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(54) **A single shaft timing system, particularly for internal combustion engines**

(57) The timing system (1) described comprises a unitary, tubular camshaft (2) and a phase variator (3) operatively associated therewith for varying the phase angle between first and second sets of cams (41a-d ; 5a-d) of the shaft (2) ; the cams of the second sel and of the first set are fixed for rotation with the camshaft and with an operating shaft (51) of the variator (3), respectively, so that a variation of the phase angle between the cams of the sets (4a-d ; 5a-d) is brought about as a result of the active operation of the variator (3).

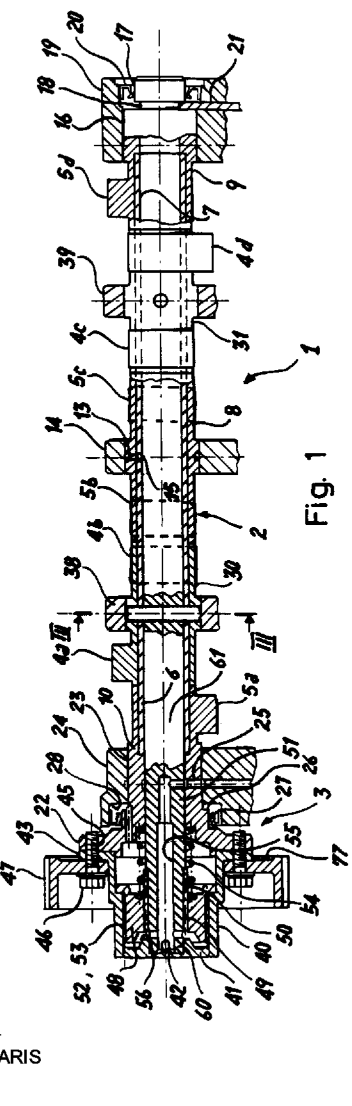

Fig. 1

EP 0 686 754 A2

The present invention relates to a timing system of the so-called "single-shaft" type, that is, with various sets of cams mounted on a single shaft. Typically, in an internal combustion engine, these sets comprise the cams for controlling the intake valves and the cams for controlling the exhaust valves, respectively. These cams will also be referred to in the context of the present specification by the terms intake cams and exhaust cams, respectively.

In a timing system of this type, it is desirable to vary the phase angle between the intake and exhaust cams as changes take place in predetermined operating parameters of the engine. This variation is achieved by means of a phase variator.

A single-shaft timing system suitable for permitting the phase variation indicated above is described, for example, in EP-A-0 397 540.

This system provides for a plurality of individual cams mounted on an actuator shaft with the interposition of a coupling such that an axial sliding movement of the shaft relative to the cams corresponds to a predetermined and desired variation of the phase angle between the cams.

The individual cams are intercalated with and spaced by sleeves which together prevent them from moving axially.

Although this system is operatively effective in regulating the desired phase variation, it has some disadvantages. Amongst these is the fact that the solution is structurally complex and that the camshaft does not have a unitary and fixed structure, at least until it is assembled and fitted on respective mountings of an engine.

The problem upon which the invention is based is that of providing a timing system which is designed structurally and functionally to avoid all of the disadvantages complained of with reference to the prior art cited.

This problem is solved by the invention by means of a timing system of the type indicated at the beginning and including the characteristic features of the main claim.

The characteristics and advantages of the invention will become clearer from the following detailed description of a preferred embodiment thereof, described by way of non-limiting example with reference to the appended drawings, in which:

Figure 1 is a schematic, axial section of a single-shaft timing system formed in accordance with the present invention,

Figure 2 is an exploded, schematic view of the system of Figure 1,

Figure 3 is a sectional view of the camshaft taken on the line III-III of Figure 1,

Figure 4 is a partially-sectioned front view of the system of the previous drawings,

Figure 5 is an axial section of a variant of the variator in the single-shaft timing system of the present invention.

In the drawings, a single-shaft timing system formed in accordance with the present invention is generally indicated 1. This system comprises a camshaft 2 and a phase variator 3. The camshaft 2 carries first and second sets of cams constituted by four intake cams, indicated 4a-d and four exhaust cams, indicated 5a-d, respectively.

All of these cams are restrained axially on the camshaft 2 but only the exhaust cams 5a-d are fixed for rotation therewith, the remaining cams 4a-d being free for limited rotation, as will be explained further below. The camshaft 2 comprises two tubular half-shafts 6, 7 joined together by a central sleeve 8 and carrying first and second end sleeves 9, 10, respectively, at their axially opposite ends. The two half-shafts 6, 7 are fitted with interference in the respective sleeves 8, 9 and 10 so that, once assembled, the camshaft 2 has a unitary character.

The central sleeve 8 carries the two exhaust cams 5b and 5c as well as a cylindrical surface 11 disposed between them and having a central groove 12 and one or more radial holes 13. The surface 11 is held in a bearing 14 of the engine head on which the timing system 1 is mounted. The groove 12 and the holes 13 serve for the passage of lubricating oil from a duct in the bearing 14 towards the interior of the camshaft 2 through respective recesses 15 formed in one and/or the other of the abutting surfaces of the two half-shafts 6, 7.

The first end sleeve 9 carries the exhaust cam 5d and is fitted with interference (force-fitted) on the free end of the half-shaft 7. In addition to the cam 5d, it is possible to identify two cylindrical surfaces, indicated 16 and 17, respectively, between which there is a groove 18. The surface 16 is held in a bearing 19 of the head and the surface 17 faces an oil seal 20 concealed in the bearing 19. When the shaft 2 is mounted on the engine, the groove 18 is engaged by a plate 21 which restrains the shaft 2 axially in the respective bearings whilst allowing it to rotate.

In the embodiment of Figure 1, the second end sleeve 10 is an integral part of the phase variator 3. It is fitted with interference on the free end of the half-shaft 6 and carries the exhaust cam 5a, a flange 22 and an intermediate surface 23 between the cam and the flange. The surface 23 is held in a further bearing 24 of the engine head and has a radial hole 25 for the admission of oil under pressure for the active operation of the phase variator 3. A further cylindrical surface 26 is formed concentrically with the surface 23 for an oil seal 27 held in a seat 28 in the bearing 24. Behind the surface 26 there is a shoulder 29 for forcing the seal 27 into the seat 28 during the assembly of the shaft 2.

The camshaft 2 also comprises a pair of rotatable sleeves 30, 31 carrying the intake cams 4a, b and 4c, d, respectively. These sleeves are engaged with radial clearance on the respective free tubular portions of the two half-shafts 6, 7. Between the pairs of cams 4a, 4b and 4c, 4d are respective cylindrical surfaces 32, 33 with radial through-holes 34, 35 in which respective pins 36, 37 are inserted. The cylindrical surfaces 32, 33 are also held in respective bearings 38, 39 of the engine head. For each pin 36, 37 the corresponding half-shaft 6, 7 has a corresponding pair of slot-like holes 36a, 36b for permitting limited relative rotation between the sleeves 30, 31 and the corresponding half-shafts 6, 7. The phase variator 3 controls this rotation in the manner described below.

The variator 3 comprises a tubular housing 40 which is closed at one end by a cover 41 with a blind hole 42, and which is open at the opposite end where it carries a flange 43 extending radially outwardly. The flange 43 has slot-like holes 44 in positions corresponding to those of a similar number of threaded holes 45 in the flange 22. These flanges are clamped together as an assembly by screws 46, by means of which a pulley or similar transmission member 47 is fixed to the variator 3. It will be noted that the slot-like holes 44 permit an adjustment of the relative angular positions of the housing 40 and of the camshaft 2. An annular piston 48, slidable in the housing 40, has an internal set of teeth 49 engaged on an external set of teeth 50 of an operating shaft 51 of the variator 3. The piston 48 also has an external set of teeth 52 engaged with a corresponding internal set of teeth 53 of the housing 40. The shapes of these sets of teeth 49, 50 and 52, 53 are such that sliding of the piston on the shaft 51 corresponds, in known manner, to relative rotation between the housing 40 and the operating shaft 51. For example, one pair of sets of teeth is helical whereas the other pair is straight.

The piston 48 is urged against the cover 41 by a spring 54. A pressurized-oil supply chamber 56 is defined between the facing walls of the piston and of the cover, and a duct 55, arranged as an extension of the hole 25, opens therein. As a result, when oil is supplied to the chamber 56 under pressure, a thrust such as to overcome the resistance of the spring 54 is exerted on the piston 48 and the piston is consequently translated along the operating shaft 51, bringing about a rotation of the latter relative to the housing 40. The portion of the shaft 51 which is inside the phase variator 3 is supported with its end 60 in the blind hole 42 in the cover 41 but a predominant portion 61 extends out of the variator and is inserted coaxially in the camshaft 2 so as to be rotatable relative thereto. Two radial holes 62, 63 are formed in the portion 61 and the pins 36, 37 are driven therein so that, for each rotation of the operating shaft 51 relative to the camshaft 2, there is a corresponding identical rotation of the sleeves 30, 31 and a consequent phase variation of the intake cams 4a-d relative to the exhaust cams 5a-d. To favour the rotation of the operating shaft relative to the camshaft, lubricating oil is supplied to the space between the two through the radial holes 13, 15.

A variant of the invention is shown in Figure 5 in which details similar to those of the preceding embodiment are indicated by the same reference numerals. The variator, generally indicated 70, of this variant can be assembled independently of the camshaft 2 and can be fitted thereon by the force-fitting, on a shank 72 of the camshaft, of a collar 71 which is equivalent, from an operative point of view, to the sleeve portion 10 close to the flange 22 of the previous embodiment. The collar 71 has a shoulder 73 for the spring 54 so that the spring keeps the piston 48 in abutment with the cover 41 even when the variator 70 is separated from the camshaft 2. The initial phase-setting is adjusted by means of slots, not shown, in the pulley 47 in positions corresponding to those of the screws 46.

The assembly of the timing system of the invention is particularly simple and effective both with the use of the variator 70, which can be assembled separately, and with the use of the variator 3, and is carried out in the following manner.

First of all, the rotatable sleeves 30, 31 are fitted on the respective half-shafts 6, 7 and the camshaft assembly 2 is locked axially by the forcing of the half-shafts into the respective sleeves 8, 9 and 10. The operating shaft 51 is then inserted in the camshaft 2 coaxially. The rotatable sleeves 30, 31 are then fixed for rotation with the operating shaft 51 by means of the pins 36, 37. The phase variator 3 is then fitted. To facilitate the phase-setting of the pulley 47 relative to the camshaft 2, a pin 75 projecting from the flange 22 is intended to engage a corresponding hole (not shown) in a predetermined position in the radial flange 77 of the pulley 47, extending through a slot 76 in the flange 43. This brings about unequivocal relative positioning between the pulley 47 and the camshaft 2 whilst permitting adjustment of the angular position of the housing 40 relative to the shaft 2 by means of the slot 76.

The timing system thus assembled has a unitary structure, that is, its components are connected to one another and are ready for fitting on the head of an engine.

Structural simplicity, ease of assembly of the various components and the unitary nature of the assembled system when it is not yet fitted in an engine will be counted amongst the advantages of this technical solution.

Claims

1. A timing system of the so-called "single-shaft" type, particularly for internal combustion engines, comprising a camshaft (2) with at least first and second sets of cams (4a-d; 5a-d), a phase

variator (3) including an operating shaft (51) extending coaxially in the camshaft (2) and operatively associated therewith in order to vary the phase angle between the sets of cams (4a,-d; 5a-d), characterized in that the camshaft is unitary and the cams are restrained axially thereon, the cams of the second set (5a-d) and of the first set (4a-d) being fixed for rotation with the camshaft (2) and with the operating shaft (51), respectively, the phase variator (3) including first and second variator elements (40, 51) which can rotate relative to one another as a result of active operation of the variator, the variator elements being fixed for rotation with the camshaft 2 and with the operating shaft 51, respectively, so as to bring about a phase variation between the cams of the sets (4a-d; 5a-d) as a result of the active operation of the variator (3).

2. A system according to Claim 1, in which the first and second variator elements are a housing (40) of the variator and the operating shaft (51), respectively, the camshaft 2 being fixed for rotation with the housing 40.

3. A system according to Claim 1 or Claim 2, in which the camshaft (2) comprises at least two half-shafts (6, 7) joined together by a central sleeve (8).

4. A system according to Claim 3, in which the central sleeve (8) carries some of the cams.

5. A system according to Claim 3 or Claim 4, in which the half-shafts (6, 7) are fitted with interference in the central sleeve (8).

6. A system according to one or more of the preceding claims, in which the half-shafts (6, 7) are in turn coupled to respective end sleeves (9, 10), the sleeves together carrying all of the cams (5a-d) of the second set.

7. A system according to Claim 6, in which one of the end sleeves comprises means (22) for the attachment of the housing (40) of the variator (3).

8. A system according to one or more of the preceding claims in which the cams (4a-d) of the first set are formed on sleeves (30, 31) mounted rotatably on the half-shafts (6, 7).

9. A system according to Claim 8, in which the rotatable sleeves (30, 31) are mounted in positions between the central sleeve (8) and the end sleeves (9, 10).

10. A system according to Claim 8 or Claim 9, in which the rotatable sleeves (30, 31) are restrained axially on the half-shafts (6, 7) by the end sleeves (9, 10) and the central sleeve (8).

11. A system according to one or more of Claims 8 to 10, in which the rotatable sleeves (30, 31) are connected to the operating shaft (51) of the variator by means of pins (36, 37) driven into the rotatable sleeves and into the operating shaft and extending through slot-like holes 36a, 36b) in the corresponding half-shafts (6, 7).

12. A system according to one or more of the preceding claims in which the angular position of the housing (40) of the variator (3) relative to the camshaft is adjustable.

13. A system according to Claim 12, in which the housing carries a flange for attachment to the camshaft, the flange having slot-like holes (44).

14. A system according to one or more of the preceding claims, in which a toothed portion (50) is provided on an axial end of the operating shaft 51 of the variator (3) and a piston (48) of the variator (3) is engaged slidingly thereon.

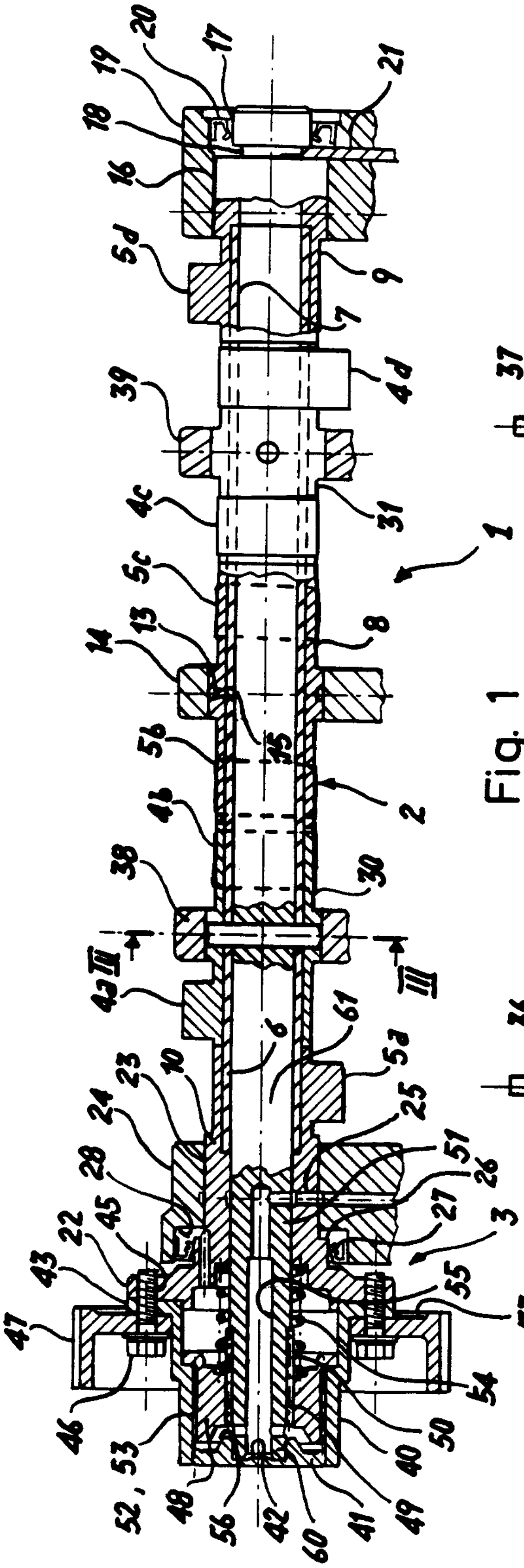

Fig. 1

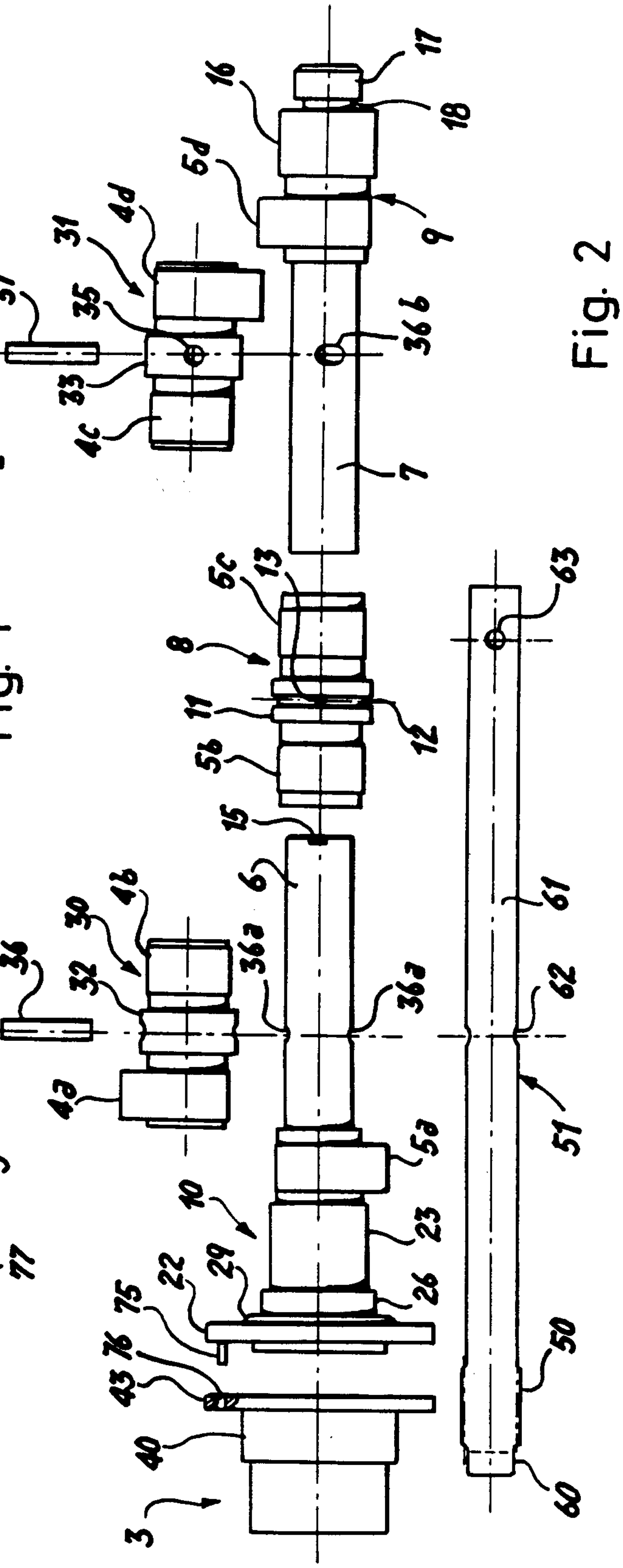

Fig. 2

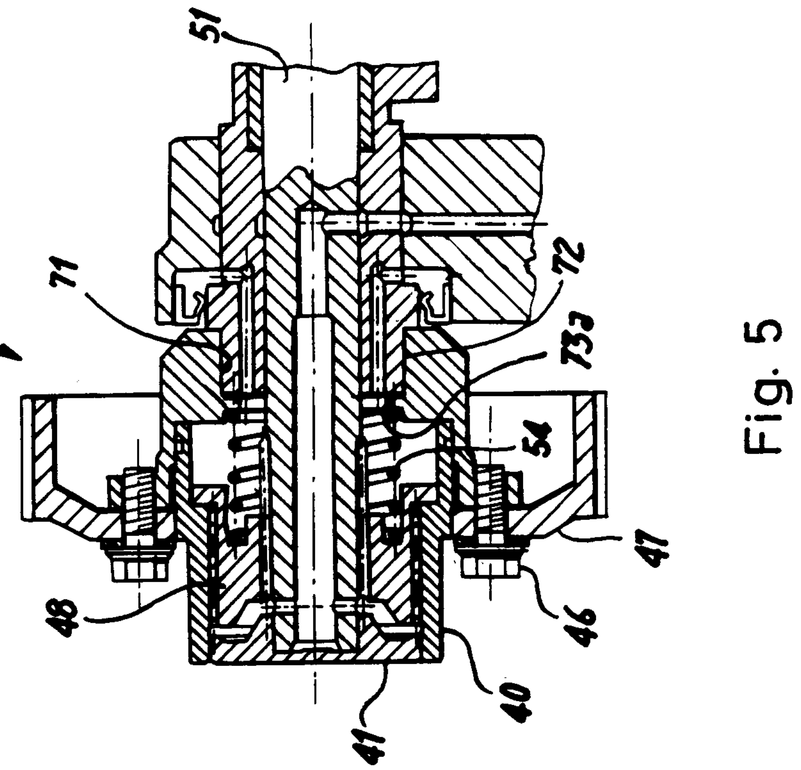

Fig. 5

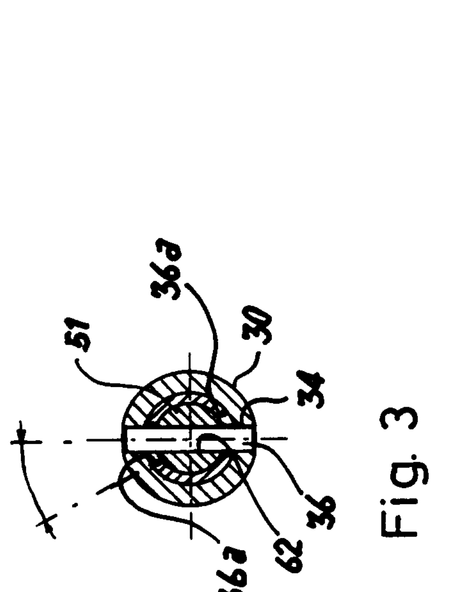

Fig. 3

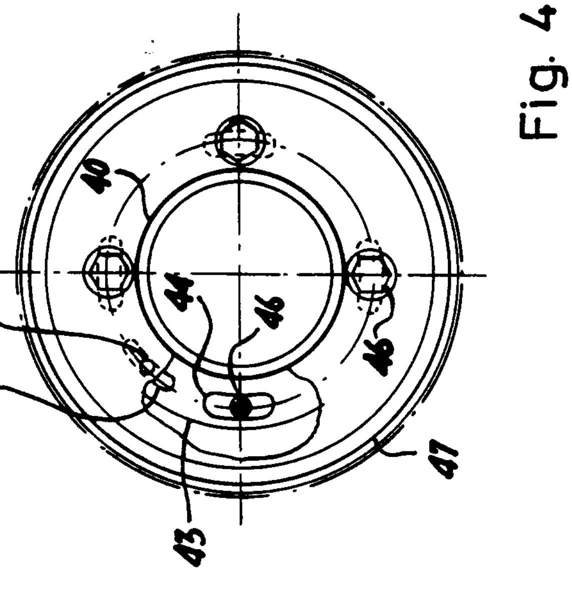

Fig. 4