US008210137B2

(12) **United States Patent**
Kono et al.

(10) **Patent No.: US 8,210,137 B2**
(45) **Date of Patent: Jul. 3, 2012**

(54) **LINK TYPE VARIABLE STROKE ENGINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 492 days.

(21) Appl. No.: **12/469,806**

(22) Filed: **May 21, 2009**

(65) **Prior Publication Data**

US 2009/0288643 A1 Nov. 26, 2009

(30) **Foreign Application Priority Data**

May 21, 2008 (JP) 2008-133208

(51) **Int. Cl.**
F02B 75/04 (2006.01)

(52) **U.S. Cl.** .... **123/48 B**; 123/196 R

(58) **Field of Classification Search** .... 123/48 A, 123/48 AA, 48 B, 48 R, 78 A, 78 B, 196 R
See application file for complete search history.

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(57) **ABSTRACT**

In a link type variable stroke engine in which a piston, a crankshaft and an eccentric shaft are linked by a linking mechanism, an oil supply hole for supplying lubricating oil to a position between a connection tubular part of a sub connecting rod and a crank pin is provided in an upper portion of the connection tubular part at a position which is deviated from a direction of application of maximum load applied from the crank pin to an inner surface of the connection tubular part by maximum in-tube pressure, and which is immediately behind a point of application of the maximum load along a direction in which the crank pin rotates relative to the sub connecting rod. Accordingly, it is possible to prevent leak of oil from the oil supply hole and thereby reliably lubricating the position between the connection tubular part of the sub connecting rod and the crank pin by a splash lubrication system.

2 Claims, 6 Drawing Sheets

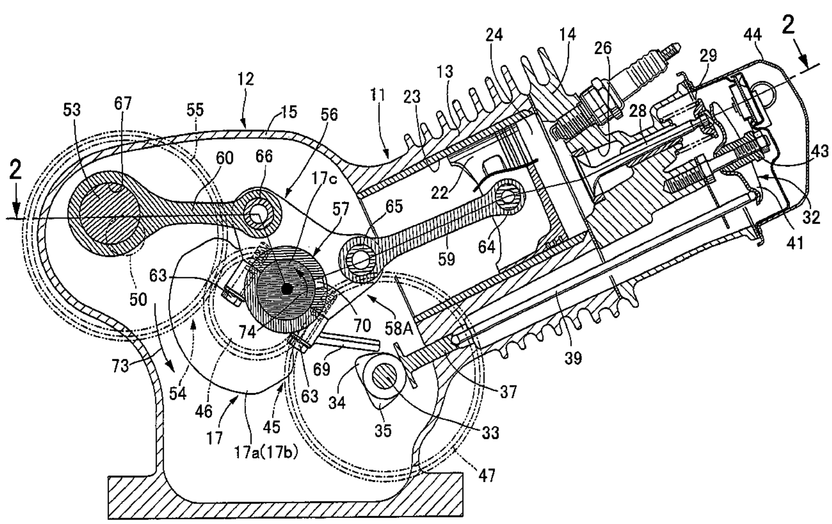

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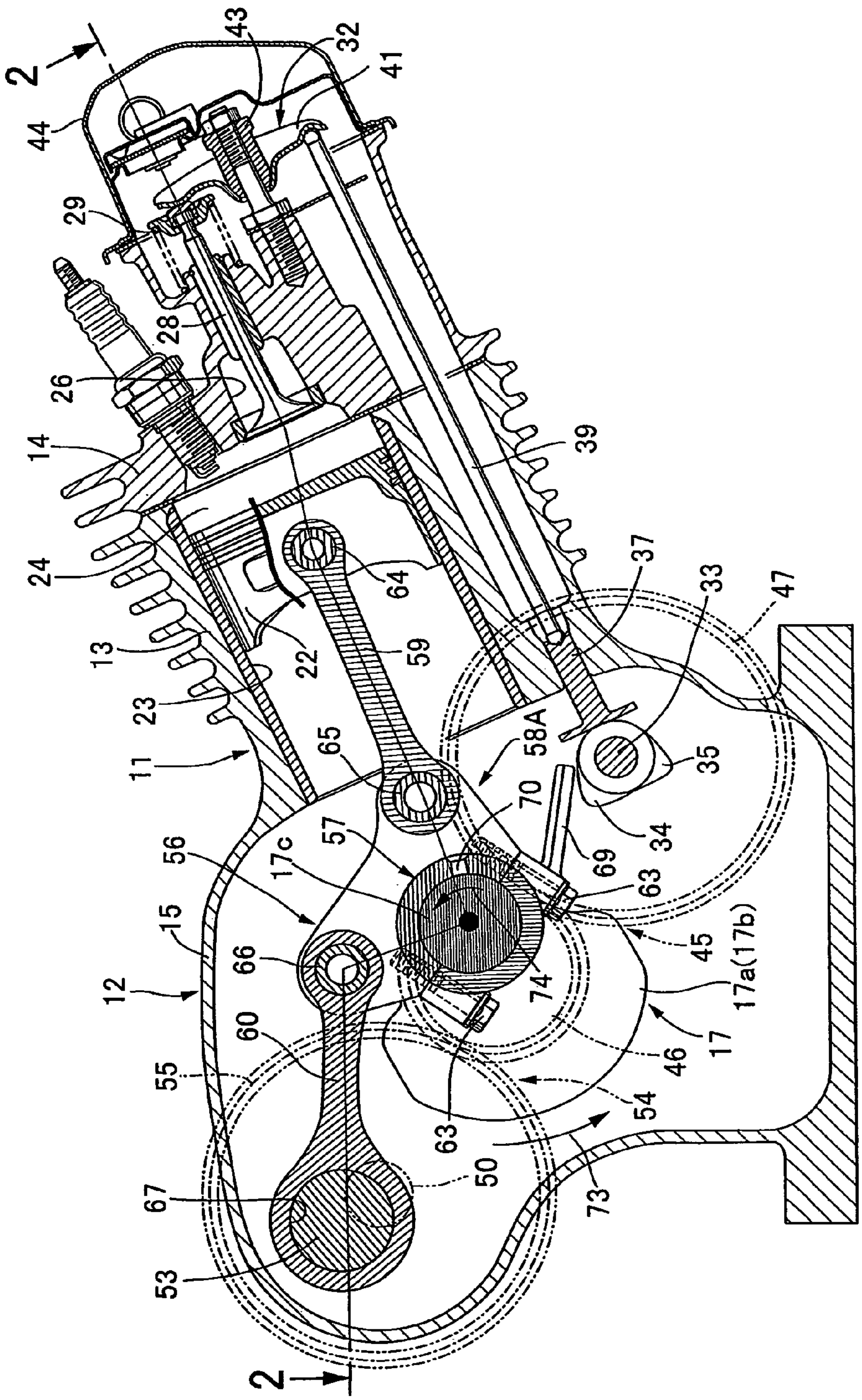
FIG.1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58A
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64
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59
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37
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34
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17a(17b)
17
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60
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73
67
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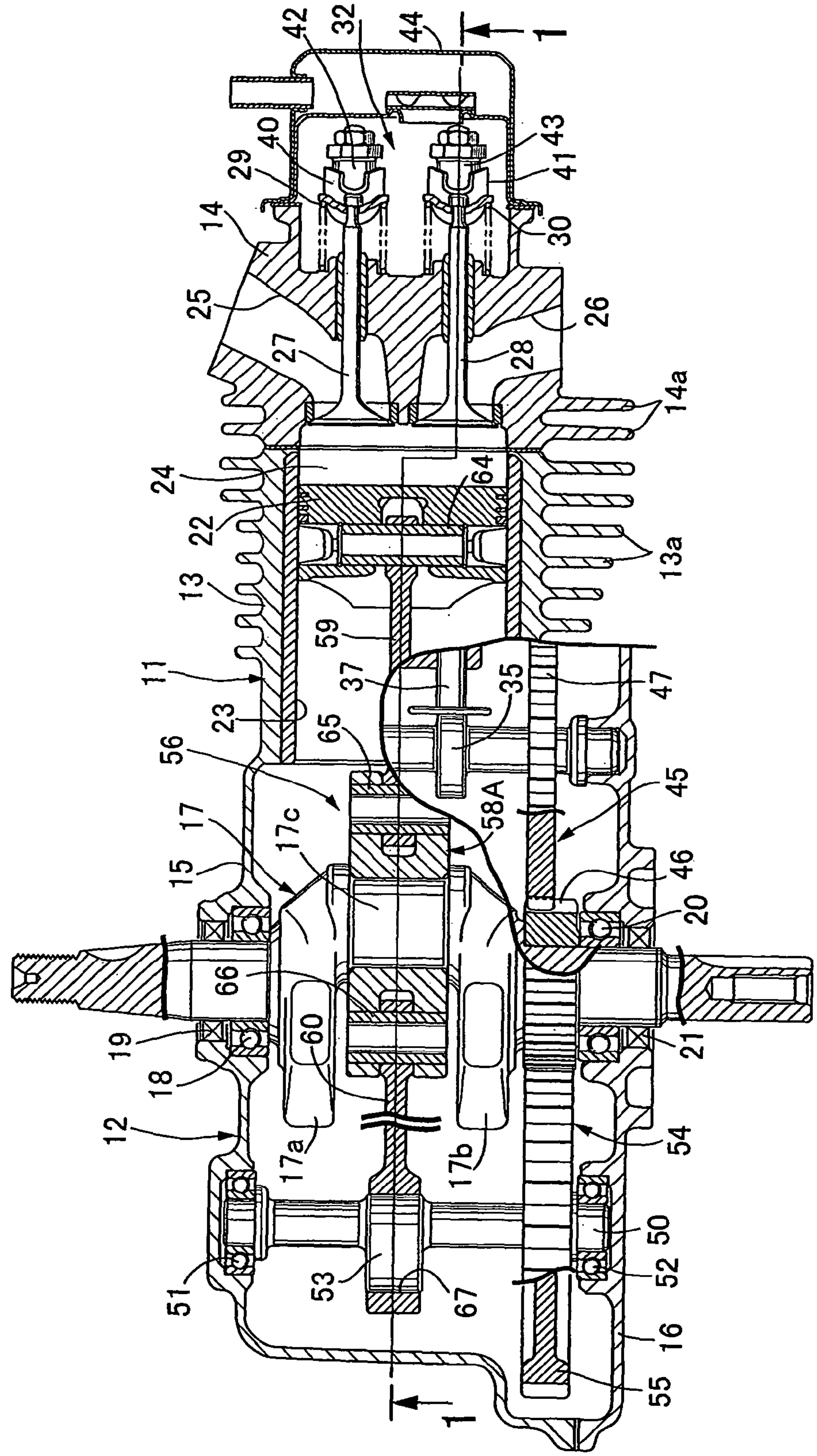
FIG.2



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58A
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17
17c
15
46
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FIG.3

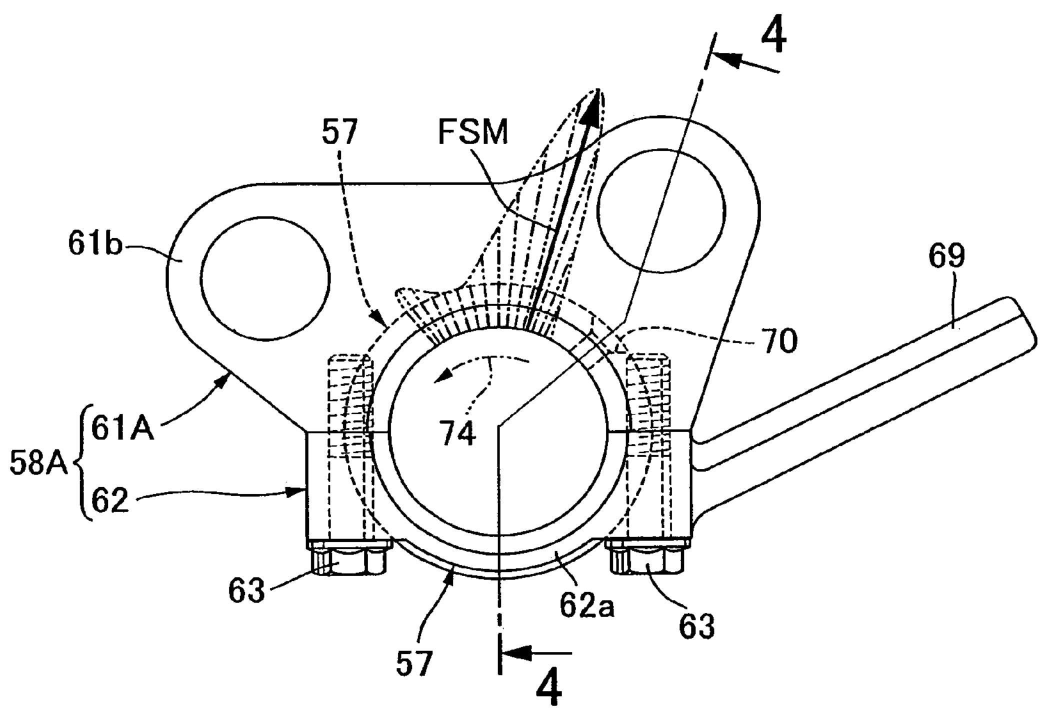


FIG.4

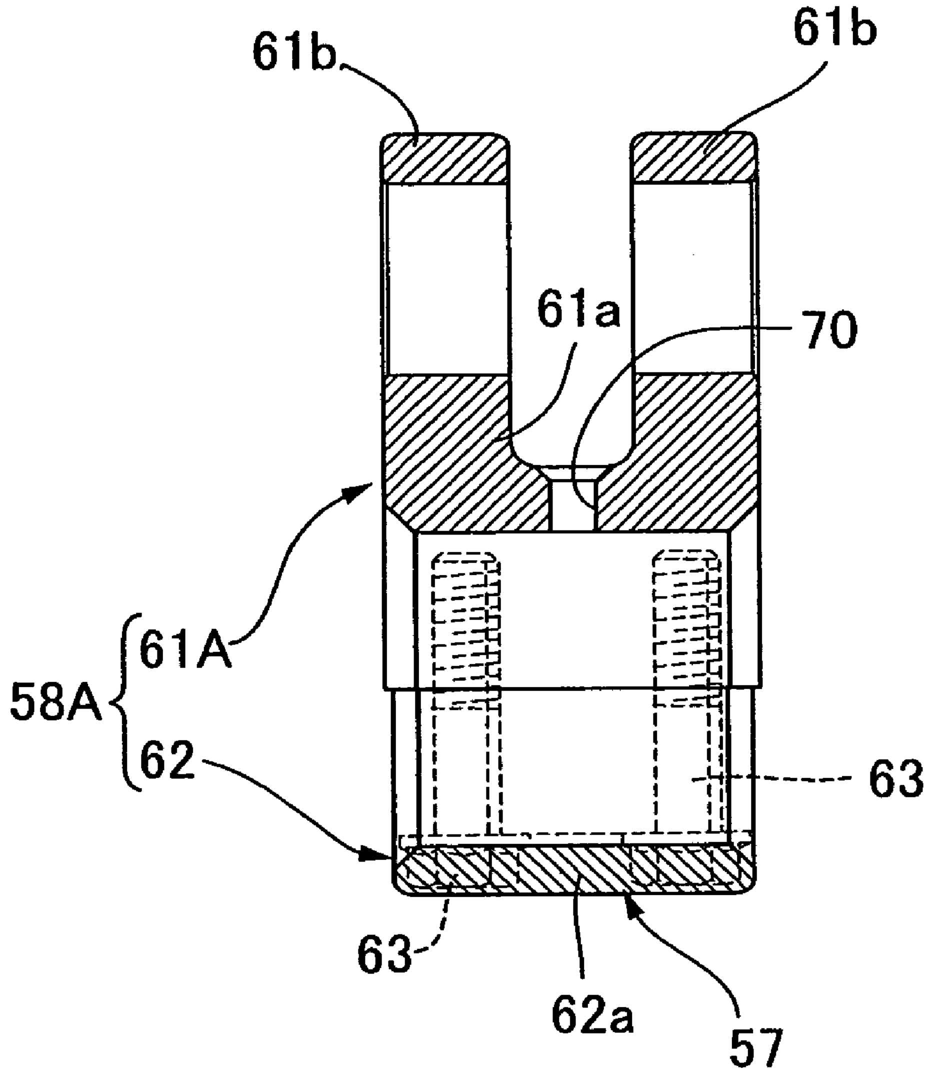
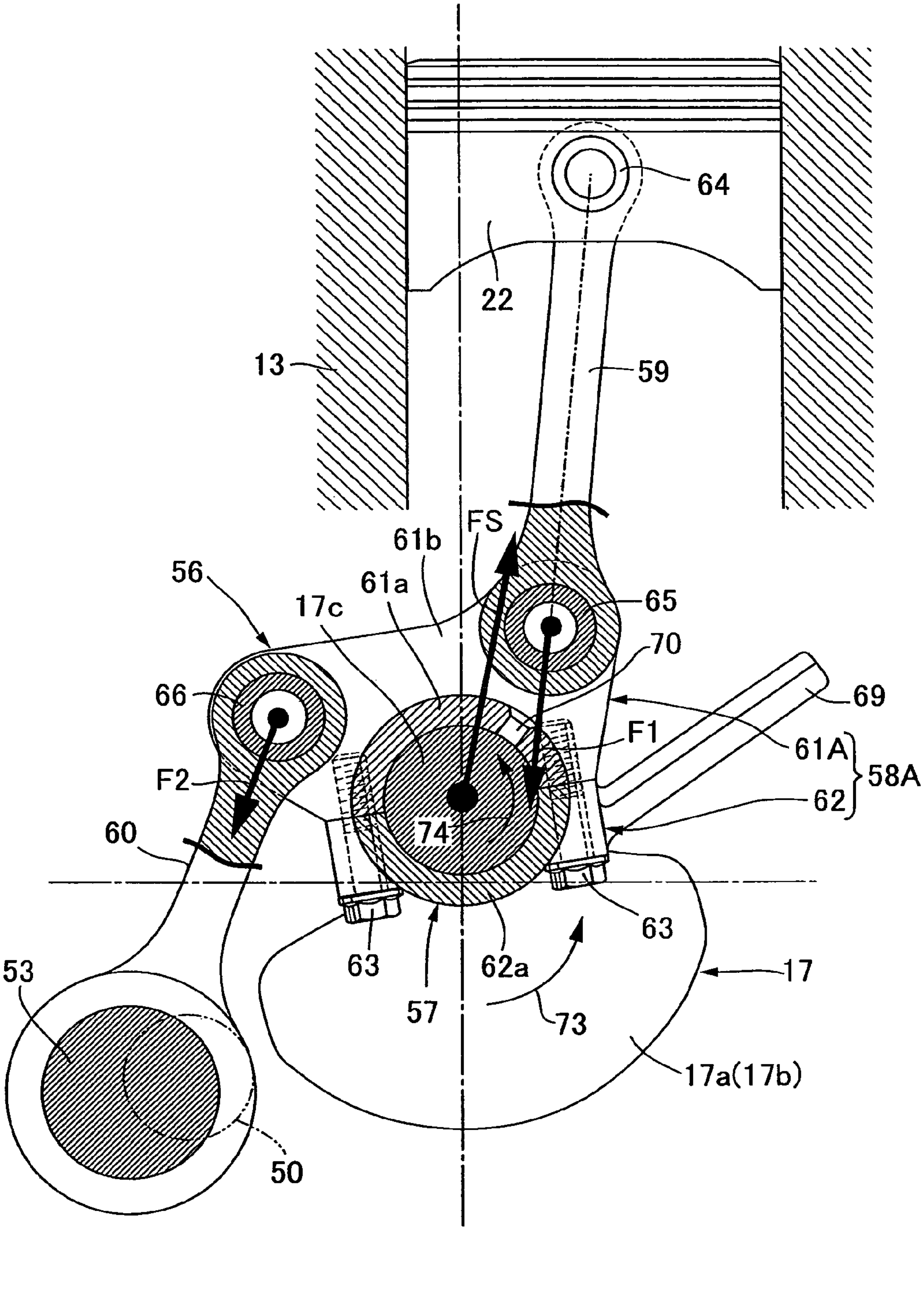


FIG.5



64
22
13
59
FS
61b
56
61a
17c
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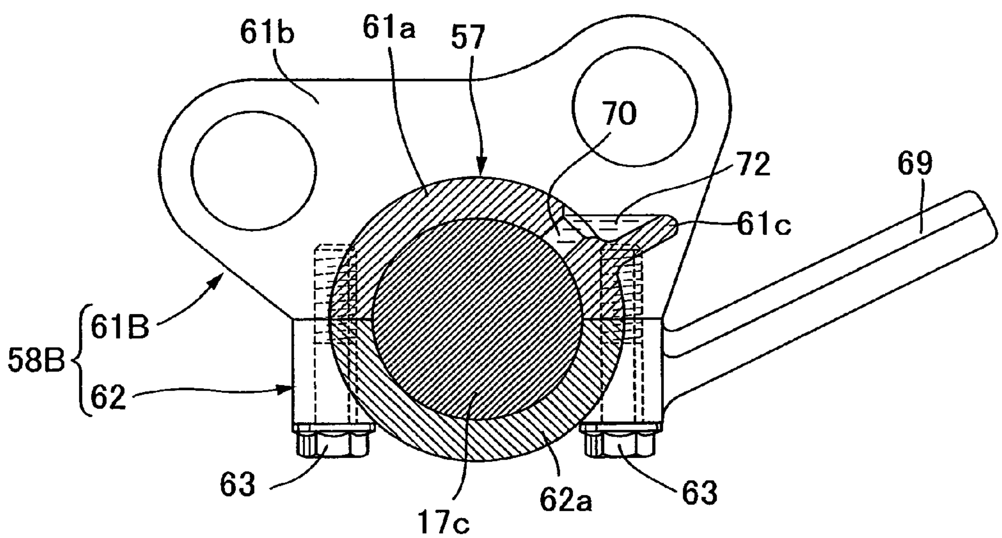
70
66
69
F1
61A
58A
F2
62
74
60
63
63
53
62a
57
73
17
17a(17b)
50

FIG.6



LINK TYPE VARIABLE STROKE ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a link type variable stroke engine, and especially relates to a link type variable stroke engine in which a piston slidably fitted to a cylinder block; a crankshaft rotatably supported at a crankcase; and a rotary shaft having an axis parallel with the crankshaft, being rotatably supported at the crankcase, and being provided with an eccentric shaft at an eccentric position, are linked by a linking mechanism, the linking mechanism including: a sub connecting rod having a connection tubular part into which a crank pin of the crankshaft is relatively rotatably fitted, and being rotatably connected with the crank pin; a main connecting rod connecting the sub connecting rod and the piston; and a swing rod connecting the sub connecting rod and the eccentric shaft, and oil scattered in the crankcase is guided to a position between the connection tubular part of the sub connecting rod and the crank pin.

2. Description of the Related Art

In conventional reciprocating engines, an oil supply hole is formed at a big end of a connecting rod to lubricate a position between the big end of the connecting rod and a crank pin by using oil scattered in a crankcase. Since load caused by explosion in a combustion chamber is applied to the big end of the connecting rod, the oil supply hole is formed in a position at the big end of the connecting rod, the position deviated from the direction of application of the load.

On the other hand, a link type variable stroke engine has already been known through Japanese Patent Application Laid-open No. 2003-278567. In the link type variable stroke engine, a piston, a crankshaft and an eccentric shaft provided to a rotary shaft parallel with the crankshaft are linked by a linking mechanism including a sub connecting rod, a main connecting rod and a swing rod. The sub connecting rod includes a connection tubular part into which a crank pin is relatively rotatably fitted, and thus is rotatably coupled with the crank pin. The main connecting rod connects the piston and the sub connecting rod. The swing rod connects the sub connecting rod and the eccentric shaft. Such a link type variable stroke engine also requires an oil supply hole formed at the connection tubular part of the sub connecting rod to lubricate a position between the connection tubular part of the sub connecting rod and the crank pin by a splash lubrication system using oil scattered in a crankcase.

Meanwhile, in the link type variable stroke engine, reaction force from the swing rod is applied to the sub connecting rod in addition to load by in-tube pressure acting thereon from the main connecting rod. Accordingly, the resultant force of the load by such in-tube pressure and the reaction force is applied to an inner surface of the connection tubular part of the sub connecting rod. Here, the direction of application of the resultant force is determined by the angle between the main connecting rod and the sub connecting rod, the magnitude of the force applied from the main connecting rod to the sub connecting rod, the angle between the sub connecting rod and the swing rod, the magnitude of the force applied from the swing rod to the sub connecting rod, and is not fixed in an operation cycle of the engine. If the oil supply hole is provided in a wrong position, oil leaks out from the oil supply hole under application of the maximum load by the maximum in-tube pressure, bringing serious effects on lubrication.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above-described circumstances. It is an object of the present invention to provide a link type variable stroke engine capable of preventing leak of oil from an oil supply hole and thereby reliably lubricating a position between connection tubular part of a sub connecting rod and a crank pin by a splash lubrication system.

In order to achieve the object, according to a first feature of the present invention, there is provided a link type variable stroke engine in which a piston slidably fitted to a cylinder block; a crankshaft rotatably supported at a crankcase; and a rotary shaft having an axis parallel with the crankshaft, being rotatably supported at the crankcase, and being provided with an eccentric shaft at an eccentric position, are linked by a linking mechanism, the linking mechanism including: a sub connecting rod having a connection tubular part into which a crank pin of the crankshaft is relatively rotatably fitted, and being rotatably connected with the crank pin; a main connecting rod connecting the sub connecting rod and the piston; and a swing rod connecting the sub connecting rod and the eccentric shaft, and oil scattered in the crankcase is guided to a position between the connection tubular part of the sub connecting rod and the crank pin, wherein an oil supply hole for supplying lubricating oil to the position between the connection tubular part of the sub connecting rod and the crank pin is provided in an upper portion of the connection tubular part at a position which is deviated from a direction of application of maximum load applied from the crank pin to an inner surface of the connection tubular part by maximum in-tube pressure, and which is immediately behind a point of application of the maximum load along a direction in which the crank pin rotates relative to the sub connecting rod.

According to the first feature of the present invention, the oil supply hole is formed in the upper portion of the connection tubular part at a position which is deviated from the direction of application of the maximum load by the maximum in-tube pressure applied from the crank pin to the inner surface of the connection tubular part of the sub connecting rod and which is immediately behind the point of application of the maximum load along the relative rotation direction of the crank pin with respect to the sub connecting rod. Accordingly, even when the maximum load by the maximum in-tube pressure is applied to the connection tubular part of the sub connecting rod, leak of the oil from the oil supply hole is prevented, and consequently oil film shortage is prevented. Thus, efficient and reliable lubrication can be provided.

According to a second feature of the present invention, in addition to the first feature, the sub connecting rod includes: a pair of mutually facing plate parts integrally provided at right angles on an upper portion of the connection tubular part so as to sandwich, from opposite sides, end portions, on the sub connecting rod side, of the main connecting rod and the swing rod, respectively; and a connection plate part rising from an outer surface of the connection tubular part at a position below an opened end of the oil supply hole open to the outer surface of the connection tubular part, the connection plate part connecting both the facing plate parts, and an oil sump communicating with the oil supply hole and being opened upward is formed by the outer surface of the connection tubular part, both the facing plate parts and the connection plate part.

According to the second feature of the present invention, oil is collected in the oil sump. Thus, oil supply from the oil supply hole can be reliable.

The above description, other objects, characteristics and advantages of the present invention will be clear from detailed descriptions which will be provided for the preferred embodiments referring to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** to **5** show a first embodiment of the present invention:

FIG. **1** is a longitudinal cross-sectional side view of an engine and a cross-sectional view taken along a line **1-1** in FIG. **2**;

FIG. **2** is a cross-sectional view taken along a line **2-2** in FIG. **1**;

FIG. **3** is a side view of a sub connecting rod;

FIG. **4** is a cross-sectional view taken along a line **4-4** in FIG. **3**; and

FIG. **5** is a cross-sectional view of a linking mechanism corresponding to FIG. **1** for explaining a load applied to the sub connecting rod.

FIG. **6** is a longitudinal cross-sectional view of a sub connecting rod of a second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will be explained below based on FIGS. **1** to **5**.

First, in FIG. **1** and FIG. **2**, this link type variable stroke engine is an air-cooled single cylinder engine, which is used for working machines and the like, for example. An engine body **11** includes: a crankcase **12**; a cylinder block **13** protruding in upwardly tilting manner from one side surface of the crankcase **12**; and a cylinder head **14** joined to a head portion of the cylinder block **13**. A large number of air-cooling fins **13***a* and **14***a* are provided on outer side surfaces of the cylinder block **13** and the cylinder head **14**.

The crankcase **12** comprises: a case main body **15** formed integrally with the cylinder block **13** by molding and opened at one side; and a side cover **16** joined to the opened end of the case main body **15**. A crankshaft **17** is rotatably supported in the crankcase **12**. The crankshaft **17** integrally has a pair of counterweights **17***a* and **17***b*, as well as a crank pin **17***c* which connects between the counter weights **17***a* and **17***b*. Accordingly, both end portions of the crankshaft **17** rotatably penetrate the case main body **15** and the side cover **16** of the crankcase **12** and protrude outwardly. A ball bearing **18** and an annular sealing member **19** are disposed between the crankshaft **17** and the case main body **15**, the sealing member **19** disposed on the outer side of the ball bearing **18**, and a ball bearing **20** and an annular sealing member **21** are disposed between the crankshaft **17** and the side cover **16**, the sealing member **21** disposed on the outer side of the ball bearing **20**.

A cylinder bore **23** is formed in the cylinder block **13**. A piston **22** is slidably fitted in the cylinder bore **23**. A combustion chamber **24** is formed between the cylinder block **13** and the cylinder head **14**, and a top portion of the piston **22** faces the combustion chamber **24**. An intake port **25** and an exhaust port **26**, both communicating with the combustion chamber **24**, are formed in the cylinder head **14**. In addition, an intake valve **27** for opening and closing the passage between the intake port **25** and the combustion chamber **24** as well as an exhaust valve **28** for opening and closing the passage between the exhaust port **26** and the combustion chamber **24** are disposed in the cylinder head **14** so as to be capable of performing the opening and closing operations. The intake valve **27** and the exhaust valve **28** are urged in a valve-closing direction by valve springs **29** and **30**, respectively.

A valve operating mechanism **32** opening and closing the intake valve **27** and the exhaust valve **28** includes: a cam shaft **33** including an intake cam **34** and an exhaust cam **35** and rotatably supported at the crankcase **12**; an intake tappet (not illustrated) supported at the cylinder block **13** so that the intake cam **34** causes the intake tappet to slide up and down following motion of the intake cam **34**; an exhaust tappet **37** supported at the cylinder block **13** so that the exhaust cam **35** causes the exhaust tappet **37** to slide up and down following motion of the exhaust cam **35**; an intake push rod (not illustrated) continuously connected, at its lower end portion, with an upper end portion of the intake tappet and extending in the up-down direction; an exhaust push rod **39** continuously connected, at its lower end portion, with an upper end portion of the exhaust tappet and extending in the up-down direction; an intake rocker arm **40** swingably supported by a spherical supporting part **42** fixed to the cylinder head **14**; and an exhaust rocker arm **41** swingably supported by a spherical supporting part **43** fixed to the cylinder head **14**. One end portion of the intake rocker arm **40** is in contact with an upper end of the intake push rod, whereas one end portion of the exhaust rocker arm **41** is in contact with an upper end of the exhaust push rod **39**. The other end portions of the intake rocker arm **40** and the exhaust rocker arm **41** are in contact respectively with head portions of the intake valve **27** and the exhaust valve **28**.

The spherical supporting parts **42** and **43** and the intake and exhaust rocker arms **40** and **41** of the valve operating mechanism **32** are covered with a head cover **44**, and the head cover **44** is connected with the cylinder head **14**.

The cam shaft **33** has an axis parallel with the crankshaft **17**. Between the camshaft **33** and the crankshaft **17**, first timing transmitting means **45** is provided which transmits the rotation power of the crankshaft **17** at a speed reduction ratio of 1/2. The first timing transmitting means **45** includes: a driving gear **46** fixed to the crankshaft **17**; and a first driven gear **47** provided to the cam shaft **33**.

Opposite end portions of a rotary shaft **50** are rotatably supported at the case main body **15** and the side cover **16** of the crankcase **12** with ball bearings **51** and **52**, respectively, the rotary shaft **50** having an axis parallel with the crankshaft **17** while having a rotation axis above an axis of the crankshaft **17**. Between the rotary shaft **50** and the crankshaft **17**, second timing transmitting means **54** is disposed which reduces the rotation power of the crankshaft **17** at a speed reduction ratio of 1/2 and then transmits the rotation power to the rotary shaft **50**. The second timing transmitting means **54** comprises the driving gear **46** fixed to the crankshaft **17** and a second driven gear **55** integrally provided to the rotary shaft **50** so as to mesh with the driving gear **46**.

An eccentric shaft **53** is provided integrally with the rotary shaft **50** at a position corresponding to a portion between the pair of counterweights **17***a* and **17***b* of the crankshaft **17**. The eccentric shaft **53** has its axis at a position eccentric with respect to the axis of the rotary shaft **50**. The eccentric shaft **53**, the piston **22** and the crankshaft **17** are linked by a linking mechanism **56**.

The linking mechanism **56** includes: a sub connecting rod **58**A having a connection tubular part **57** into which the crank pin **17***c* of the crankshaft **17** is relatively rotatably fitted, and being rotatably coupled with the crank pin **17***c*; a main connecting rod **59** connecting the sub connecting rod **58**A and the piston **22**; and a swing rod **60** which connects the sub connecting rod **58**A and the eccentric shaft **53**.

Referring to FIG. **3** and FIG. **4** in combination, the sub connecting rod **58**A comprises: a sub connecting rod main body **61**A; and a crank cap **62** fastened to the sub connecting rod main body **61**A by using multiple, for example, four, bolts **63** and **63**.

The sub connecting rod main body **61**A includes: a semicylinder **61***a* which has a cross section in a semicircular shape and into which a substantially half of the crank pin **17***c* is fitted; and a pair of facing plate parts **61***b* and **61***b* integrally connected respectively with two axial-direction ends of the semicylinder **61***a* at right angles, extending upward, and facing each other. The crank cap **62** includes a semicylinder **62***a* which has a cross section in a semicircular shape and into which the residual substantially half of the crank pin **17***c* is fitted. The sub connecting rod **58**A is formed by fastening the crank cap **62** to the sub connecting rod main body **61**A, and, in this state, the two semicylinders **61***a* and **62***a* form the connection tubular part **57** into which the crank pin **17***c* of the crankshaft **17** is relatively rotatably fitted, while the two facing plate parts **61***b* and **61***b* are integrally connected with the upper portion of the connection tubular part **57** at right angles and extend upward from the connection tubular part **57**.

One end portion of the main connecting rod **59** is connected with the piston **22** by using a piston pin **64**, and the other end portion of the main connecting rod **59** is sandwiched between the two facing plate parts **61***b* and **61***b* of the sub connecting rod **58**A and rotatably connected with the two facing plate parts **61***b* and **61***b* by using a connecting rod pin **65**.

One end portion of the swing rod **60** is sandwiched between the two facing plate parts **61***b* and **61***b* of the sub connecting rod **58**A at a position deviated from the connecting rod pin **65**, and is rotatably connected with the two facing plate parts **61***b* and **61***b* by using a swing pin **66**. At the other end portion of the swing rod **60**, a circular connection hole **67** into which the eccentric shaft **53** is relatively rotatably fitted is formed.

When the rotary shaft **50** is rotated at a speed reduction ratio of 1/2 along with rotation of the crankshaft **17** and the eccentric shaft **53** thereby rotates about the rotation axis of the rotary shaft **50**, the linking mechanism **56** operates, for example, in a manner that the stroke of the piston **22** in the expansion stroke becomes larger than that in the compression stroke. Thus, a higher expansion work is achieved with the same amount of intake of the air-fuel mixture, so that the cycle thermal efficiency can be improved.

An oil dipper **69** extending to a side is integrally formed on the crank cap **62** of the sub connecting rod **58**A. Upon rotation of the crank pin **17***c* about the axis of the crankshaft **17**, the oil dipper **69** stirs and scoops up oil stored in a lower portion of the crankcase **12**, thereby the oil droplets are scattered in the crankcase **12**. A portion between the connection tubular part **57** and the crank pin **17***c* are lubricated by a splash lubrication system using oil droplets in the crankcase **12**, and an oil supply hole **70** is formed in an upper portion of the connection tubular part **57** of the sub connecting rod **58**A to guide the oil droplets to a position between the connection tubular part **57** and the crank pin **17***c*.

Now, in the link type variable stroke engine having the above-described configuration, reaction force F**2** is applied from the swing rod **60** to the sub connecting rod **58**A in addition to load F**1** by in-tube pressure from the main connecting rod **59** to the sub connecting rod **58**A, as shown in FIG. **5**. Accordingly, such resultant force FS of the load F**1** by in-tube pressure and the reaction force F**2** is applied from the crank pin **17***c* to an inner surface of the connection tubular part **57** of the sub connecting rod **58**A.

Here, the direction of application of the resultant force FS is determined by the angle between the main connecting rod **59** and the sub connecting rod **58**A, the magnitude of the force F**1** applied from the main connecting rod **59** to the sub connecting rod **58**A, the angle between the sub connecting rod **58**A and the swing rod **60**, the magnitude of the force F**2** applied from the swing rod **60** to the sub connecting rod **58**A. Accordingly, the direction of application of the resultant force FS is not fixed in an operation cycle of the engine, and changes as indicated by chain lines in FIG. **3**.

According to the present invention, the oil supply hole **70** is formed in a position deviated from a direction of application of a maximum load FSM (see FIG. **3**) by the maximum in-tube pressure applied from the crank pin **17***c* to the inner surface of the connection tubular part **57**. Upon rotation of the crank pin **17***c* in the direction indicated by an arrow **73** in FIG. **1** in response to reciprocating sliding of the piston **22** in the cylinder bore **23**, the crank pin **17***c* relatively rotates, with respect to the sub connecting rod **58**A, in the relative rotation direction indicated by an arrow **74**. The oil supply hole **70** is formed in the upper portion of the connection tubular part **57** so as to be located immediately behind the point of application of the maximum load FSM along the relative rotation direction **74**.

Next, operations of this embodiment will be described. The oil supply hole **70** for supplying lubricating oil to a position between the crank pin **17***c* and the connection tubular part **57** of the sub connecting rod **58**A in the linking mechanism **56** is formed in the upper portion of the connection tubular part **57**. The oil supply hole **70** is set in a position which is deviated from the direction of application of the maximum load FSM applied from the crank pin **17***c* to the inner surface of the connection tubular part **57** by the maximum in-tube pressure and which is immediately behind the point of application of the maximum load FSM along the relative rotation direction **74** of the crank pin **17***c* with respect to the sub connecting rod **58**A.

Accordingly, even when the maximum load FSM is applied to the connection tubular part **57** of the sub connecting rod **58**A by the maximum in-tube pressure, leak of oil from the oil supply hole **70** can be prevented, and consequently occurring of oil film shortage can be prevented. Thus, efficient and reliable lubrication can be provided.

FIG. **6** shows a second embodiment of the present invention. The components corresponding to those of the first embodiment are simply denoted by the same reference numerals in the drawings and detailed descriptions thereof are omitted.

A sub connecting rod **58**B comprises: a sub connecting rod main body **61**B; and a crank cap **62** fastened to the sub connecting rod main body **61**B by using multiple, for example, four, bolts **63** and **63**.

The sub connecting rod main body **61**B includes: a semicylinder **61***a* which has a cross section in a semicircular shape and into which a substantially half of a crank pin **17***c* is fitted; and a pair of facing plate parts **61***b* and **61***b* integrally connected respectively with two axial-direction ends of the semicylinder **61***a* at right angles, extending upward, and facing each other. The crank cap **62** includes a semicylinder **62***a* which has a cross section in a semicircular shape and into which the residual substantially half of the crank pin **17***c* is fitted. The sub connecting rod **58**B is formed by fastening the crank cap **62** to the sub connecting rod main body **61**B, and, in this state, the two semicylinders **61***a* and **62***a* form a connection tubular part **57** into which the crank pin **17***c* of the crankshaft **17** is relatively rotatably fitted.

Moreover, the sub connecting rod main body **61**B of the sub connecting rod **58**B includes a connection plate part **61***c* formed integrally thereon and rising from an outer surface of the connection tubular part **57** at a position below the open end of the oil supply hole **70** at the outer surface of the connection tubular part **57** to connect the pair of facing plate parts **61***b*. An oil sump **72** communicating with the oil supply hole **70** and opened upward is formed by the outer surface of the connection tubular part **57**, the two facing plate parts **61***b* and the connection plate part **61***c*.

According to the second embodiment, the same effects as those of the first embodiment can be provided, and also, since oil can be collected in the oil sump **72**, oil supply from the oil supply hole **70** can be reliable.

Embodiments of the present invention are explained above, but the present invention is not limited to the above-mentioned embodiments and may be modified in a variety of ways as long as the modifications do not depart from its gist.

The invention claimed is:

1. A link type variable stroke engine in which

a piston slidably fitted to a cylinder block; a crankshaft rotatably supported at a crankcase; and a rotary shaft having an axis parallel with the crankshaft, being rotatably supported at the crankcase, and being provided with an eccentric shaft at an eccentric position, are linked by a linking mechanism, the linking mechanism including: a sub connecting rod having a connection tubular part into which a crank pin of the crankshaft is relatively rotatably fitted, and being rotatably connected with the crank pin; a main connecting rod connecting the sub connecting rod and the piston; and a swing rod connecting the sub connecting rod and the eccentric shaft, and

oil scattered in the crankcase is guided to a position between the connection tubular part of the sub connecting rod and the crank pin,

wherein an oil supply hole for supplying lubricating oil to the position between the connection tubular part of the sub connecting rod and the crank pin is provided in an upper portion of the connection tubular part at a position which is deviated from a direction of application of maximum load applied from the crank pin to an inner surface of the connection tubular part by maximum in-tube pressure, and which is immediately behind a point of application of the maximum load along a direction in which the crank pin rotates relative to the sub connecting rod.

2. The link type variable stroke engine according to claim **1**, wherein

the sub connecting rod includes: a pair of mutually facing plate parts integrally provided at right angles on an upper portion of the connection tubular part so as to sandwich, from opposite sides, end portions, on the sub connecting rod side, of the main connecting rod and the swing rod, respectively; and a connection plate part rising from an outer surface of the connection tubular part at a position below an opened end of the oil supply hole open to the outer surface of the connection tubular part, the connection plate part connecting both the facing plate parts, and

an oil sump communicating with the oil supply hole and being opened upward is formed by the outer surface of the connection tubular part, both the facing plate parts and the connection plate part.

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