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(54) **Decompressing device of internal-combustion engines.**

(57) A decompression device of an internal combustion engine having a release lever (18) pivotally supported on a cam driven gear (15d) and urged by centrifugal force to swing radially outwardly, when the cam driven gear rotates, so as to permit a valve tappet (17) to return into normal contact with a valve cam (15e). During a start-up compression stroke, the release lever (18) swings radially inwardly by a spring (20) to contact and move the tappet (17) to a position for partially opening the valve for decompression. The release lever (18) has a pivot shaft (18a) fixed perpendicularly to the lever and rotatably passing through the cam driven gear (15d). The pivot shaft (18d) has a decompression cam (18b) for allowing the tappet to return to a normal position. The spring (20) is a coil torsion spring fitted loosely around the pivot shaft (18a).

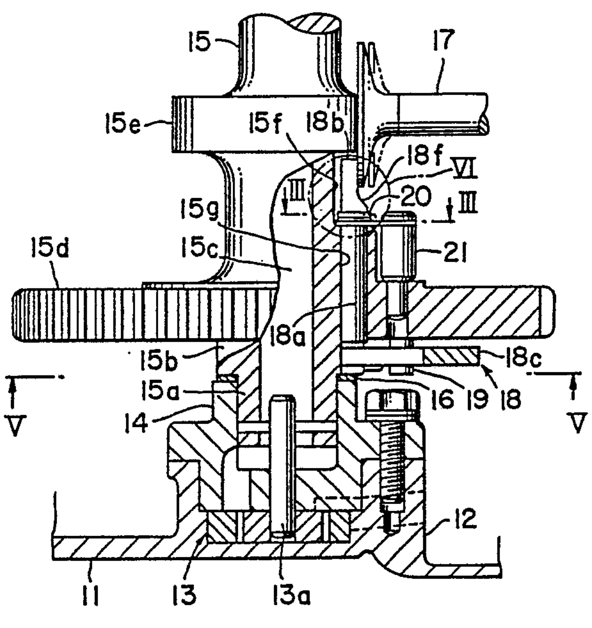

FIG. 2

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DECOMPRESSION DEVICE OF INTERNAL-COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention relates generally to internal combustion engines and decompression devices thereof. More particularly, the invention concerns a decompression device of an engine of high compression ratio which device, at the time of starting of the engine, forcibly opens at least one of the valves of each cylinder thereby to provide easy starting.

In the case when a conventional engine, such as a diesel engine, having a high compression ratio is being started manually, a strong force is required for the operator to start the engine. Accordingly, decompression devices have heretofore been proposed to facilitate such manual starting. In a typical example of such devices, at least one of the intake valves or the exhaust valves is forcibly opened to a partial degree, as disclosed in Japanese Utility Model Laid-Open (Unexamined) Publication No. 97308/1985.

A decompression device of this type essentially has the following construction. A release lever is fixed at its proximal end to a pivot pin. The pivot pin is rotatably supported on a cam driven gear. An end of the release lever constitutes a flyweight. A return spring is provided at its one end to a pin fixed to the cam driven gear and at the other end to the end of the release lever. A decompression cam is formed at an end part of the pivot pin mentioned above. The decompression cam is in contact with a tappet of a valve of the engine.

At the initial stage of starting of the engine, the return spring is retaining the release lever at a "closed" angular position. At this position, the decompression cam is raising the tappet to a position outside the base circle or minimum radius of the corresponding cam. The corresponding valve is therefore in a partially opened state. Decompression is thus obtained.

When the engine starts and its speed increases, a gradually increasing centrifugal force acts on the flyweight. The release lever is thereby urged to move in a reverse direction to the return spring. As a result, the decompression cam is turned to an angle at which its effective cam surface is accomodated within the minimum radius of the cam corresponding to the tappet mentioned above. Therefore the decompression is automatically terminated.

This decompression device of the prior art, which will be described in detail hereinafter, is accompanied by certain problems arising primarily from the nature of the return spring. One problem is the lack of space for satisfactory decompression operation of the mechanism. Another problem is the vulnerability of the return spring to adverse causes such as vibration. These problems will be described more fully hereinafter.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above described circumstances of the prior art. It is an object of the present invention to provide an engine decompression device which is of simple construction and has the following features. The return spring does not strike or interfere with other constituent parts even in a small space. The device cam perform decompression positively. Furthermore, the device is not easily affected adversely by external disturbances such as vibration.

According to the present invention there is provided a decompression device of an engine having a camshaft, a cam driven gear fixed to the camshaft and driven by the crankshaft of the engine, a valve cam fixed to the camshaft, a tappet actuated by the valve cam to open and close a valve of a cylinder of the engine, and a release lever pivotally supported on the cam driven gear thereby to be swingable in opening and closing directions in a plane parallel to the cam driven gear and being urged by centrifugal force to swing in an opening direction; said compression device comprising a pivot shaft fixed perpendicularly to the release lever and rotatably fitted in the cam driven gear thereby to pivotally support the release lever; and a coil spring fitted loosely around the pivot shaft and anchored at one end to the pivot shaft and at the other end to the cam driven gear thereby to exert a return torque on the release lever urging the same to rotate in a closing direction, the pivot shaft having a decompression cam which is shaped such that during a compression stroke and when the engine speed is low, the cam part contacts and moves the tappet to a position for partially opening the valves for decompression and that the decompression cam permits the tappet to return into normal contact with the cam as the release lever swings in the opening direction under centrifugal force increasing with increasing engine speed.

In a specific embodiment of the decompression device according to the present invention of the general construction described above, a longitudinal cutout surface is provided in the camshaft, and the decompression cam is disposed close to the cutout surface of the camshaft and partially within the base circle of the valve cam and comprises a flat part of the pivot shaft formed parallel to the pivot shaft axis as a longitudinal cutout surface of the pivot shaft at the end thereof remote from the release lever, the longitudinally inner end of the flat surface and an intermediate part of the pivot shaft being joined by way of a tapered part to form a continuous surface, the flat surface confronting the tappet when the release lever swings in the opening direction, the end part of the pivot shaft other than the flat surface contacting the tappet thereby to move the tappet to a position for partially opening the valve when the release lever is returned in the closing direction.

In assembling the decompression device, the pivot shaft of the release lever is first inserted into and rotatably supported on the cam driven gear. Thereafter the coil torsion spring is fitted around the decompression cam part formed at the end of the pivot shaft so that the end of the spring to be anchored to the pivot shaft is remote from the release lever.

Then the spring is pushed further along the pivot shaft towards the release lever. The end of the coil spring to be anchored to the pivot shaft is bent inwardly toward the axis of the coil spring to function as an engagement catch. As the coil spring is thus pushed further, this bent end thereof is guided by the tapered part of the pivot shaft and is thereby pushed outwardly until the coil spring reaches its prescribed position. The engagement catch end of the coil spring thereupon slips into a transverse hole in the pivot shaft and is thus anchored.

The other end of the coil spring is anchored to the cam driven gear. The coil spring thus exerts constantly a torque on the release lever tending to rotate it in its closing direction. Consequently the decompression cam, pushing the tappet, forcibly opens the valve.

The initial rotational speed of the engine at the time of starting is low. Therefore, the centrifugal force acting on the release lever is insufficient to overcome the returning force of the coil spring. The decompression cam thereby forcibly opens the valve. Thus the combustion chamber of the cylinder is decompressed.

As the engine speed increases, the centrifugal force increases and, overcoming the force of the coil spring, causes the release lever to swing in the opening direction. The decompression is thus terminated automatically.

A preferred embodiment of the present invention will become understood from the following detailed description referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of an engine to which the decompression device of the present invention is applied;

FIG. 2 is a side view, partially in section and with parts cut away, showing a decompression device according to the present invention;

FIG. 3 is a section taken along the line III-III in FIG. 2;

FIG. 4 is an enlarged fragmentary side view of the parts with the circle IV in FIG. 2;

FIG. 5 is a section taken along the line V-V in FIG. 2; and

FIG. 6 is a partial view in a plane perpendicular to the camshaft of the engine of a known decompression device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As conducive to a full understanding of the present invention, the general nature, attendant problems, and limitations of the conventional decompression device will first be described with reference to FIG. 6.

An essential part of the conventional decompression device shown in FIG. 6 is a release lever 2 pivotally supported at a pivot pin part 2a thereof on a cam driven gear 5. The cam driven gear 5 is meshed with a cam drive gear (not shown) unitarily fixed to the crankshaft (also not shown) of an engine. The cam driven gear 5 is fixed to the camshaft 1. Thus the camshaft 1 rotates in synchronism with the crankshaft. A return spring 3 in stretched state is anchored at its one end to a pin 5a fixed to the cam driven gear 5 and is connected at its other end to the distal end of the release lever 2. The release lever 2 is thus urged by the return spring 3 to rotate about its pivot pin part 2a in the counterclockwise direction as viewed in FIG. 6. A decompression cam 2b is formed at an end part of the pivot pin part 2a. The decompression cam 2b is in contact with a valve tappet 4. The decompression cam 2b functions upon rotating to lift the tappet 4 forcibly to a highest position as indicated by single-dot chain lines. The pressure within the cylinder combustion chamber 21 (FIG. 1) is thus lowered slightly. Thus, at the time of engine starting manually, the work which must be exerted by the operator is reduced.

The release lever 2 mentioned above has a shape such that a flyweight 2c is formed at its distal end remote from its pivot pin part 2a. After the engine has been started, its speed increases. Therefore the centrifugal force acting on the flyweight 2c gradually increases. Consequently the release lever 2 is urged by the centrifugal force to move in the direction counter to that of the force of the return spring 3. As a result, the decompression cam 2b is turned to an angle at which its effective cam surface is accommodated within the base circle, or minimum radius of the corresponding cam 1a provided on the camshaft 1. Therefore the decompression is automatically ended.

The decompression device of the prior art, however, is accompanied by the following problems.

1. When the flyweight 2c swings by centrifugal force, the return spring 3 tends to rub against the camshaft 1 as indicated in FIG. 6. For this reason, it is necessary to separate this return spring amply from the camshaft 1. At the same time, it is necessary to anchor the end of the return spring 3 on the cam driven gear 5 at a position on the side face so as to return the flyweight 2c to its normal angular position.

Then, the diameter of the cam driven gear 5 must be determined so as to obtain an ample space for assuring stretching of the return spring 3. However, it is difficult to obtain sufficient space for stretching the return spring 3 on the small side face of the cam driven gear 5. Consequently, this difficulty is an obstacle to positively carrying out decompression operation.

2. During normal operation, the return spring 3 is rotated in a continually stretched state as shown in FIG. 6. For this reason, the spring 3 is apt to be adversely affected by disturbances such as vibration. Thus a disturbance in the operation may occur. As a consequence, there occurs malfunctioning such as striking of the spring 3 against the camshaft 1 and pulling back of the release lever 2 to its returned position against the centrifugal force.

The present invention, in which the above described difficulties have been overcome, will now be described in detail with respect to a preferred embodiment thereof and with reference to FIGS. 2 through 5.

The engine with the decompression device according to the present invention is applied is a conventional vertical-shaft engine E shown in FIG. 1. The engine has an oil pan 11 formed integrally with the engine crankcase 22. On the inner side of this oil pan 11, a pump housing 12 is formed as shown in FIG. 2. An oil pump (trochoid pump) 13 is housed within the pump housing 12. Above the oil pump 13, a camshaft bearing 14 is fitted into and fixed to the pump housing 12.

A journal 15a formed at the lower end of the camshaft 15 is rotatably supported by the bearing 14. At the upper part of the journal 15a, a flange-like stepped part 15b is formed on the camshaft 15. The annular lower surface of the stepped part 15b rests rotatably on the upper end of the camshaft bearing 14 over a thrust shim 16 interposed therebetween.

An oil passage 15c is formed centrally in the camshaft 15. The oil pump 13 has a driving shaft 13a coupled to the camshaft 15 at a lower end opening of the oil passage 15c.

Above the stepped part 15b, a cam driven gear 15d is formed coaxially with the camshaft 15. The cam driven gear 15d is meshed with a cam drive gear coaxially fixed to the engine crankshaft 20 (FIG. 1). Above and spaced apart from the cam driven gear 15d, an exhaust cam 15e is formed integrally with the camshaft 15. The cam surface of the exhaust cam 15e is slidably contacted by an exhaust tappet 17 connected to the exhaust valve (not shown).

Although not shown in the figures, a journal part of the upper end of the camshaft 15 is rotatably supported by a bearing provided at an upper part of the engine crankcase 22.

A flat cutout 15f is formed on one lateral side of the camshaft 15 at a part thereof below the lower surface of the exhaust cam 15e and facing the exhaust tappet 17 at the time of the compression stroke. That is, the cutout 15f is positioned on the back side of the cam lobe of the exhaust cam 15e.

The cutout 15f is confronted by a decompression cam 18b formed at the upper end part of a pivot shaft 18a of a release lever 18. The pivot shaft 18a extends through and is rotatably supported in a bore 15g formed in the cam driven gear 15d. The lower base end of the pivot shaft 18a is seated on the thrust shim 16 mentioned before. The release lever 18 has a curved claw-like shape as viewed in plan view in FIG.3 and is fixed at its proximal end on the lower base end of the pivot shaft 18a. Thus the release lever 18 is disposed below and parallel to the lower surface of the cam driven gear 15d. The release lever 18 is thereby pivotable about the axis of the pivot shaft 18a.

The outer part of the release lever 18 constitutes a flyweight 18c. As the camshaft 15 rotates, a centrifugal force acts on the flyweight 18c. The flyweight is thereby urged to swing outwardly in an "opening" direction about the axis of the pivot shaft 18a. This swinging direction is counterclockwise as viewed in FIG. 3. The angle of this swing of the release lever 18 is limited by a stop pin 19 imbeddedly fixed to the lower surface of the cam driven gear 15d.

As shown in FIG. 4, the pivot shaft 18a at the upper end has a lift part 18d in addition to the aforementioned decompression cam 18b. Furthermore, a flat part 18e of the decompression cam 18b is formed as a flat cutout in the upper part of the pivot shaft 18a. Contiguous to the lower end of the flat part 18e is formed a tapered part 18f. A transverse hole 18g is formed through the pivot shaft 18a at a position below the lower end of the tapered part 18f.

A coil spring 20 is loosely fitted around the upper part of the pivot shaft 18a below the tapered part 18f thereof. The upper end of the coil spring 20 is bent inwardly to form an anchor part 20a. The anchor part 20a is fitted in and engaged with the hole 18g in the pivot shaft 18a. The other end of the coil spring 20 extends away from the pivot shaft 18a. An end of the spring 20 is formed into a hook 20b (FIG. 2). The hook 20b is engaged with the upper end of a vertical stud pin 21 press fitted into the cam driven gear 15d.

The coil spring 20 applies a certain torque to the release lever 18 urging it to rotate in the "closing" direction, i.e., clockwise as viewed in FIG. 3. When the release lever 18 (and therefore the flyweight 18c) is in its closed angular state, the lift part 18d of the decompression cam 18b formed at the upper end of the pivot shaft 18a is projected outside of the base circle of the exhaust cam 15e.

On the other hand, when the flyweight 18c is forced open and is stopped by the stop pin 19, the flat part 18e of the decompression cam 18b confronts the exhaust tappet 17. In this state of the mechanism, the flat part 18e is inside the base circle of the exhaust cam 15e.

The decompression device of the above described construction according to the present invention is assembled in the following manner.

First, the coil spring 20 is placed in the cutout 15f formed in the camshaft 15. Then the pivot shaft 18a of the release lever 18, which has been previously assembled in a prescribed manner, is inserted upwardly through the bore 15g from below the cam driven gear 15d.

The decompression cam 18b provided at the upper tip of the pivot shaft 18a is thereupon inserted through the coil spring 20 placed in the cutout 15f. Then the pivot shaft 18a is inserted further upwardly. The anchor part 20a formed at the upper end of the coil spring 20 is thereupon guided in sliding movement along and relative to the tapered part 18f contiguous to the flat part 18e of the decompression cam 18b. The anchor part 20a is thus forced to open outwardly until the tip reaches the hole 18g formed in the back of the tapered part 18f. The anchor part 20a is thereupon forced by its own elastic reaction forced to snap into the hole 18g and thus be engaged therewith.

The hook 20b formed at the other end of the coil spring 20 is fastened to the pin 21 fixed to the cam driven gear 15d. This can be done either before or after the coil spring 20 is loosely fitted on the pivot shaft 18a.

As a result, the coil spring 20 continually exerts a specific torque on the release lever 18 urging it to rotate in its "closing" direction or clockwise as viewed in FIG. 3.

The camshaft 15 with the release lever 18 thus assembled in place as prescribed is then assembled in the engine crankcase.

As described above, the anchor part 20a of the coil spring 20 is guided by the tapered part 18f of the pivot shaft 18a until the part 20a enters and engages with the hole 18g. Therefore there is no necessity of using special tools or jigs for assembly. Thus the assembly efficiency is high.

The decompression device of the above described construction according to the present invention operates in the following manner.

When the engine is stopped, the flyweight 18c of the release lever 18 is in the "closed" state under the biasing force of the coil torsion spring 20. The lift part 18d of the decompression cam 18b formed at the upper tip of the pivot shaft 18a coupled to the flyweight 8c is then projected out of the base circle of the exhaust cam 15e.

Then, when the engine is cranked manually, the camshaft 15 rotates. The rotational speed of the camshaft 15 is low during the initial period of starting. Consequently the centrifugal force acting on the flyweight 18c is weak. Thus the flyweight 18c retains the "closed" state. The decompression cam 18b is forcing the exhaust tappet 17 to be in a position for partially opening the valve at the time of the compression stroke of the pertinent cylinder. The exhaust valve (not shown) is thereby partially opened.

As a result, a portion of the pressure within the cylinder combustion chamber leaks out into the exhaust passage. Then the force to the crank exerted by the operator becomes lighter by that amount.

Then, when the engine has been started, and the rotational speed rises steadily, the centrifugal force acting on the flyweight 18c also increases. After a while, the flyweight 18c overcomes the spring force of the coil spring 20 and pivots outwardly in its opening direction.

Therefore the pivot shaft 18a rotates in the same direction as the flyweight 18c. The lift part 18d thereby enters the base circle of the exhaust cam 15e.

The flyweight 18c pivots in the opening direction until it is arrested by the stop pin 19 as shown by single-dot chain line in FIG. 5. The flat part 18e of the decompression cam 18b thereupon confronts the exhaust tappet 17.

This flat part 18e is on the inner side of the base circle of the exhaust cam 15e. For this reason, the exhaust tappet 17 is released from the lift-up state. Thus the decompression state is automatically terminated. The decompression device is then in the state indicated in FIG. 2.

In this connection, the coil torsion spring 20 is biasing the flyweight 18c in the closing direction with a specific torque. Therefore there is no stretching as in the case of a conventional compression spring even during regular operation. Thus the stability is good at the time of inaction of the decompression device.

The present invention is not limited to the embodiment thereof described above. For example, the intake tappet may be used for obtaining decompression operation. Another possible modification is the use of both the exhaust tappet and the intake tappet for the decompression operation.

Furthermore, the present invention is not limited in application to a vertical-shaft engine. For example, it can be applied with equal effectiveness to other engine types such as the L-type, the V-type, and the horizontal type.

As described above, the present invention affords the features of merit and effectiveness enumerated below.

1. The extreme tip of the pivot shaft of the release lever functions doubly as a decompression cam for forcibly opening a valve. The flat part is formed by providing the pivot shaft with a cutout. Therefore, the shape is simple, and fabrication is facilitated.

2. The rear part of the flat part and an intermediate part of the pivot shaft are continuously formed by way of an intervening tapered part. Furthermore, the return spring is provided around the shaft and is anchored at one end to the cam driven gear. The other end of the return spring is engaged in a hole formed in the pivot shaft at the rear of the tapered part. Therefore, during the assembly of this return spring, the tapered part guides the other end of the spring. Thus, a jig, tools, and the like for assembling are unnecessary. The assembling efficiency is thereby high.

3. A further advantageous feature is due to the disposition of the coil spring around the pivot shaft of the release lever. By this arrangement, the coil spring will not interfere with the movements of the other constituent parts in spite of the extremely small space. As a result, the decompression operation is carried out positively, and disturbances due to causes such as vibration are prevented. Therefore prevention of decompression during normal driving can be assured.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.

Claims

1. A decompression device of an engine having a camshaft (15), a cam driven gear (15d) fixed to said camshaft and driven by a crankshaft of the engine, a valve cam (15e) formed on the camshaft (15), a tappet (17) actuated by said valve cam to open and close a valve of a cylinder of the engine, and a release lever (18) pivotally supported at an end thereof on said cam driven gear (15d) thereby to be swingable in opening and closing directions and being urged by centrifugal force to swing in an opening direction when the cam driven gear rotates: characterized by a pivot shaft (18a) fixed perpendicularly to said release lever (18) at said proximal end thereof and rotatably fitted in the cam driven gear (15d) thereby to pivotally support and be unitarily rotatable with the release lever (18); and spring means (20) provided to exert a return torque on the release lever (18) urging the same to rotate in a closing direction, said pivot shaft (18a) having a cam part (18d) formed as a decompression cam (18b) which is shaped such that during a compression stroke and when the engine speed is low, said cam part (18d) contacts and moves said tappet (17) to a position for partially opening said valve for decompression and that said cam part (18d) permits the tappet (17) to return into normal contact with said valve cam (15e) as the release lever (18) swings in said opening direction under centrifugal force increasing with increasing engine speed.

2. The decompression device according to claim 1, wherein said camshaft (15) is provided with a longitudinal cutout surface (15f) near the cam driven gear (15d), and said decompression cam part (18d) of said pivot shaft (18a) is disposed close to said cutout surface (15f) of the camshaft and partially within the base circle of said valve cam (15e) and comprises a flat part (18e) of the pivot shaft formed parallel to the pivot shaft as a longitudinal cutout surface of the pivot shaft at an end part thereof remote from the release lever (18), said flat surface (18e) confronting said tappet (17) when the release lever (18) has swung in said opening direction, said end part (18d) of the pivot shaft other than the flat surface (18e) contacting the tappet (17) thereby to move the tappet to a position for partially opening said valve when the release lever (18) has been returned in said closing direction.

3. The decompression device according to claim 2, wherein said flat surface (18e) and an intermediate part of the pivot pin (18a) are joined by way of a tapered part (18f) to form a continuous transitional surface.

4. The decompression device according to claim 1,2 or 3 wherein said spring means is a coil

spring (20) fitted loosely around the pivot shaft (18a) and anchored at one end (20a) to the pivot shaft and at the other end (20b) to the cam driven gear (15d) at a part thereof apart from the axis of the pivot shaft (18a).

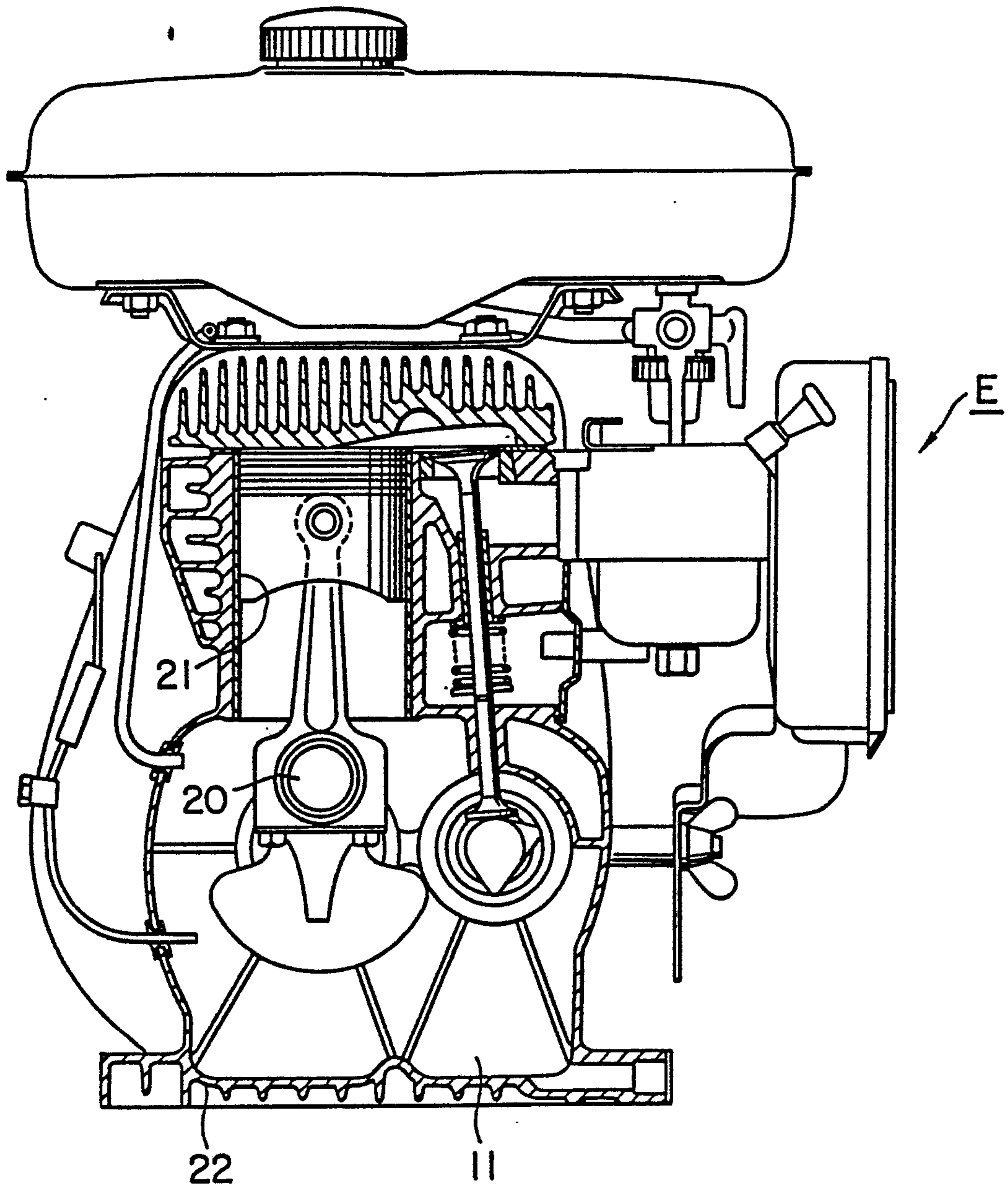
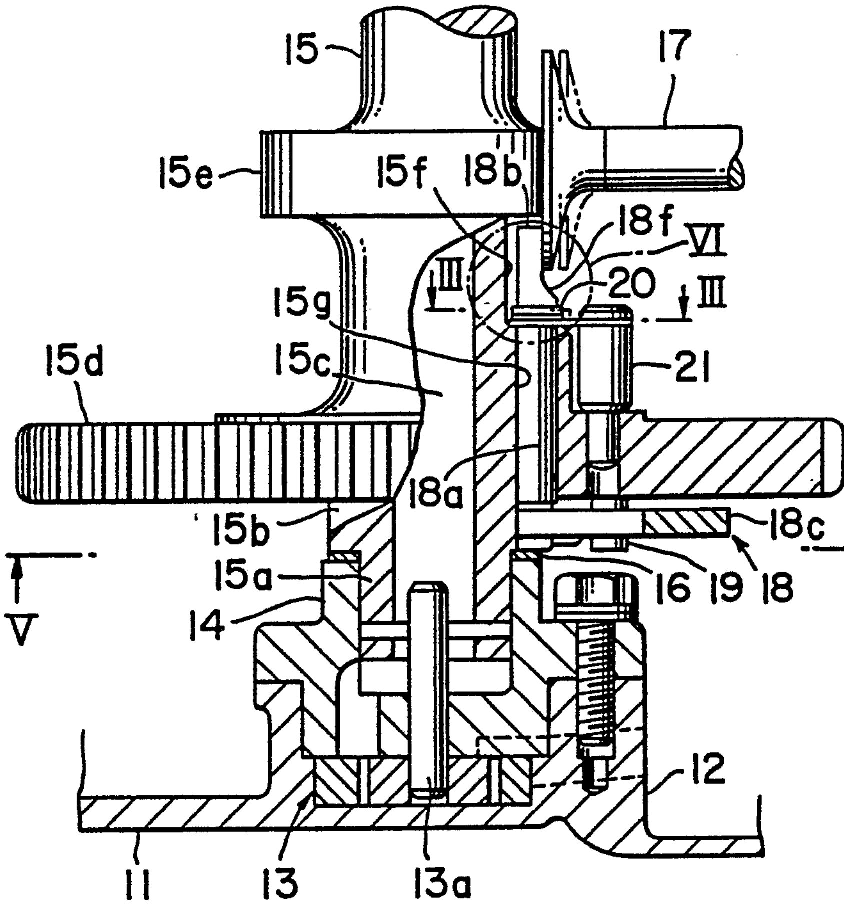


FIG. 1


15
17
15e
15f
18b
18f
VI
III
20
III
15g
15d
15c
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11
13
13a

FIG. 2

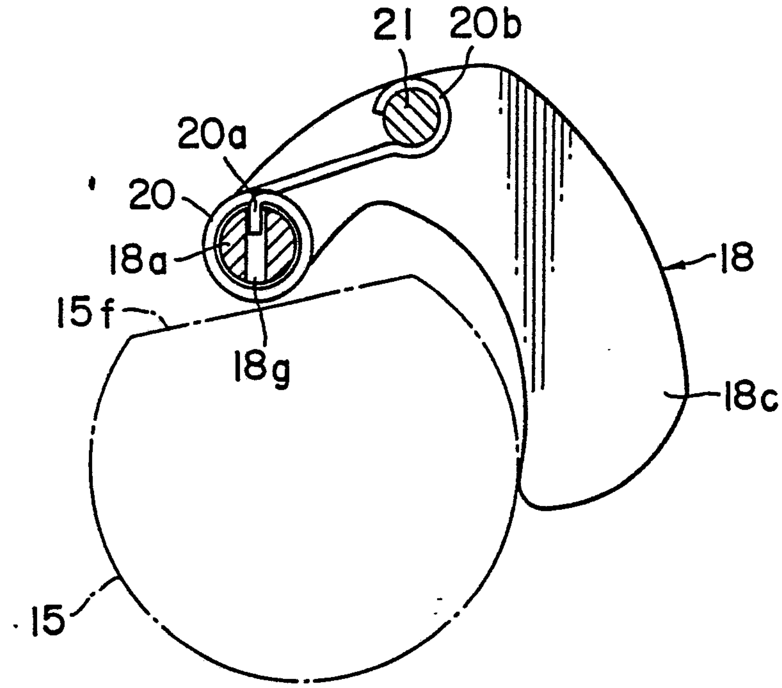

FIG. 3

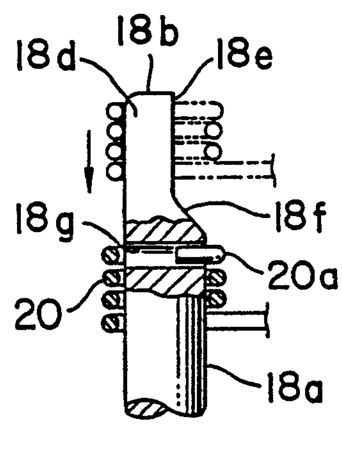

FIG. 4

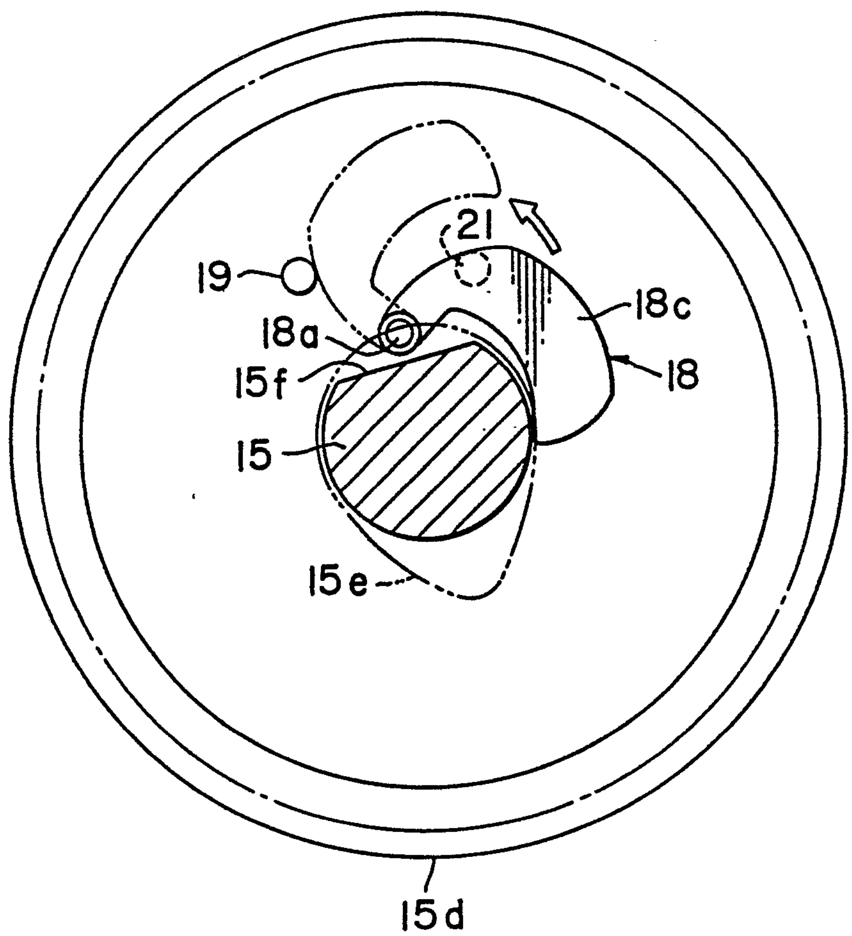

FIG. 5

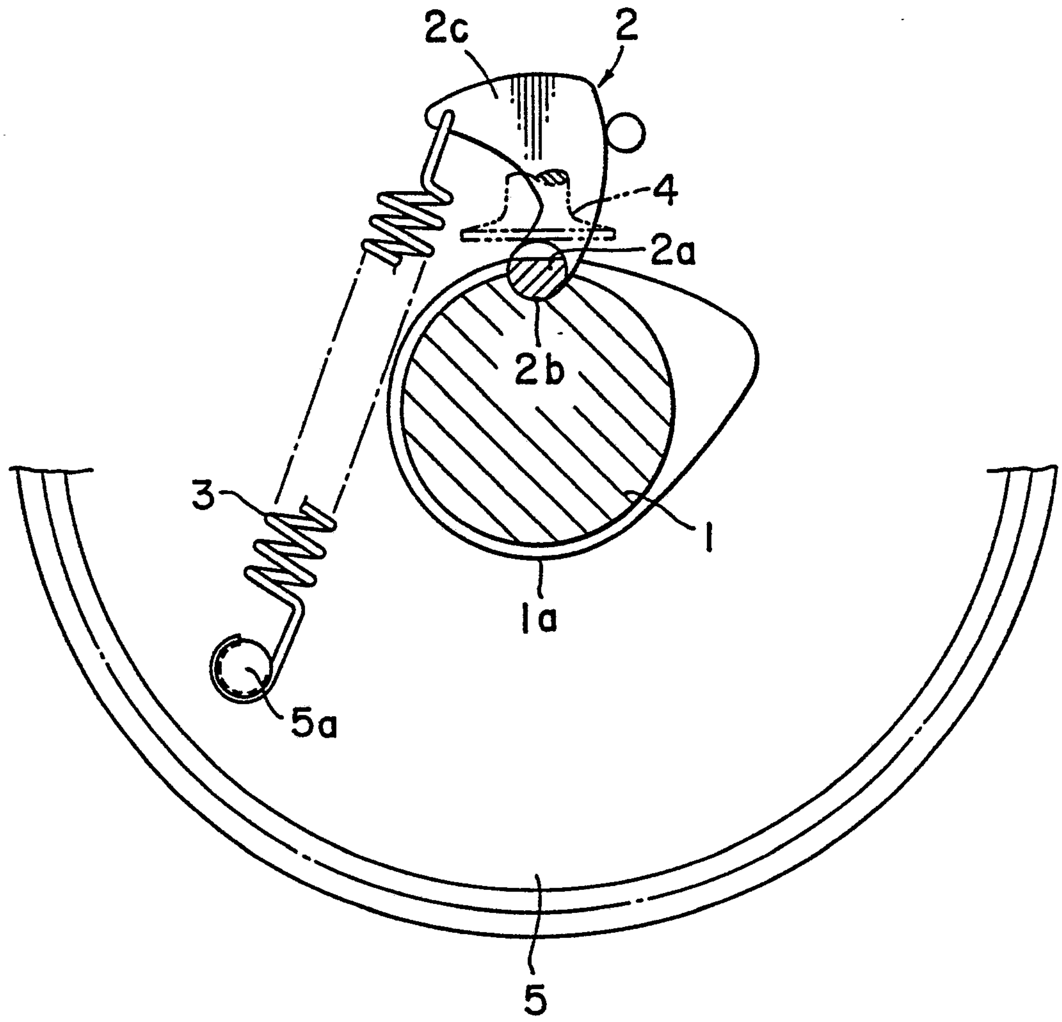

FIG. 6 PRIOR ART

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 11 8252

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-1918844 (TECUMSEH) * page 7, line 18 - page 10, line 17 * * page 17, line 21 - page 18, line 17; figures 1-8 *	1, 4	F01L13/08
A	---	2	
A	EP-A-167691 (FUJI JUKOGYO) * page 6, line 18 - page 7, line 19 * * page 8, line 19 - page 9, line 18; figures 1-3, 6, 7 * -----	1, 2, 4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 JANUARY 1990	LEFEBVRE L.J.F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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