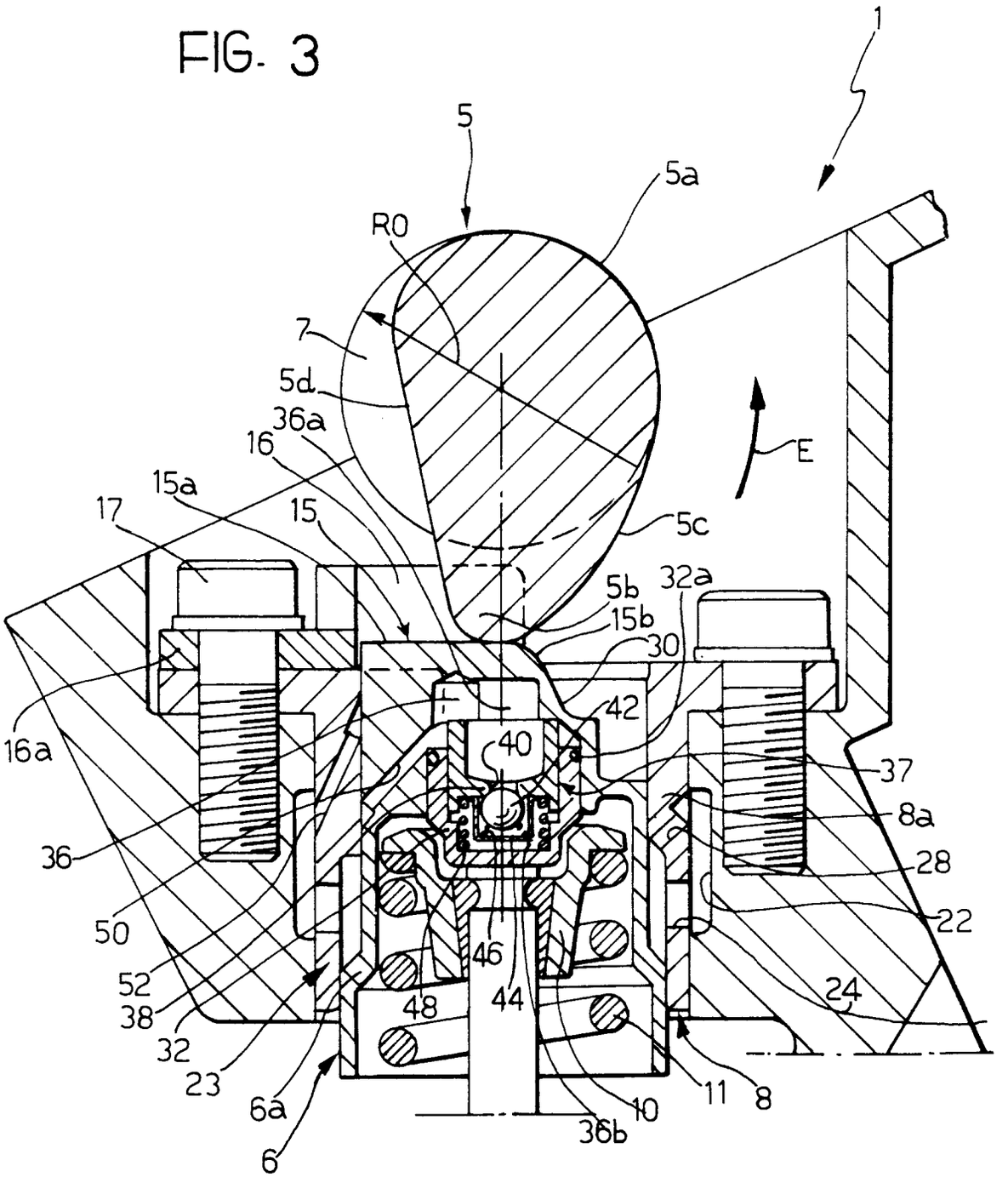
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FIG. 4

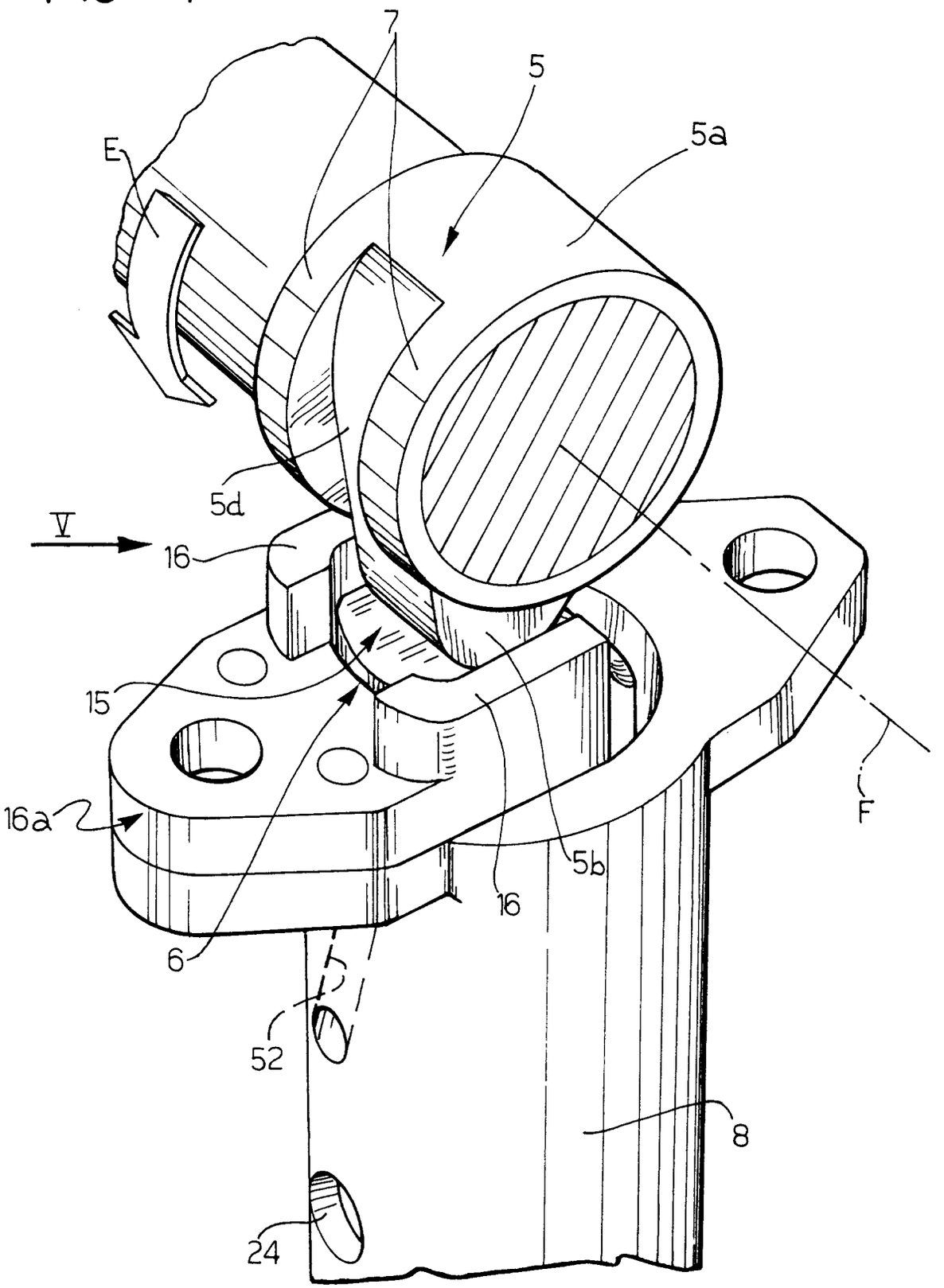


FIG. 6

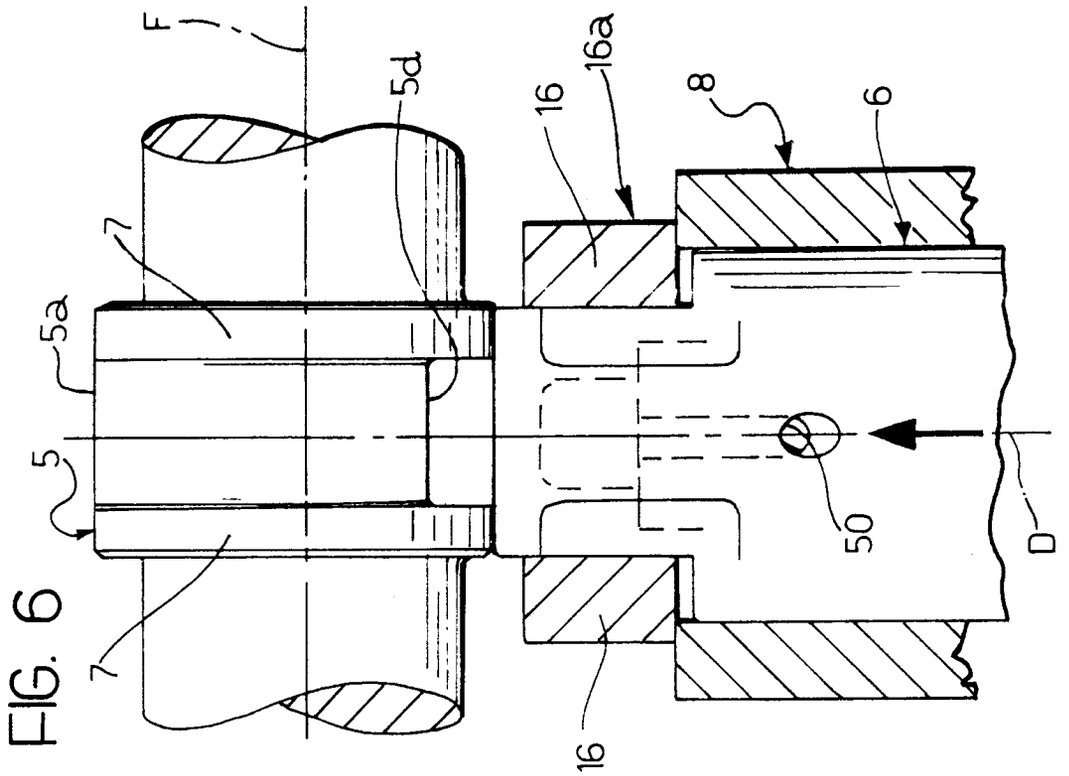


FIG. 5

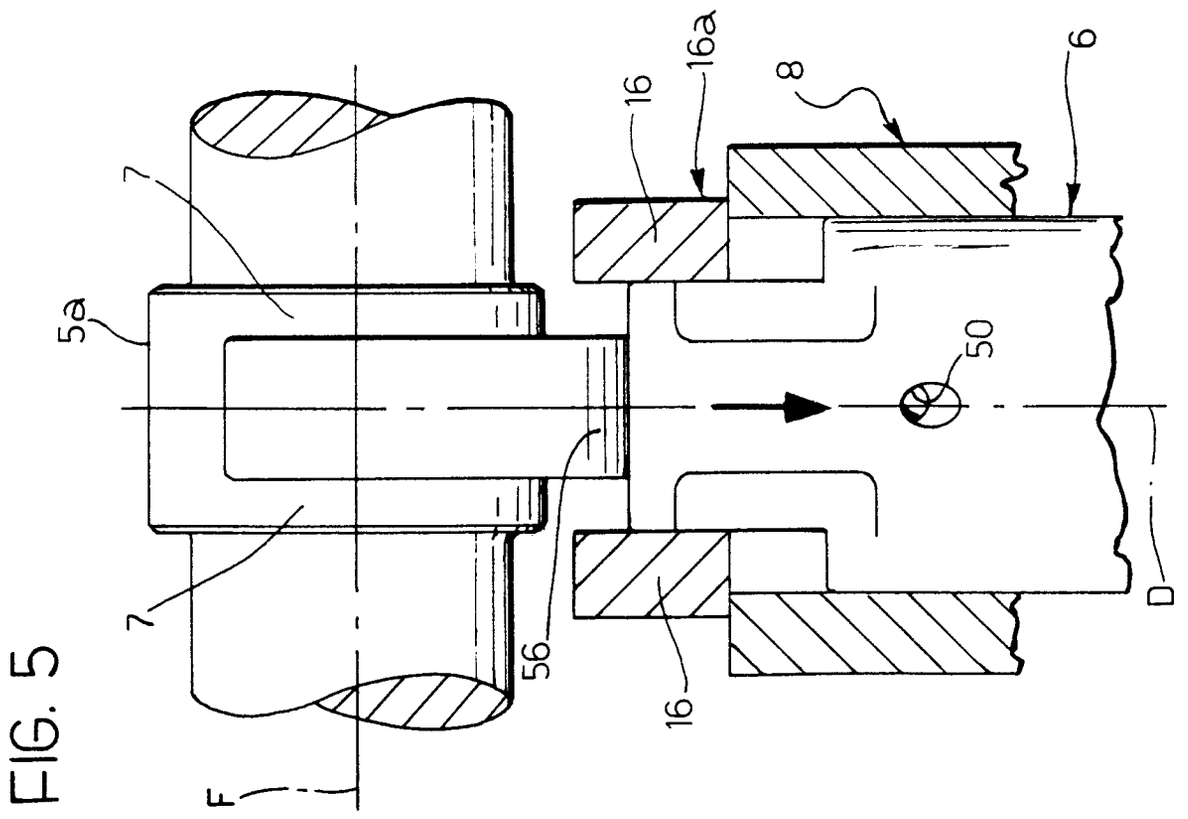
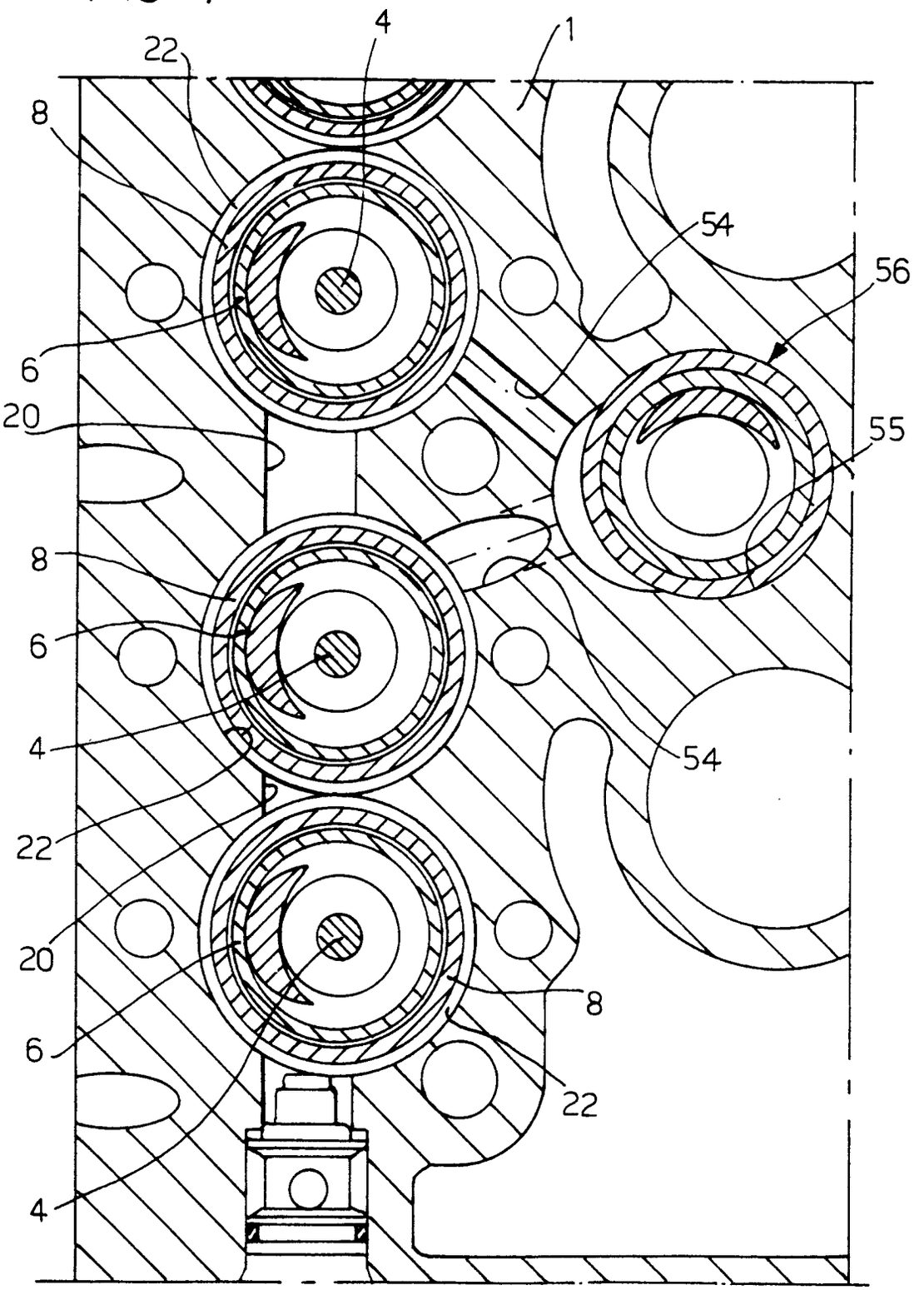


FIG. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 95 10 6560

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,A	EP-A-0 574 867 (FIAT) * column 4, line 12 - line 49 * * column 6, line 37 - column 7, line 13 * * figures 2,3 *	1,5	F01L1/08 F01L1/16 F01L13/00
A	DE-A-40 35 376 (VOLKSWAGEN) * column 3, line 47 - column 4, line 15 * * figures 1,2 *	1,2	
A	DE-A-43 17 607 (VOLKSWAGEN) * column 2, line 67 - column 3, line 65 * * figures 1,2 *	1,2	
P,A	DE-A-44 19 768 (VOLKSWAGEN) * column 2, line 39 - column 3, line 7 * * figures 1,2 *	1,2	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	7 August 1995	Lefebvre, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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