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(54) **Vane-Type Camshaft Phaser**

(57) The present invention is directed towards a vane-type camshaft phaser comprising a unitized housing including a lobed stator and a vaned rotor disposed within the housing, the lobed stator and the vaned rotor defining therebetween at least one advancing chamber and at least one retarding chamber, at least one controllable fluid leakage means being provided between the at least one advancing chamber (61) and the at least one retarding chamber. The at least one controllable fluid leakage means is provided in a vane of the vaned rotor or in a lobe of the lobed stator.

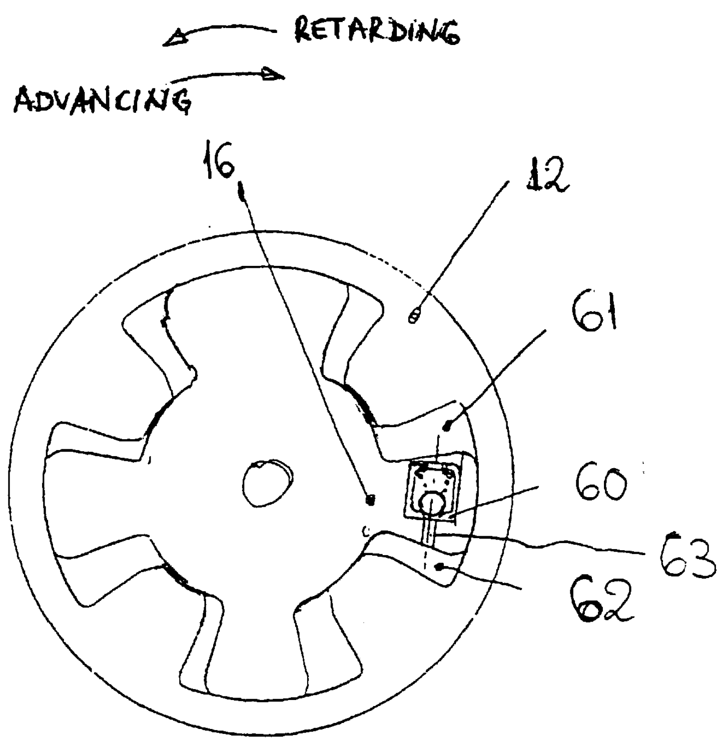

Fig. 4

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Description

Technical Field

[0001] The present invention relates in general to vane-type camshaft phasers and more particularly to vane-type camshaft phasers with means for offsetting the valve-opening-retarding frictional bias of the camshaft.

Background of the Invention

[0002] Cam phasers are well known in the automotive art as elements of systems for reducing combustion formation of nitrogen oxides (NOX), reducing emission of unburned hydrocarbons, improving fuel economy, and improving engine torque at various speeds. The terms "cam phaser" and "camshaft phaser" may be used interchangeably herein. Typically, a cam phaser employs a first element driven in fixed relationship to the crankshaft and a second element adjacent to the first element and mounted to the end of the camshaft in either the engine head or block. A cam phaser is commonly disposed at the camshaft end opposite the engine flywheel, herein referred to as the "front" end of the engine. The first element is typically a cylindrical stator mounted onto a crankshaft-driven gear or pulley, the stator having a plurality of radially-disposed inwardly-extending spaced-apart lobes and an axial bore. The second element is a vaned rotor mounted to the end of the camshaft through the stator axial bore and having vanes disposed between the stator lobes to form actuation chambers therebetween such that limited relative rotational motion is possible between the stator and the rotor. Such a phaser is known in the art as a vane-type cam phaser or a vane-type camshaft phaser.

[0003] The disposition of the rotor in the stator forms a first, or timing-advancing, array of chambers on first sides of the vanes and a second, or timing-retarding, array of chambers on the opposite sides of the vanes. The apparatus is provided with suitable porting so that hydraulic fluid, for example, engine oil under engine oil pump pressure, can be brought to bear controllably on opposite sides of the vanes in the advancing and retarding chambers. Control circuitry and valving, commonly a multiport spool valve, permit the programmable addition and subtraction of oil to the advance and retard chambers to cause a change in rotational phase between the stator and the rotor, in either the rotationally forward or backwards direction, and hence a change in timing between the pistons and the valves.

[0004] As an engine camshaft rotates, each eccentric cam lobe, in its turn, displaces a spring-loaded cam-following mechanism outwards from the axis of the camshaft to open its dedicated valve, then allows return motion of the mechanism to close the valve. Because of friction, more energy is expended in opening each valve than is recovered in closing each valve. This energy imbalance is reinforced by friction in the camshaft bearings and in camshaft driven components. Within a cam phaser, this energy imbalance is expressed as a torsional bias in the opening-retarding direction. That is, the operating equilibrium position of the rotor within the phaser appears biased in the retarding direction with reference to an anticipated position based solely on hydraulic considerations. This means that the hydraulic system driving the rotation of the rotor, in responding to a demand for advancing of the valve timing, must overcome not only the inertia of the system but also the retarding bias of the camshaft friction.

[0005] In the above vane-type camshaft phasers there is the need for offsetting or neutralizing the retarding frictional bias of the camshaft to permit compensated hydraulic operation of the phaser and, consequently, more rapid opening-advancing response of the phaser.

[0006] A device including a mechanical means for offsetting or neutralizing the retarding frictional bias of the camshaft is known from the US Patent No. 6,276,321. In particular, according to US Patent No. 6,276,321, there is provided a coil spring for biasing the cam phaser rotor towards the advance direction in order to compensate for the retarding of the frictional bias of the camshaft.

[0007] Unfortunately, the coil spring mechanical solution known US Patent No. 6,276,321 causes problems for integration into the packaging of the vane-type camshaft phaser. Furthermore, the accommodation of the coil spring in a fluidly sealed cavity increases the complexity of the vane-type camshaft phaser and thus the danger of malfunctioning. In addition, the known coil spring solution adds significant costs to the vane-type camshaft phaser, as this coil spring needs to provide for a constant spring rate over a fairly large angular travel.

Summary of the Invention

[0008] Therefore, it is an object of the present invention to provide for a vane-type camshaft phaser which can be easily integrated in a vane-type camshaft phaser.

[0009] The above object as well as further objects which will become apparent hereinafter are achieved by a vane-type camshaft phaser with controllable fluid leakage means as defined in the appended claims.

Brief Description of the Drawings

[0010] The foregoing and other objects, features, and advantages of the invention, as well as presently preferred embodiments thereof, will become more apparent from a reading of the following description, in connection with the accompanying drawings in which:

Fig. 1 is an exploded isometric view of a generic prior art camshaft phaser;

Fig. 2 is an exploded isometric view of a portion of a vane-type camshaft phaser with a coil spring for biasing the cam phaser rotor towards the advance direction in order to compensate for the retarding of the frictional bias of the camshaft as known from US Patent No. 6276321;

Fig. 3 is an axial cross-sectional view of the complete vane-type camshaft phaser shown in Fig. 2;

Fig. 4 is a top view of the rotor and the stator of vane-type camshaft phaser in an assembled state in accordance with a first embodiment of the present invention; and

Fig. 5 is a top view of the rotor and the stator of vane-type camshaft phaser in an assembled state in accordance with a second embodiment of the present invention.

Description of the Preferred Embodiments

[0011] The benefits of the invention can be more fully appreciated by examining vane-type camshaft phasers as known from the prior art.

[0012] Referring to Fig. 1, a prior art vane-type cam phaser 10 includes a stator 12 having a plurality of inwardly-extending lobes 14, and a rotor 16 having a cylindrical hub 18 and a plurality of outwardly-extending vanes 20. A plurality of timing-advancing chambers and timing-retarding chambers are formed between the rotor vanes and the stator lobes when the rotor is assembled into the stator. Axially-extending lobe seals 19 and vane seals 21 prevent hydraulic leakage between the chambers. Back plate 22, which seals the back side of stator 12, rotor 16, and the respective timing-advancing chambers and timing-retarding chambers, is attached to sprocket 24 for being rotationally driven, as by a timing chain or ribbed belt, from a crankshaft sprocket or gear in known fashion. Bore 23 in back plate 22 typically is receivable of the outer end of an engine camshaft (not shown) on which the vane-type phaser 10 may be thus mounted in known fashion. An actuable lock 26 in a recess in a vane of rotor 16 may be extended at certain times in the cam phaser operation to engage a recess in back plate 22 for preventing relative rotation between the rotor and the back plate.

[0013] Opposite back plate 22 is a cover plate 28 for sealing the front side of the phaser hydraulics analogously to back plate 22. Cover plate 28 has an axial bore 30 for receiving a formed central portion 31 of segmented target wheel 32, as shown in Fig. 1 or a threaded plug 33 as shown in Fig. 3. Bolts 34 extend through cover plate 28 and stator 12 and are secured into threaded bores 36 in back plate 22. The assembled cover plate, stator, and back plate define a unitized housing wherein rotor 16 may rotate through an axial angle sufficient to advance or retard the opening of engine valves through a predetermined angular range, typically about 30 DEG.

[0014] Referring to Figs. 2 and 3, an embodiment of a camshaft phaser in accordance with the prior art of US Patent No. 6,276,321 includes the above-listed parts. In addition, the inward-facing surface 36 of cover plate 28 is provided with an annular cavity 38 for receiving a coil spring 40. Cavity 38 preferably is separated from bore 30 by a rim 42 which is a level extension of surface 36. Cavity 38 is closed by a ring-shaped spacer 39 which fits into an annular groove 41 such that the upper surface 43 of spacer 39 is flush with surface 36.

[0015] Spring 40 comprises preferably about 1 1/2 turns and is provided at one end with an outwardly extending tang 44 which fits into a like-shaped recess 46 in surface 36 thereby rotationally anchoring spring 40 to cover plate 28 upon assembly of the phaser. The opposite end of spring 40 is formed as a second tang 48 extending axially of the phaser radially inboard of the convolutions of spring 40 through a bore 50 in spacer 39 to engage a bore 52 in rotor 16, thereby rotationally anchoring spring 40 to rotor 16 upon assembly of the phaser.

[0016] Preferably, the angular relationship between tangs 44 and 48 is such that when the phaser is assembled the valve timing is in the desired position, which may not necessarily be neutral timing. For example, for exhaust camshaft phaser applications, the desired default position ("engine-off position") may be timing-advanced. Lock mechanism 26 holds the phaser in the default position once the engine has stopped, but the rotationally-compressed or -extended bias spring helps to move the rotor to the advance position to enable the lock pin to slide into place. This can be especially beneficial at low engine speeds and high temperatures when the oil pressure may be very low.

[0017] Because tang 48 extends through spacer 39, the spacer must be able to rotate in groove 41 with the spring and rotor as the rotor turns within the stator.

[0018] According to the present invention the coil spring 40 of Fig. 2 and its receiving 38 cavity along with the sealing and holding structure are removed from the cover plate 28. In fact, the cover plate 28 may be of the design indicated in prior art Fig. 1. Instead, as indicated in Fig. 4 with reference numerals 60 and 63 at least one means for providing controlled leakage is provided in the outwardly-extending vanes 20 of the rotor 16 so as to fluidly connect an advancing chamber 61 and a retarding chamber 62 of the vane-type cam phaser 10.

[0019] While in the embodiment of Fig. 4 only one means for providing controlled leakage is shown, the person skilled in the art will appreciate that the number of valves may vary according to the flow rate (leakage rate) between the chambers. Accordingly, more than one vane may be provided with respective means for controlled leakage and/or the number of means for controlled leakage per vane may by more than one.

[0020] Preferably, according to the invention, the means for controlled leakage may be implemented by providing a channel 63 linking the advancing chamber

61 to the retarding chamber 62 and a check valve 60 integrated into the channel 63 in order to enable oil to flow unidirectionally from one of the chambers towards the other.

[0021] The check valve 60 may allow oil leakage from the retarding chamber 62 to the advancing chamber 61. Depending on the type of the valve, the check valve 60 may alternatively allow oil leakage from the advancing chamber 61 to the retarding chamber 62.

[0022] Advantageously the check valve 60 may be calibrated in order to open at a specific pressure drop.

[0023] The flow rate (leakage rate) between the chambers 61 and 62 can be adjusted by suitable calibration of the bore or opening of the check valve 60 and/or the opening of the channel 63. Leakage may be provided between several (advancing chamber/retarding chamber)-pairs, and in this case the calibration of the flow rate occurs by the number of leakages (i.e. the number of pairs). This aspect of the present invention provides for particular advantages, as the flow rate is easily adjustable according to the required degree of biasing. The person skilled in the art will appreciate that the foregoing flow rate adjustment can be achieved by each of the above described measures alone or combinations thereof. In addition, it is conceivable that the degree of opening of a variable valve is controlled by corresponding (not shown) means, so as to control the flow rate therethrough in a flexible manner.

[0024] In a second embodiment of the present invention, as shown in Fig. 5, the channel 63 with check valve 64 may be integrated into a lobe 14 of the stator 12. The number of the check valves can be varied in this case in a similar manner to the first embodiment set forth in respect to Fig. 4. In fact, all considerations on flow rate control, direction of flow etc. set forth in connection with Fig. 4 are fully applicable to the second embodiment of the invention.

[0025] The foregoing description of the invention, including a preferred embodiment thereof, has been presented for the purpose of illustration and description. It is not intended to be exhaustive nor is it intended to limit the invention to the precise form disclosed. It will be apparent to those skilled in the art that the disclosed embodiments may be modified in light of the above teachings. In particular, a person skilled in the art will readily understand that the check valve or valves may be replaced by any other suitable hydraulic means to provide for a controlled (or controllable) fluid leakage between the advancing chamber and the retarding chamber.

[0026] The embodiments described are chosen to provide an illustration of principles of the invention and its practical application to enable thereby one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. Therefore, the foregoing description is to be considered exemplary, rather than limiting, and the true scope of the invention is that described in the following claims.

[0027] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included just for the sole purpose of increasing intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. A vane-type camshaft phaser comprising a housing including a lobed stator (12) and a vaned rotor (16) disposed within the housing, the lobed stator (12) and the vaned rotor (16) defining therebetween at least one advancing chamber (61) and at least one retarding chamber (62), at least one controllable fluid leakage means (60, 63; 64, 63) being provided between the at least one advancing chamber (61) and the at least one retarding chamber (62).

2. The vane-type camshaft phaser according to claim 1, wherein the at least one controllable fluid leakage means (60, 63; 64, 63) is controllable for biasing the vaned rotor (16) towards any valve timing position.

3. The vane-type camshaft phaser according to claims 1 or 2, wherein the at least one controllable fluid leakage means (60, 63) is provided in a vane (20) of the vaned rotor (16).

4. The vane-type camshaft phaser according to claims 1 or 2, wherein the at least one controllable fluid leakage means (64, 63) is provided in a lobe (14) of the lobed stator (12).

5. The vane-type camshaft phaser according to one or more of the preceding claims, wherein the at least one controllable fluid leakage means (60, 63; 64, 63) includes a check valve (60; 64).

6. The vane -type camshaft phaser according to claim 5, wherein the check valve (60; 64) is provided in a channel (63) linking the at least one advancing chamber (61) to the at least one retarding chamber (62), the check valve (60; 64) being further adapted to enable a fluid flow unidirectionally from one of the chambers towards the other.

7. The vane-type camshaft phaser according to claim 6, wherein the check valve (60; 64) is adapted to allow fluid flow from the at least one retarding chamber (62) to the at least one advancing chamber (61).

8. The vane-type camshaft phaser according to claim 6, wherein the check valve is adapted to allow fluid flow from the at least one advancing chamber (61) to the at least one retarding chamber (62).

9. The vane-type camshaft phaser according to one or more of claims 5 to 8, wherein the check valve (60; 64) is calibrated in order to open at a specific pressure drop.

10. The vane-type camshaft phaser according to one or more of claims 1 to 9, wherein the lobed stator (12) includes a plurality of lobes (14) and the vaned rotor (16) includes a plurality of vanes (20), and wherein several ones of the lobes (14) and/or the vanes (20) include a respective controllable fluid leakage means (60, 63; 64, 63).

11. The vane-type camshaft phaser according to one or more of the preceding claims, wherein the at least one controllable fluid leakage means (60, 63; 64, 63) includes a variable valve.

12. The vane-type camshaft phaser according to one or more of claims 1 to 11, wherein the at least one controllable fluid leakage means (60, 63; 64, 63) is adapted to allow fluid flow from the at least one retarding chamber (62) to the at least one advancing chamber (61).

13. The vane-type camshaft phaser according to one or more of claims 1 to 11, wherein the at least one controllable fluid leakage means (60, 63; 64, 63) is adapted to allow fluid flow from the at least one advancing chamber (61) to the at least one retarding chamber (62).

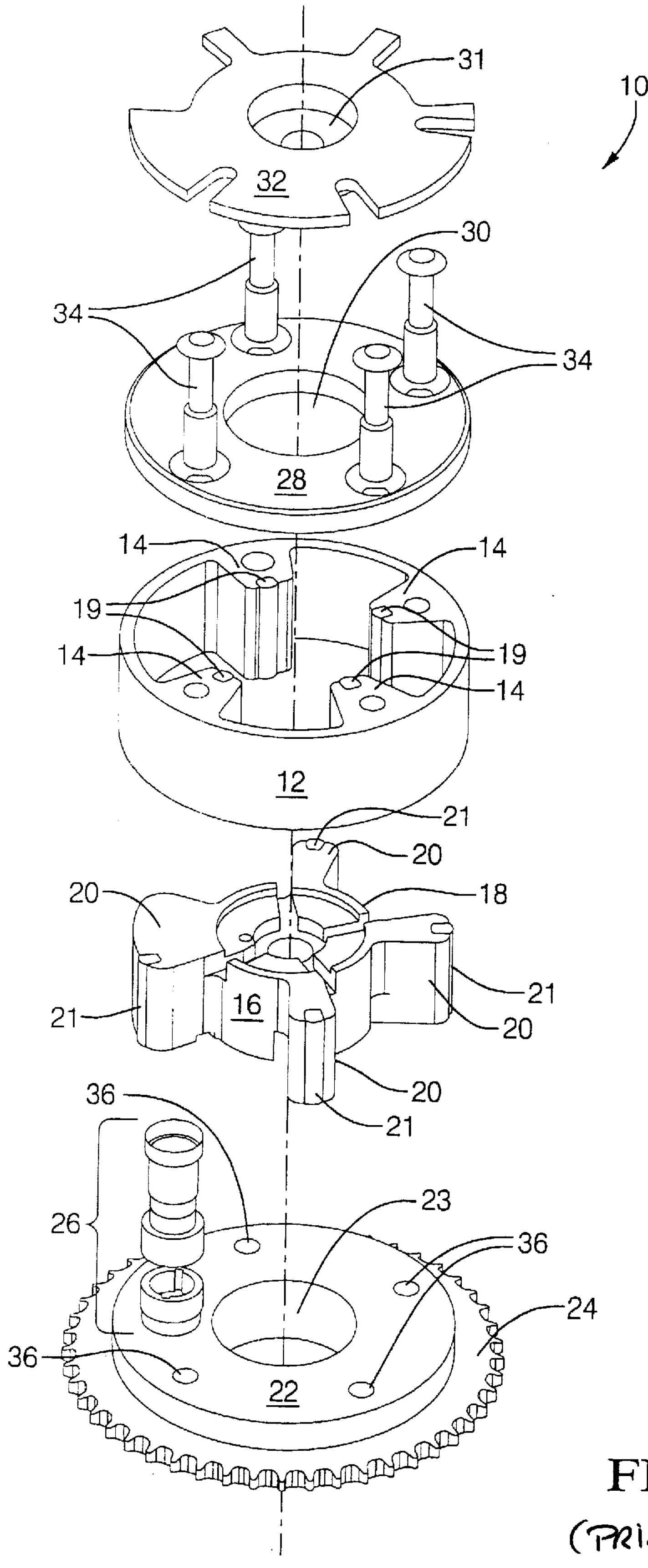

FIG. 1
(PRIOR ART)

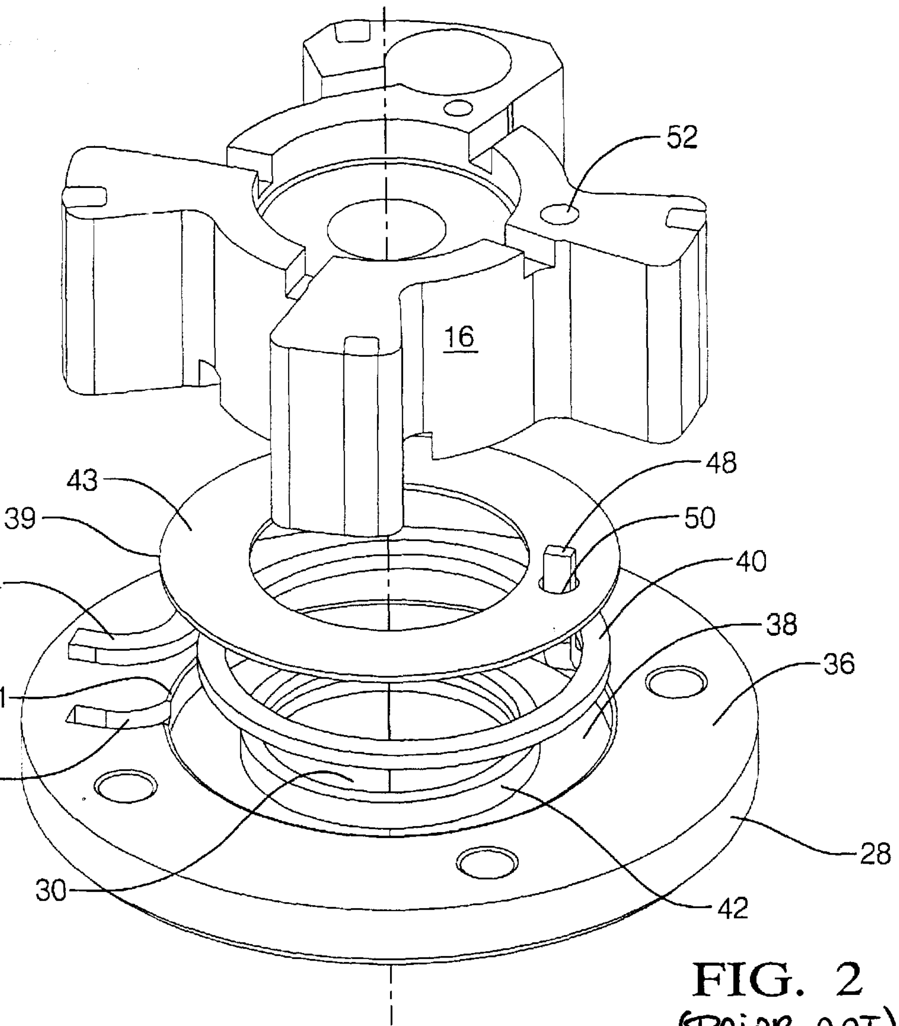

FIG. 2
(PRIOR ART)

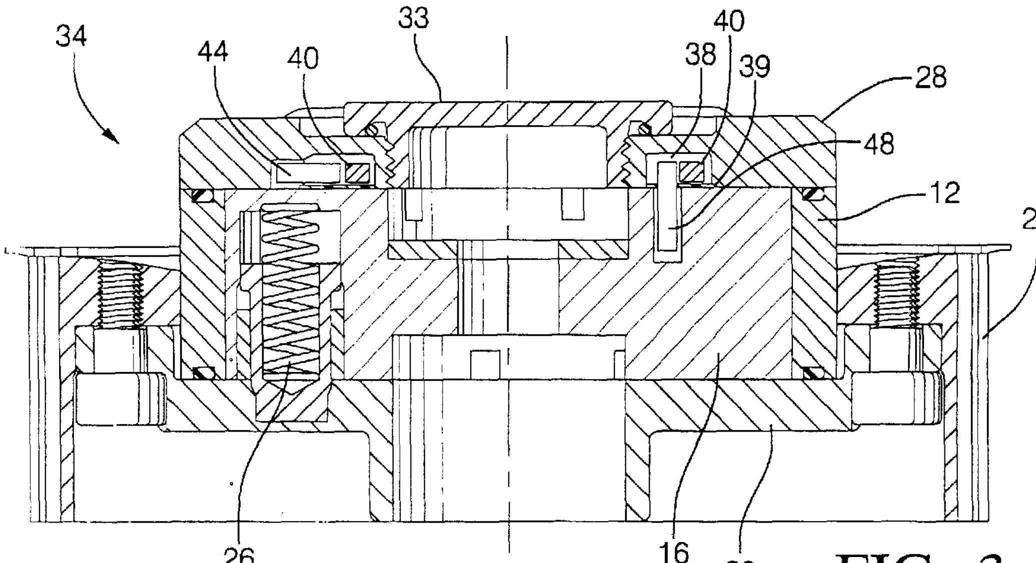

FIG. 3
(PRIOR ART)

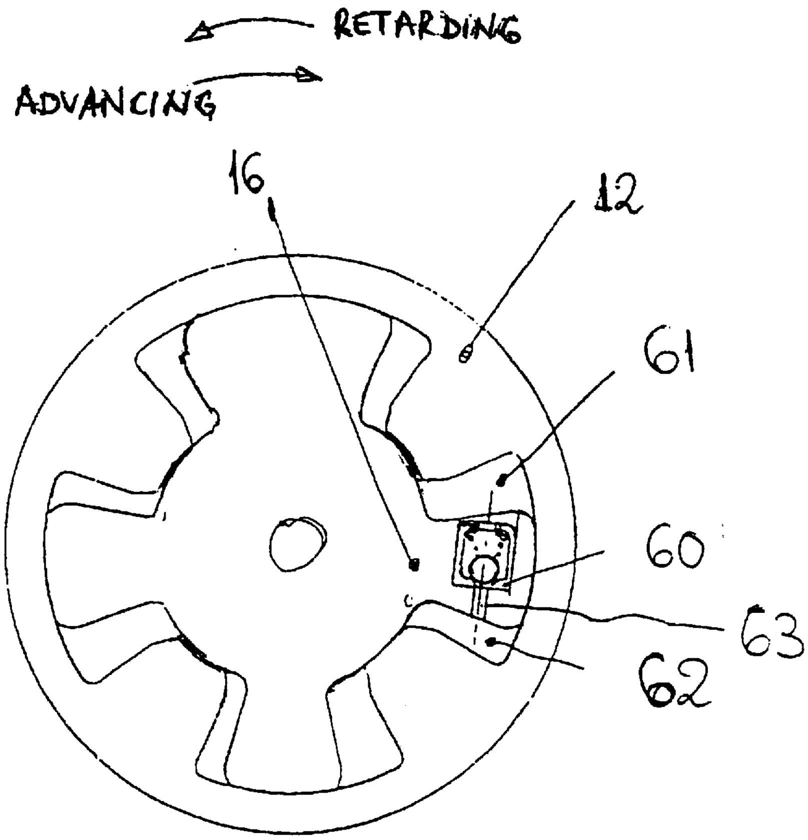

Fig. 4

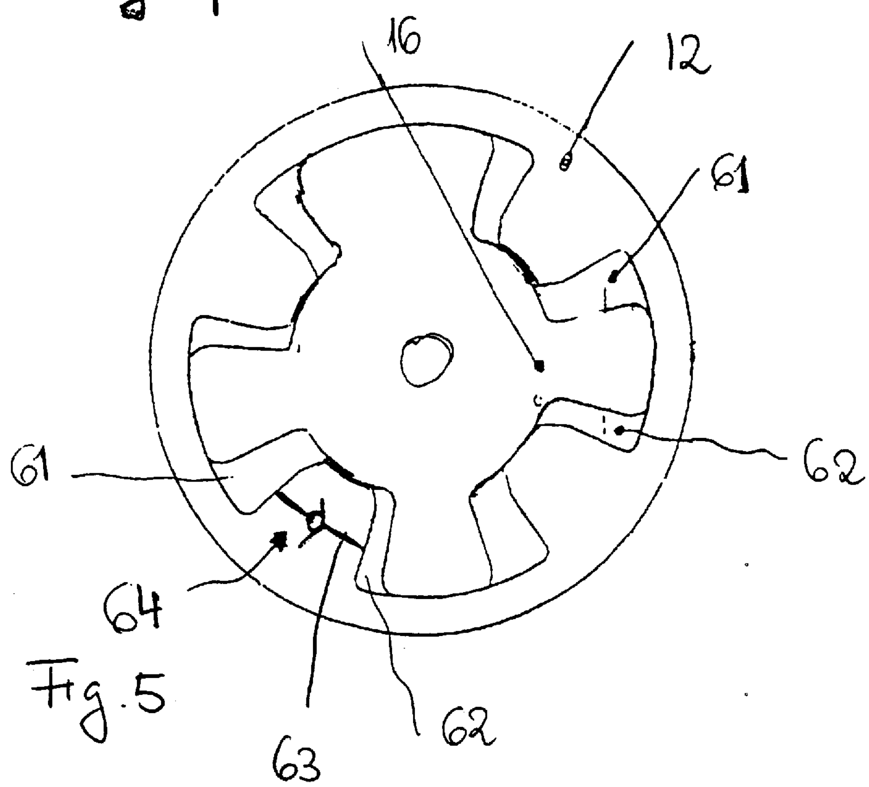

Fig. 5