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(54) VALVE TIMING CONTROL APPARATUS

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(57) ABSTRACT

Disclosed is a valve timing control apparatus capable of avoiding inadvertent realization of a locked state by effectively preventing pulsating pressure of fluid generated in association with torque variation of a cam shaft from having any effect on a fluid passageway used for lock releasing. The apparatus includes a first fluid passageway for feeding/discharging fluid to/from an advanced angle chamber, a second fluid passageway for feeding/discharging fluid to/from a retarded angle chamber, a third fluid passageway for feeding/discharging fluid to/from a locking mechanism capable of locking relative rotation between an inner rotor and an outer rotor, a first switching valve for controlling the feeding/discharging of the fluid to/from the first fluid passageway and the second fluid passageway, a second switching valve for controlling the feeding/discharging of the fluid to/from the third fluid passageway, a pump for feeding fluid to the first switching valve and the second switching valve, and a check valve for inhibiting communication of the fluid from the first switching valve to the second switching valve and allowing communication of the fluid from the second switching valve to the first switching valve.

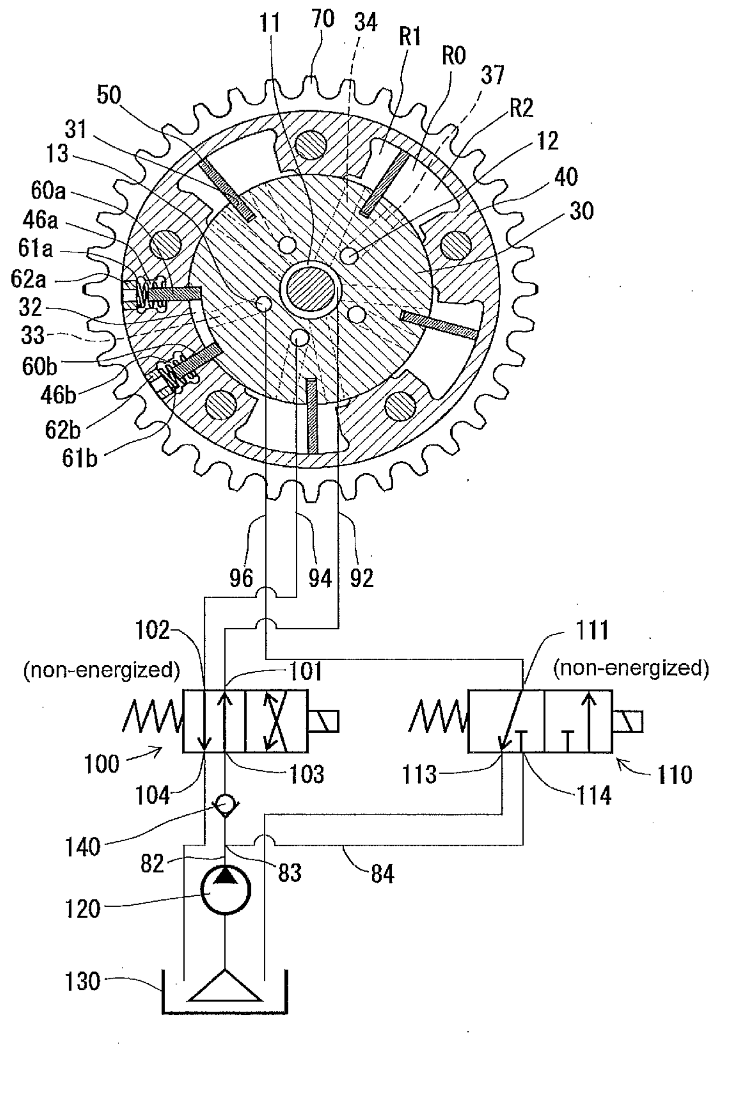


Fig.1

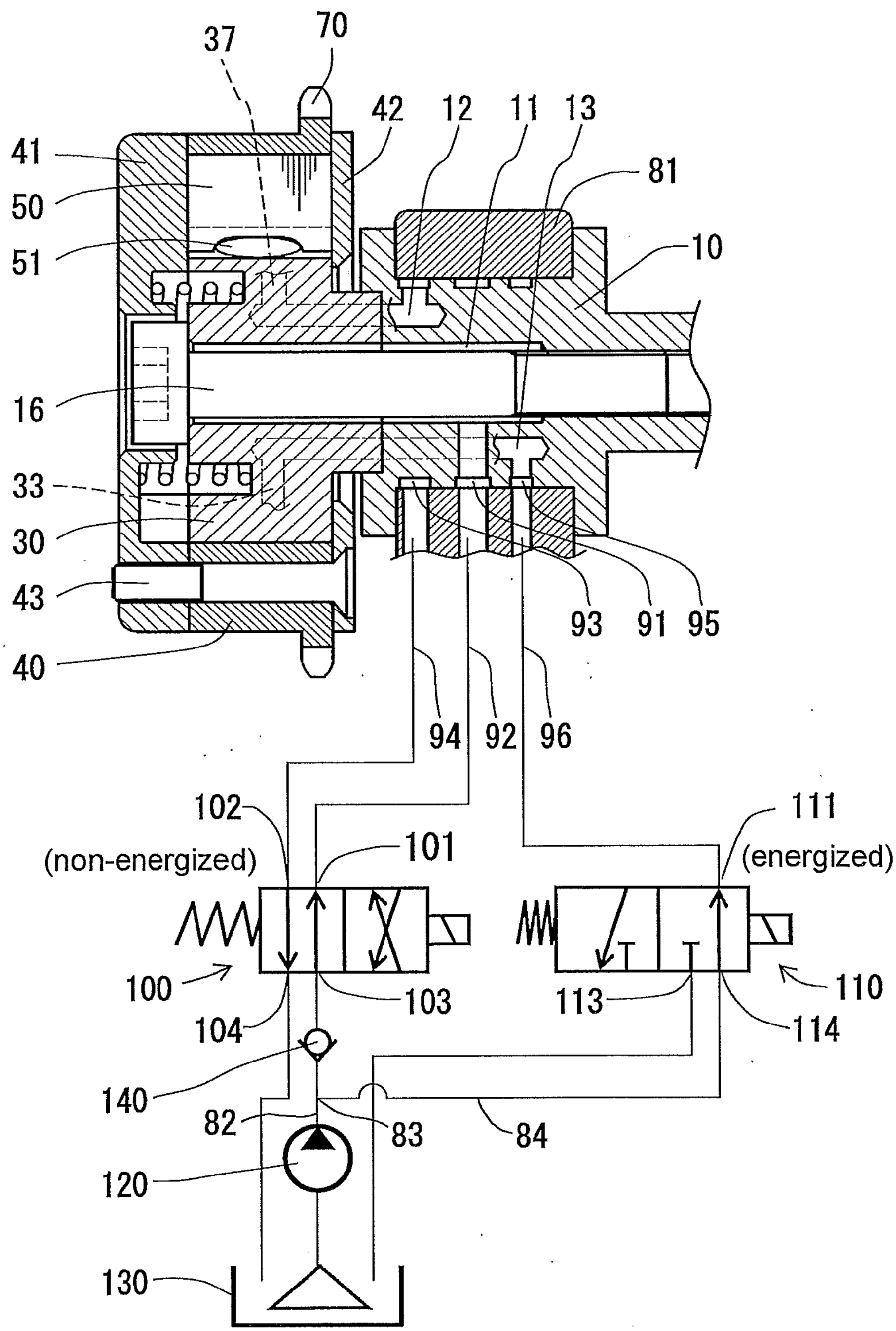

37
70
42
12
11
13
81
41
50
51
10
16
33
30
43
40
93
91
95
94
92
96
102
111
(non-energized)
101
(energized)
100
103
110
104
113
114
140
82
83
84
120
130

Fig.2

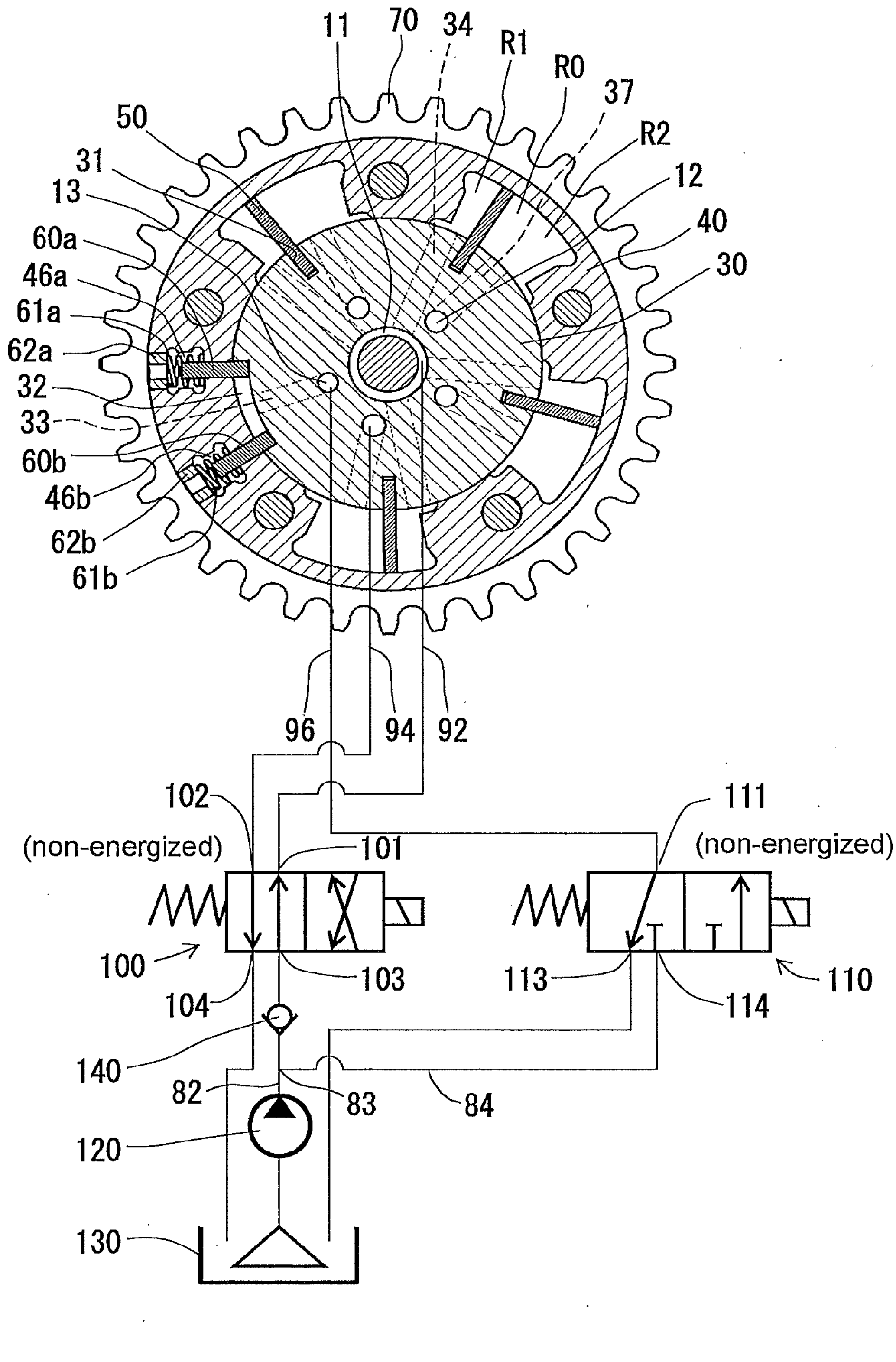
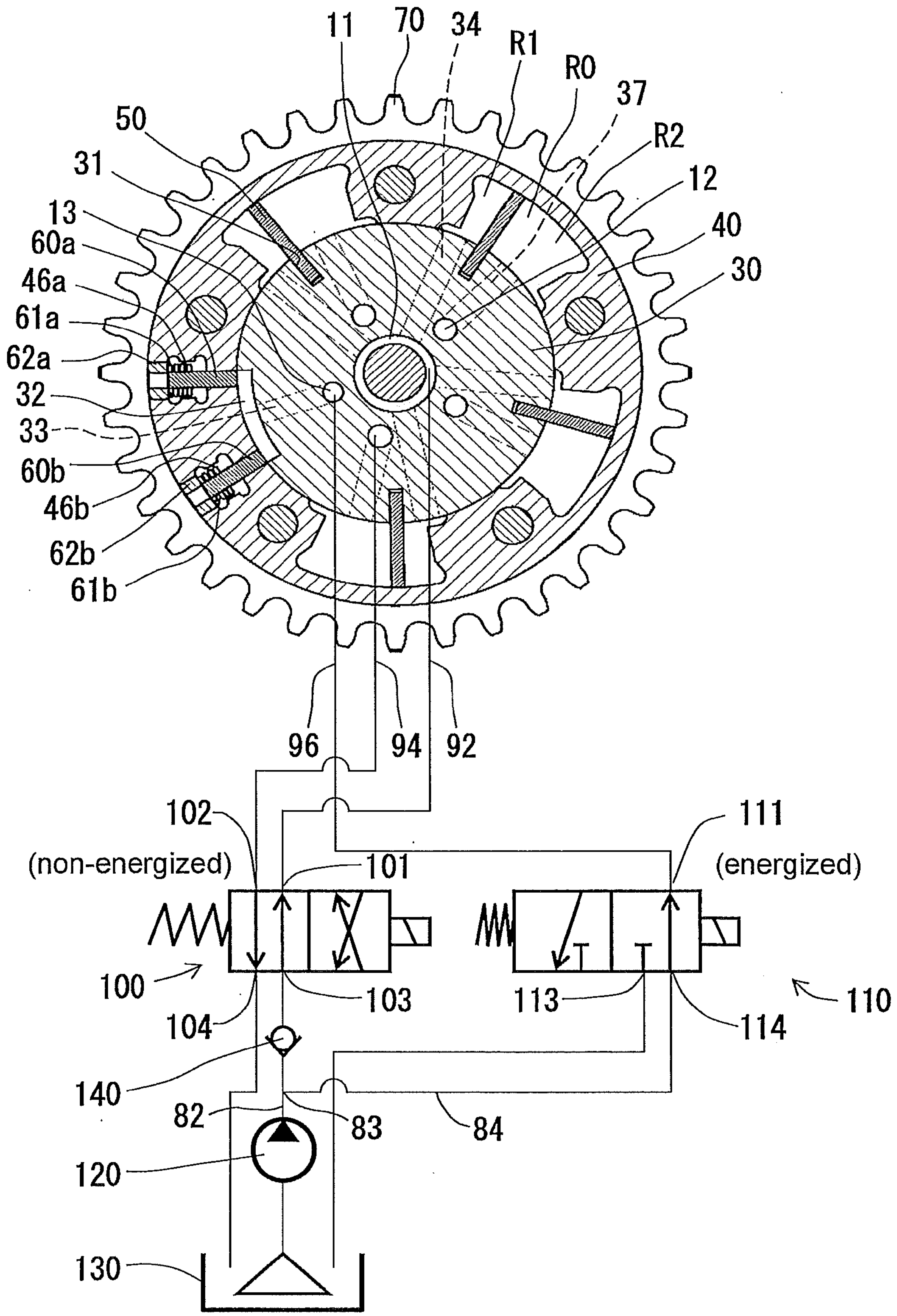
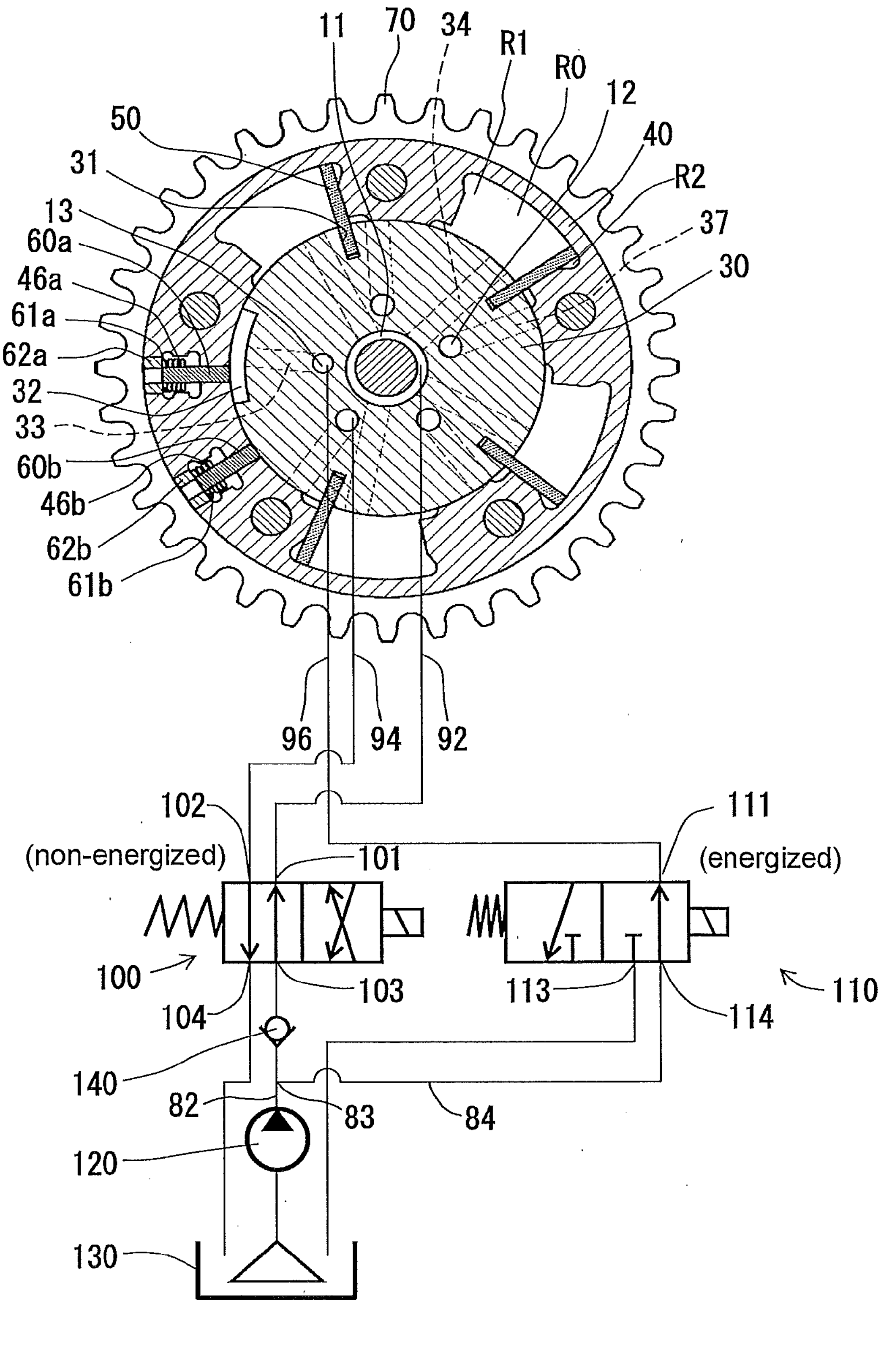

11
70
34
R1
R0
37
R2
50
31
13
12
40
60a
30
46a
61a
62a
32
33
60b
46b
62b
61b
96
94
92
102
101
111
(non-energized)
(non-energized)
100
104
103
113
114
110
140
82
83
84
120
130

Fig.3



11
70
34
R1
R0
37
R2
12
40
30
50
31
13
60a
46a
61a
62a
32
33
60b
46b
62b
61b
96
94
92
102
(non-energized)
101
111
(energized)
100
103
104
113
114
110
140
82
83
84
120
130

Fig.4


11
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34
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R0
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R2
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31
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60a
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61a
62a
32
33
60b
46b
62b
61b
96
94
92
102
(non-energized)
101
111
(energized)
100
104
103
113
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140
82
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120
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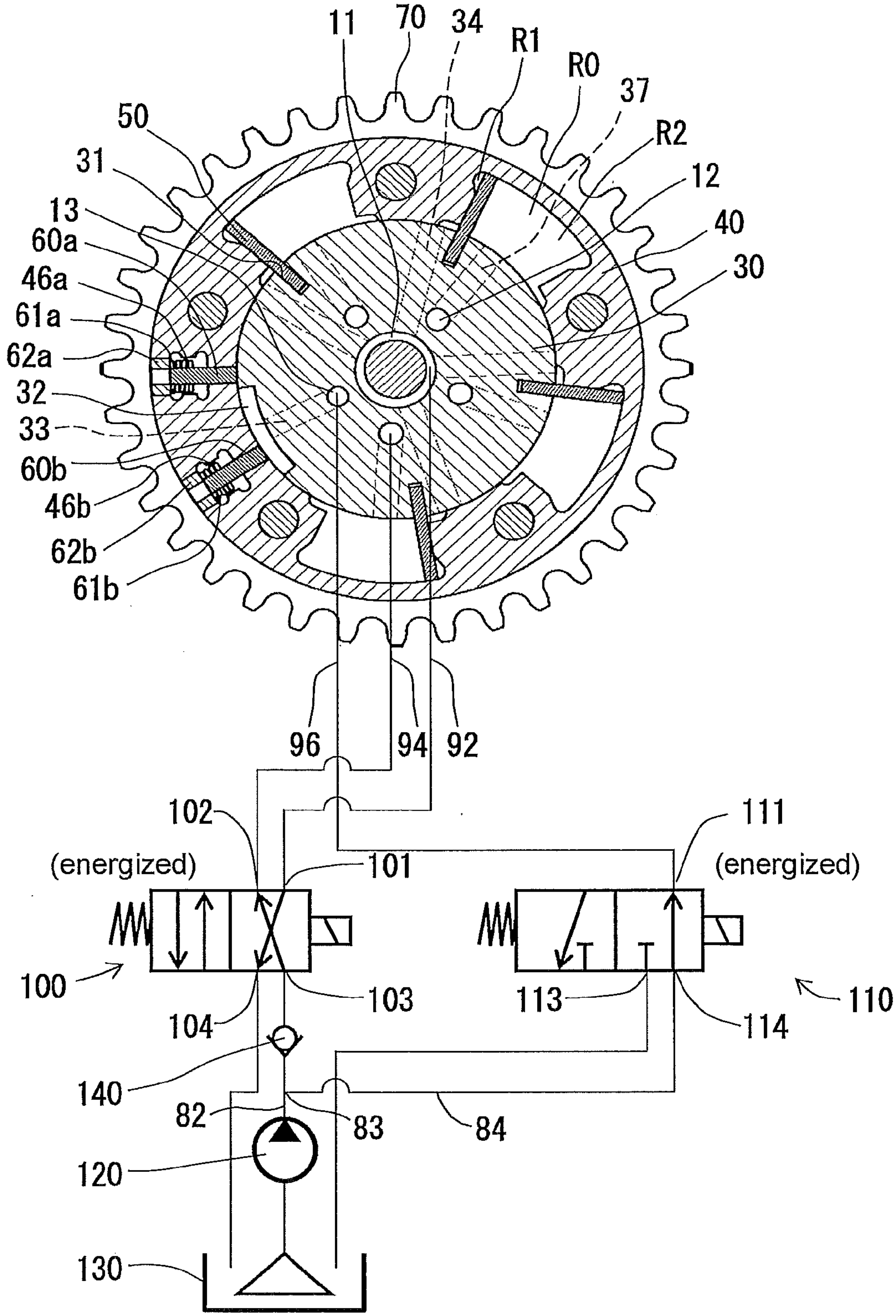
Fig.5


11
70
34
R1
R0
37
R2
12
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31
13
60a
46a
61a
62a
32
33
60b
46b
62b
61b
96
94
92
102
101
111
(energized)
(energized)
100
103
104
113
114
110
140
82
83
84
120
130

VALVE TIMING CONTROL APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a valve timing control apparatus used for controlling opening/closing timing of an exhaust valve or an intake value in a valve operated device of an internal combustion engine.

BACKGROUND ART

[0002] Conventionally, as an example of a valve timing control apparatus, there is disclosed an apparatus including a rotation transmitting member rotatably mounted on a valve opening/closing rotational shaft to be rotatable relative thereto over a predetermined range and receiving a rotational drive force from a crank pulley, a vane mounted on a rotational shaft comprised of a cam shaft and an inner rotor provided integrally therewith, a fluid pressure chamber formed between the rotational shaft and the rotation transmitting member and divided into an advanced angle chamber and a retarded angle chamber, a first fluid passageway for feeding/discharging fluid to/from the advanced angle chamber, a second fluid passageway for feeding/discharging fluid to/from the retarded angle chamber, a retracting hole formed in the rotation transmitting member for receiving therein a lock pin urged toward the rotational shaft, a receiving hole formed in the rotational shaft for receiving the head of the lock pin when the rotational shaft and the rotation transmitting member come into a predetermined phase synchronization or registry with each other, and a third fluid passageway for feeding/discharging fluid to/from this receiving hole (see e.g. Patent Document 1).

[0003] The invention described in Patent Document 1 provides a first switching valve for controlling feeding/discharging of the fluid to/from the first fluid passageway and the second fluid passageway and a second switching valve for controlling feeding/discharging of the fluid to/from the third fluid passageway, so that the feeding/discharging of the fluid to/from the third fluid passageway may take place independently of the feeding/discharging of the fluid to/from the first and second fluid passageways.

PRIOR ART DOCUMENT

Patent Document

[0004] Patent Document 1: Japanese Patent Application "Kokai" No. 10-220207

SUMMARY OF THE INVENTION

Object to be Achieved by Invention

[0005] However, with such valve timing control apparatus as above, torque variation which the cam shaft receives from the intake valve or the exhaust valve when this intake or exhaust valve is driven to be opened or closed is transmitted to the vane, which results in application of torque variation alternately to the inner rotor to the retarded angle side and to the advanced angle side, relative to the outer rotor.

[0006] For instance, let us suppose a case when fluid is fed to the advanced angle chamber to vary the phase of the cam shaft relative to the crank shaft from the retarded angle side to a target phase on the advanced angle side. In this case, if the inner rotor is exposed to torque variation to the retarded angle side, this torque variation results in displacement of the inner rotor to the direction for decreasing the volume of the advanced angle chamber. As a result, the fluid inside the advanced angle chamber is subject to an outflowing force from this advanced angle chamber. Conversely, if the inner rotor is exposed to torque variation to the advanced angle side, this torque variation results in displacement of the inner rotor to the direction for increasing the volume of the advanced angle chamber. As a result, the advanced angle chamber generates a force to draw in the fluid. Pulsating displacements due to such torque variations described above will occur conspicuously in particular when the pressure of the fluid fed from the pump is low. And, this phenomenon occurs also in the course of switchover of the phase of the cam shaft relative to the crank shaft to a target phase on the retarded angle side from the advanced angle side.

[0007] If the pulsating pressure of fluid due to torque variation of the cam is applied to the locking mechanism from the advanced angle chamber and/or the retarded angle chamber through the first fluid passageway and/or the second fluid passageway, the first switching valve, the second switching valve and the third fluid passageway, a pressure drop due to the pulsating pressure may lower a lock released state maintaining pressure of the lock mechanism, as a result of which the locking mechanism may be brought into its locking state inadvertently.

[0008] In the case of a valve timing control apparatus of the so-called "intermediate locking type" configured such that the relative phase between the rotational shaft and the rotation transmitting member is locked at an intermediate phase between the most advanced angle phase and the most retarded angle phase, a lock pin provided as a restricting member for the locking mechanism pivots about the outer periphery of a receiving hole while this lock pin is being accommodated within a retracting hole. Under this condition, if there occurs pulsation in the fluid pressure used for holding the lock pin in the receiving hole, the pressure pulsation will cause repeated exit and entry (retraction) of the pin from/into the retracting hole. As a result, the lock pin may accidentally enter the receiving hole, thus providing a locked state.

[0009] The object of the present invention is to provide a valve timing control apparatus capable of avoiding inadvertent realization of a locked state by effectively preventing pulsating pressure of fluid generated in association with torque variation of a cam shaft from having any effect on a fluid passageway for lock releasing, thereby to restrict occurrence of inadvertent realization of the locked state during driving of the internal combustion engine.

Solution for Accomplishing the Object

[0010] According to the first characterizing feature of a valve timing control apparatus, the apparatus comprises:

[0011] an inner rotor rotatable in unison with a valve opening/closing rotational shaft of an internal combustion engine;

[0012] an outer rotor mounted to be rotatable relative to said inner rotor over a predetermined range and rotatable by a force transmitted thereto from a crank shaft of the internal combustion engine;

[0013] a fluid pressure chamber formed between said inner rotor and said outer rotor and divided by a partitioning portion into an advanced angle chamber and a retarded angle chamber;

[0014] a first fluid passageway for feeding/discharging fluid to/from said advanced angle chamber;

[0015] a second fluid passageway for feeding/discharging fluid to/from said retarded angle chamber;

[0016] a locking mechanism capable of locking relative rotation between said inner rotor and said outer rotor;

[0017] a third fluid passageway for feeding fluid to said locking mechanism to cause this locking mechanism to release its locking state and discharging fluid from said locking mechanism to cause this locking mechanism to provide the locking state;

[0018] a first switching valve for controlling the feeding/discharging of the fluid to/from said first fluid passageway and said second fluid passageway;

[0019] a second switching valve for controlling the feeding/discharging of the fluid to/from said third fluid passageway;

[0020] a pump for feeding fluid to said first switching valve and said second switching valve; and

[0021] a check valve for inhibiting communication of the fluid from said first switching valve to said second switching valve and allowing communication of the fluid from said second switching valve to said first switching valve.

[0022] With the characterizing feature described above, there is provided a check valve that inhibits communication of the fluid from the first switching valve to the second switching valve and allows communication of the fluid from the second switching valve to the first switching valve. Therefore, it is possible to prevent pulsating pressure that occurs in association with torque variation in the rotational shaft from being transmitted from the first switching valve to the second switching valve. Hence, stable fluid free from the influence of the pulsating pressure can be fed from the second switching valve to the third fluid passageway. As a result, the locking mechanism can effectively maintain its lock-released state by this stable fluid pressure and the inadvertent locking of the mechanism can be avoided.

[0023] According to the second characterizing feature, the fluid fed from said pump can be fed to said first switching valve with bypassing said second switching valve and can be fed to said second switching valve with bypassing said first switching valve.

[0024] With the characterizing feature described above, passage resistance of the first switching valve and the passage resistance of the second switching valve do not affect each other. Hence, controlling operation of rotational phase and controlling operations of the locking mechanism can be effected more speedily.

[0025] According to the third characterizing feature, the fluid fed from said pump can be fed to said first switching valve through said check valve and can be fed to said second switching valve with bypassing said check valve.

[0026] With the characterizing feature described above, since the check valve is interposed between the pump and the first switching valve, it is possible to prevent pulsating pressure of the fluid occurring due to torque variation in the rotational shaft from being transmitted to the pump. Therefore, the pulsating pressure will not affect the second switching valve via the pump. As a result, the locking mechanism can effectively maintain its lock-released state by this even more stable fluid pressure.

[0027] According to the fourth characterizing feature of the invention, the apparatus further comprises:

[0028] a first connecting passageway for connecting said pump to said first switching valve; and

[0029] a second connecting passageway for connecting a branching point of said first connecting passageway to said second switching valve;

[0030] wherein said check valve is disposed between said branching point and said first switching valve.

[0031] With the characterizing feature described above, passage resistance of the first switching valve and the passage resistance of the second switching valve do not affect each other. Hence, controlling operation of rotational phase and controlling operations of the locking mechanism can be effected more speedily. At the same time, the pulsating pressure does not affect the second switching valve via the pump. As a result, the locking mechanism can effectively maintain its lock-released state by this even more stable fluid pressure.

[0032] According to the fifth characterizing feature of the present invention, an aperture area of said check valve when the fluid is being fed from said pump to said first switching valve is greater than a passageway aperture area of said first connecting passageway.

[0033] Normally, presence of a check valve within a passageway in which fluid flows provides a passageway resistance, so that an amount of fluid needed for relative rotational movement between the inner rotor and the outer rotor may not be fed speedily to the fluid pressure chamber. With the inventive feature described above, since the aperture area of the check valve when the fluid is being fed from the pump to the first switching valve is greater than a passageway aperture area of the first connecting passageway, the presence of the check valve does not hinder speedy supply of the fluid to the fluid pressure chamber.

[0034] According to the sixth characterizing feature of the present invention, the passageway aperture area of said first connecting passageway is greater than the passageway aperture area of said second connecting passageway.

[0035] At the time of a normal advanced/retarded angle control operation, the locking mechanism is maintained under its lock-released state, so the second connecting passageway is maintained under its fluid flowing state. On the other hand, there occurs constant and frequent change in the fluid flowing condition in the first connecting passageway since this first connecting passageway is used for switching over between the advanced angle control and the retarded angle control. Therefore, there exists higher need to supply fluid to the first connecting passageway more readily than to the second connecting passageway. With the characterizing feature described above, since the passageway aperture area of the first connecting passageway is made greater than the passageway aperture area of the second connecting passageway, fluid can be fed more readily to the first connecting passageway, so that the advanced angle control and the retarded angle control can be effected speedily.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. **1** is a general construction diagram showing an embodiment of a valve timing control apparatus relating to the present invention,

[0037] FIG. **2** is a general construction diagram showing the valve timing control apparatus under its locking state,

[0038] FIG. **3** is a general construction diagram showing the valve timing control apparatus under its lock-releasing state,

[0039] FIG. **4** is a general construction diagram showing the valve timing control apparatus under its most advanced angle state, and

[0040] FIG. **5** is a general construction diagram showing the valve timing control apparatus under its most retarded angle state.

MODES OF EMBODYING THE INVENTION

[0041] Next, embodiments of the present invention will be described with reference to the accompanying drawings. A valve timing control apparatus of the invention shown in FIG. **1** and FIG. **2** includes a driven rotational body consisting essentially of a cam shaft ("rotational shaft") **10**, an inner rotor **30** and vanes (partitioning portions) **50** attached to the inner rotor **30**, and a driving rotational body consisting essentially of an outer rotor **40** rotatably mounted on the driven rotational body to be rotatable relative thereto over a predetermined range, lock plates **60***a*, **60***b*, a timing sprocket **70**, etc. The outer periphery of the cam shaft **10** is rotatably supported by a cylinder head **81**. Further, as well-known, the timing sprocket **70** is configured to receive a rotational force in the clockwise direction in FIG. **2** from a crank shaft (not shown) via a timing chain (not shown).

[0042] The cam shaft **10** includes a cam (not shown) which per se is well known, for opening/closing an intake valve (not shown) or an exhaust valve (not shown). As shown in FIG. **1** and FIG. **2**, inside the cam shaft **10**, there are formed an advanced angle passageway **11**, a retarded angle passageway **12** and a pilot passageway **13** extending along the axial direction. The advanced angle passageway **11** is formed within an attaching hole for an attaching bolt **16** provided in the cam shaft **10**, and this passageway **11** is connected to a connection port **101** of a first switching valve **100** via an annular passageway **91** and a connecting passageway **92** provided on the outer peripheral side of the supported portion of the cam shaft **10**. The retarded angle passageway **12** is connected to a connection port **102** of the first switching valve **100** via an annular passageway **93** and a connecting passageway **94** also provided on the outer peripheral side of the supported portion of the cam shaft **10**. The pilot passageway **13** is connected to a connection port **111** of a second switching valve **110** via an annular passageway **95** and a connecting passageway **96** also provided on the outer peripheral side of the supported portion of the cam shaft **10**.

[0043] The first switching valve **100** is controlled for its switching operations by a controller (not shown). Under the condition shown in FIG. **1** and FIG. **2** wherein the valve **100** is switched to an angle advanced position (energized state), a supply port **103** connected to an oil pump **120** via a check valve **140** is connected and communicated to the connection port **101** and also the connection port **102** is connected and communicated to an exhaust port **104** connected to an oil pan **130**. Further, under the condition (non-energization) wherein the valve **100** is switched to the most retarded angle position shown on the right hand in the figure, the supply port **103** is connected and communicated to the connection portion **102** and also the connection port **101** is connected and communicated to the exhaust port **104**.

[0044] Therefore, under the advanced angle position state described above, an amount of oil is fed from the oil pump **120** via the check valve **140** to the advanced angle passageway **11** and also an amount of oil is discharged from the retarded angle passageway **12** to the oil pan **130**. On the other hand, under a state of retarded angle position, an amount of oil is fed from the oil pump **120** via the check valve **140** to the retarded angle passageway **12** and also an amount of oil is discharged from the advanced angle passageway **11** to the oil pan **130**.

[0045] The second switching valve **110** is controlled for its switching operations by the controller (not shown). Under the condition shown in FIG. **1** wherein the valve **110** is switched to the feeding position (energized state), the connection port **111** is connected and communicated to the supply port **114** connected to the oil pump **120** and at the same time, its communication to an exhaust port **113** connected to the oil pan **130** is blocked. Further, under the condition shown in FIG. **2** wherein the valve **110** is switched to the exhausting position (non-energized state), the connection port **111** is connected and communicated to the exhaust port **113** whereas the supply port **114** is blocked. Therefore, under this supplying position condition, oil is supplied to the pilot passageway **13** and under the exhausting position condition, oil is discharged through the pilot passageway **13** to the oil pan **130**.

[0046] The inner rotor **30** is fixedly and integrally attached to the cam shaft **10** by the bolt **16** and includes vane grooves **31** for allowing attachment of the four respective vanes **50** along the radial direction. Further, the inner rotor **30** includes also a receiving groove **32**, a connecting passageway **33** connecting the bottom of the receiving groove **32** to the pilot passageway **13**, a connecting passageway **34** connecting an advanced angle chamber **R1** sectioned by each vane **50** and the advanced angle passageway **11** and a connecting passageway **37** connecting a retarded angle chamber **R2** sectioned by each vane **50** and the retarded angle passageway **12**. Incidentally, each vane **50** is urged in the radially outward direction by means of a spring **51** mounted on the bottom of the vane groove **31**. The receiving groove **32** is a groove for receiving a head of the lock plate **60***a*, **60***b* by a predetermined engagement amount under the condition shown in FIG. **2**, i.e. the condition wherein the relative phases of the driven rotational body such as the cam shaft **10**, the inner rotor **30**, etc. and the driving rotational body such as the outer rotor **40**, the timing sprocket **70**, etc. come into synchronization or registry with each other at a predetermined phase (an intermediate phase between the most advanced angle phase and the most retarded angle phase suitable for startup of the internal combustion engine).

[0047] The outer rotor **40** is assembled to the outer periphery of the inner rotor **30** to be rotatable relative thereto over a predetermined range. And, on opposed sides of the outer rotor **40**, a front plate **41** and a rear plate **42** are integrally fastened by means of a bolt **43**. Further, in the outer rotor **40**, there are formed, by the inner rotor **30**, a plurality of operational chambers **R0** each of which accommodates the vane **50** corresponding thereto and which is divided into an advanced angle chamber **R1** and a retarded angle chamber **R2**. Still further, in the outer rotor **40** along its radial direction, there are formed retracting grooves **46***a*, **46***b* for accommodating the lock plates **60***a*, **60***b* and springs **61***a*, **61***b* for urging these plates **60***a*, **60***b* toward the inner rotor **30**.

[0048] The lock plates **60***a*, **60***b* are engaged in the retracting grooves **46***a*, **46***b* to be movable along the radial direction of the outer rotor **40** and are urged by the springs **61***a*, **61***b* toward the inner rotor **30**. The springs **61***a*, **61***b* are compression springs interposed between the lock plates **60***a*, **60***b* and retainers **62***a*, **62***b* and these retainers **62***a*, **62***b* are fixedly assembled to the outer rotor **40**.

[0049] Next, operations of the valve timing control apparatus having the above-described construction of the instant embodiment will be described. At the time of startup of the internal combustion engine, the engine is started up under the condition shown in FIG. **2**, that is, the condition wherein the heads of the lock plates **60***a*, **60***b* are engaged and locked within the receiving grooves **32** at a predetermined phase suitable for startup of the internal combustion engine. Upon startup of the internal combustion engine, the oil pump **120** is driven to start feeding of an amount of oil. The oil discharged from the oil pump **120** is supplied via the check valve **140** from the supply port **103** of the first switching valve **100** through the connection port **101**, the connecting passageway **92**, the annular passageway **91**, the advanced angle passageway **11**, the connecting passageway **34** to the advanced angle chamber R**1**. On the other hand, an amount of oil fed from the oil pump **120** to the second switching valve **110** is not supplied to the pilot passageway **13** because the supply port **114** of the second switching valve **110** is currently blocked, so a locking state is maintained.

[0050] After the startup of the internal combustion engine, once the second switching valve **110** is energized by a signal from a controller (not shown), as shown in FIG. **3**, oil discharged from the oil pump **120** is supplied from the supply port **114** of the second switching valve **110** through the connection port **111**, the connecting passageway **96**, the annular passageway **95**, the pilot passageway **13** and the connecting passageway **33** to the receiving groove **32**. Upon this supply of oil to the receiving groove **32**, the lock plates **60***a*, **60***b* are pushed radially outward against the springs **61***a*, **61***b* to move out of the receiving grooves **32** and then are retracted into the retracting grooves **46***a*, **46***b* respectively. In this way, the locking state by the lock plates **60***a*, **60***b* is released, whereby the driven rotational body or components such as the cam shaft **10**, the inner rotor **30**, the vanes **50**, etc. become rotatable relative to the driving rotational body such as the outer rotor **40**, etc.

[0051] Further, under the condition shown in FIG. **3** wherein the locking by the lock plates **60***a*, **60***b* is released, if an amount of oil is supplied from the oil pump **120** through the first switching valve **100**, the advanced angle passageway **11**, etc. into the advanced angle chamber R**1**, an amount of oil is discharged from the retarded angle chamber R**2** through the retarded angle passageway **12** and the switching valve **100**, etc. to the oil pan **130**. In response to this, the driven rotational body including the cam shaft **10**, the inner rotor **30** and the vanes **50**, etc. is rotated clockwise in FIG. **3** relative to the driving rotational body including the outer rotor **40**, etc., thus providing a condition shown in FIG. **4**, i.e. the condition of the most advanced angle wherein the volume of the retarded angle chamber R**2** is rendered minimum.

[0052] Further, under the most advanced angle condition shown in FIG. **4**, if the first switching valve **100** is energized by a signal from the controller (not shown), as shown in FIG. **5**, the amount of oil discharged from the oil pump **120** is supplied via the check valve **140** from the supply port **103** of the first switching valve **100** through the connection port **102**, the connecting passageway **94**, the annular passageway **93**, the retarded angle passageway **12** and the connecting passageway **37** to the retarded angle chamber R**2**. On the other hand, an amount of oil is discharged from the advanced angle chamber R**1** through the advanced angle passageway **11**, the switching valve **100**, etc. into the oil pan **130**. In response to this, the driven rotational body including the cam shaft **10**, the inner rotor **30** and the vanes **50**, etc. is rotated counterclockwise in FIG. **4** relative to the driving rotational body including the outer rotor **40**, etc., thus providing a condition shown in FIG. **5**, i.e. the condition of the most retarded angle wherein the volume of the advanced angle chamber R**1** is rendered minimum.

[0053] During driving of the internal combustion engine, in accordance with the operational conditions of the internal combustion engine, the valve opening/closing timing is controlled to an optimal phase as shuttling between the most advanced angle state and the most retarded angle state. In this, in the case of transition from the most advanced angle state shown in FIG. **4** to the most retarded angle state shown in FIG. **5**, the condition of the lock plate **60***a* accommodated in the retracting groove **46***a* is maintained. Conversely, in the case of transition from the most retarded angle state shown in FIG. **5** to the most advanced angle state shown in FIG. **4**, the condition of the lock plate **60***b* accommodated in the retracting groove **46***b* needs to be maintained.

[0054] In the instant embodiment, in the connecting passageway between the first switching valve **100** for controlling feeding/discharging of oil to/from the advanced angle passageway **11** and the retarded angle passageway **13** and the oil pump **120** for discharging oil, there is incorporated the check valve **140** which allows communication of oil to the first switching valve **100** and inhibits (checks) communication of oil to the oil pump **120**. And, the second switching valve **110** for controlling feeding/discharging of oil to/from the pilot passageway **13** is connected to the oil pump **120** via the second connecting passageway **84** branched from a branching point **83** of the first connecting passageway **82** connecting between the oil pump **120** and the check valve **140**. Therefore, by the check valve **140**, pulsating pressure of oil that occurs due to torque variation in the cam shaft **10** can be prevented from being transmitted from the first switching valve **100** to the oil pump **120**. Further, since the second switching valve **110** is supplied with oil through the second connecting passageway **84** branched from the first connecting passageway **82** connecting between the oil pump **120** and the check valve **140**, the second switching valve **110** is free from any effect of the pulsating pressure of oil that occurs due to torque variation in the cam shaft **10**. So that, the oil can be supplied in a stable manner from this second switching valve **110** to the pilot passageway **13**. As a result, the stable oil can be supplied to the receiving groove **32**, so that the condition of the lock plates **60***a*, **60***b* being accommodated within the retracting grooves **46***a*, **46***b* can be maintained, thereby to prevent occurrence of inadvertent locking.

[0055] In order to reduce the effect of passageway resistance due to the presence of the check valve **140** so as to allow speedy supply of oil to the operational chamber R**0** for achieving smooth advanced/retarded angle control operations, it is preferred that the aperture area of the check valve **140** be greater than the passageway aperture area of the first connecting passageway **82**. Further, for preferential supply of oil to the operational chamber R**0** during the advanced/retarded angle control operations, it is preferred that the passageway aperture area of the first connecting passageway **82** be greater than the passageway aperture area of the second connecting passageway **84**.

[0056] Incidentally, in the foregoing description of the embodiment, there has been described the case of the predetermined phase being an intermediate phase between the most advanced angle phase and the most retarded angle phase suitable for startup of the internal combustion engine. However, the invention is not limited thereto. Instead, the "predetermined phase" can be the most retarded angle phase or the most advanced angle phase, as a matter of course.

INDUSTRIAL APPLICABILITY

[0057] The present invention is applicable to a valve timing control apparatus used for controlling opening/closing timing of an exhaust valve or an intake value in a valving device of an internal combustion engine.

DESCRIPTION OF REFERENCE MARKS/NUMERALS

[0058] **10** . . . cam shaft (rotational shaft)
[0059] **11** . . . advanced angle passageway (first fluid passageway)
[0060] **12** . . . retarded angle passageway (second fluid passageway)
[0061] **13** . . . pilot passageway (third fluid passageway)
[0062] **30** . . . inner rotor
[0063] **32** . . . receiving groove (lock mechanism)
[0064] **40** . . . outer rotor
[0065] **41** front plate
[0066] **42** . . . rear plate
[0067] **46***a*, **46***b* retracting grooves
[0068] **50** . . . vanes (partitioning portions)
[0069] **60***a*, **60***b* . . . lock plates (lock mechanism)
[0070] **81** . . . cylinder head
[0071] **82** . . . first connecting passageway
[0072] **83** . . . branching point
[0073] **84** . . . second connecting passageway
[0074] **100** . . . first switching valve
[0075] **110** . . . second switching valve
[0076] **120** . . . oil pump (pump)
[0077] **130** . . . oil pan
[0078] **140** . . . check valve
[0079] R**0** . . . operational chamber (fluid pressure chamber)
[0080] R**1** . . . advanced angle chamber
[0081] R**2** . . . retarded angle chamber

1. A valve timing control apparatus comprising:
an inner rotor rotatable in unison with a valve opening/closing rotational shaft of an internal combustion engine;
an outer rotor mounted to be rotatable relative to said inner rotor over a predetermined range and rotatable by a force transmitted thereto from a crank shaft of the internal combustion engine;
a fluid pressure chamber formed between said inner rotor and said outer rotor and divided by a partitioning portion into an advanced angle chamber and a retarded angle chamber;
a first fluid passageway for feeding/discharging fluid to/from said advanced angle chamber;
a second fluid passageway for feeding/discharging fluid to/from said retarded angle chamber;
a locking mechanism capable of locking relative rotation between said inner rotor and said outer rotor;
a third fluid passageway for feeding fluid to said locking mechanism to cause this locking mechanism to release its locking state and discharging fluid from said locking mechanism to cause this locking mechanism to provide the locking state;
a first switching valve for controlling the feeding/discharging of the fluid to/from said first fluid passageway and said second fluid passageway;
a second switching valve for controlling the feeding/discharging of the fluid to/from said third fluid passageway;
a pump for feeding fluid to said first switching valve and said second switching valve; and
a check valve for inhibiting communication of the fluid from said first switching valve to said second switching valve and allowing communication of the fluid from said second switching valve to said first switching valve.

2. The valve timing control apparatus according to claim **1**, wherein the fluid fed from said pump can be fed to said first switching valve with bypassing said second switching valve and can be fed to said second switching valve with bypassing said first switching valve.

3. The valve timing control apparatus according to claim **1**, wherein the fluid fed from said pump can be fed to said first switching valve through said check valve and can be fed to said second switching valve with bypassing said check valve.

4. The valve timing control apparatus according to claim **1**, wherein the apparatus further comprises:
a first connecting passageway for connecting said pump to said first switching valve; and
a second connecting passageway for connecting a branching point of said first connecting passageway to said second switching valve;
wherein said check valve is disposed between said branching point and said first switching valve.

5. The valve timing control apparatus according to claim **4**, wherein an aperture area of said check valve when the fluid is being fed from said pump to said first switching valve is greater than a passageway aperture area of said first connecting passageway.

6. The valve timing control apparatus according to claim **4**, wherein the passageway aperture area of said first connecting passageway is greater than the passageway aperture area of said second connecting passageway.

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