Sept. 20, 1971 G. D. LINE 3,605,707

HYDRAULIC VALVE LIFTER WITH PUMP-UP PREVENTION MEANS

Filed Dec. 4, 1969 3 Sheets-Sheet 1

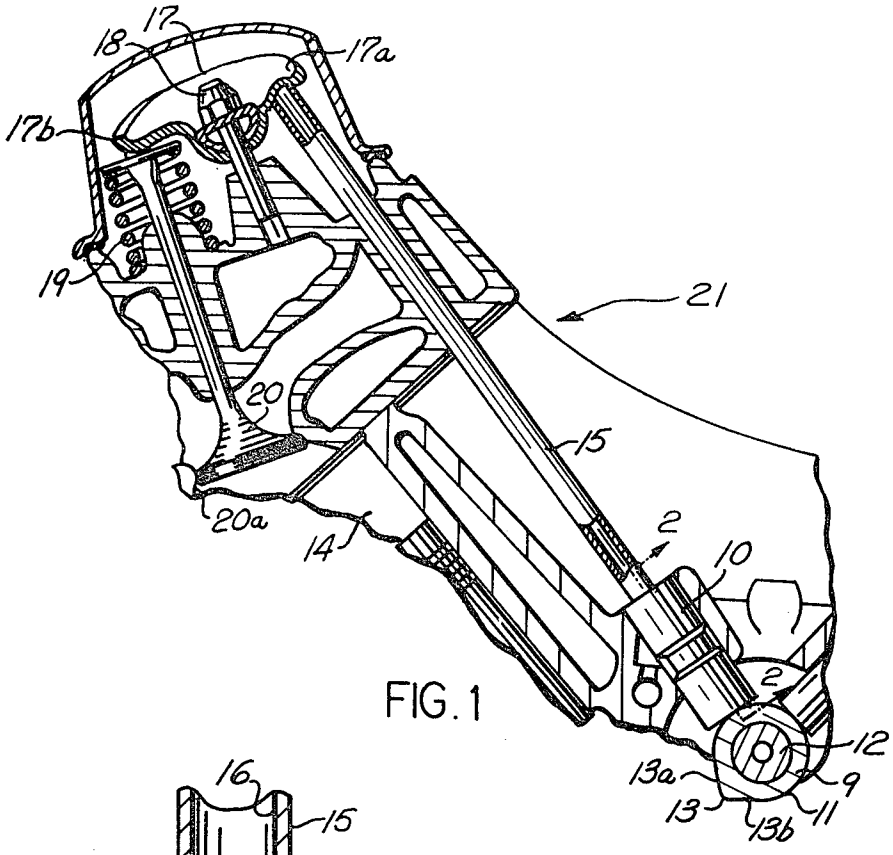


FIG. 1

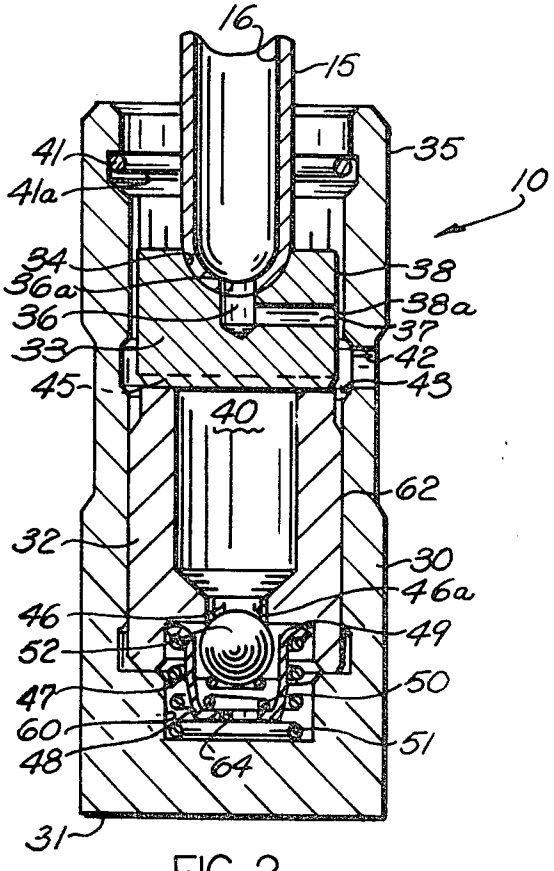


FIG. 2

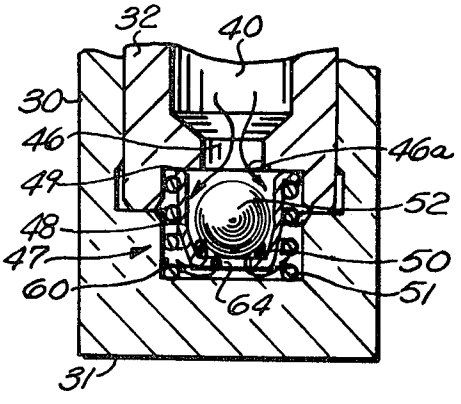


FIG. 3

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HYDRAULIC VALVE LIFTER WITH PUMP-UP PREVENTION MEANS

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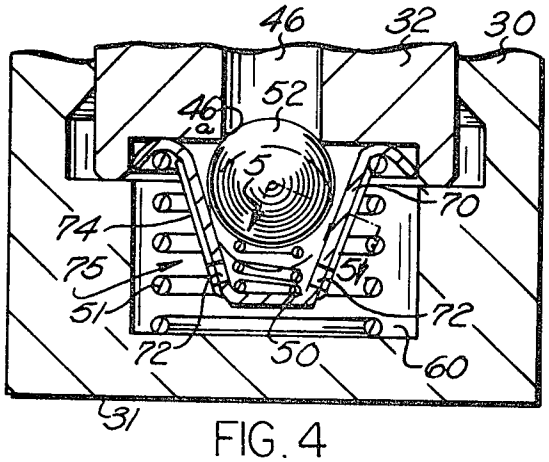


FIG. 4

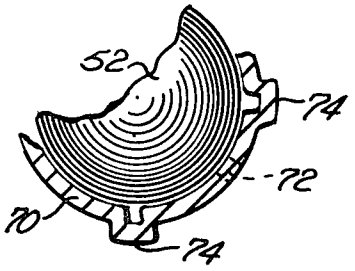


FIG. 5

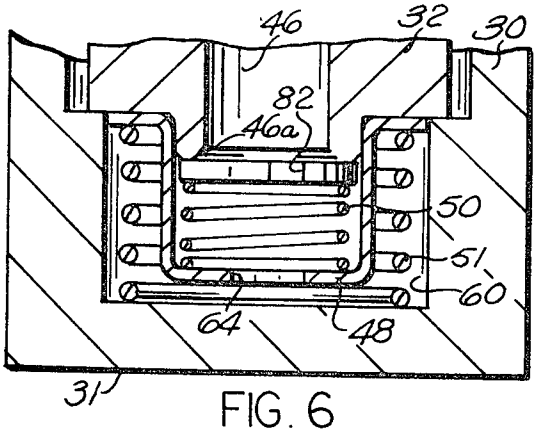


FIG. 6

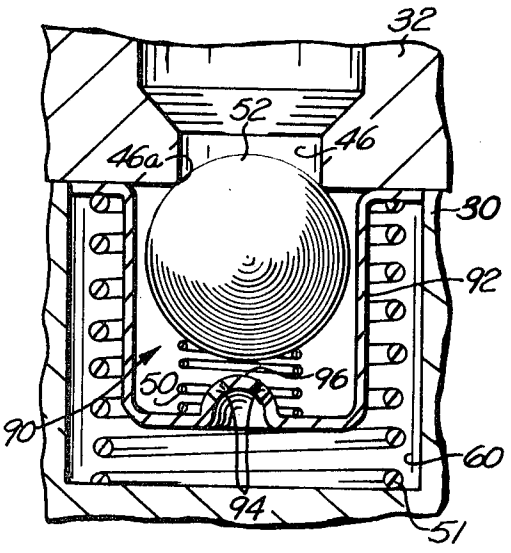


FIG. 7

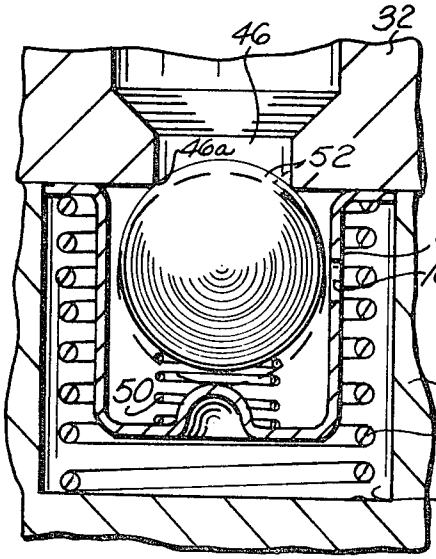


FIG. 8

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HYDRAULIC VALVE LIFTER WITH PUMP-UP PREVENTION MEANS

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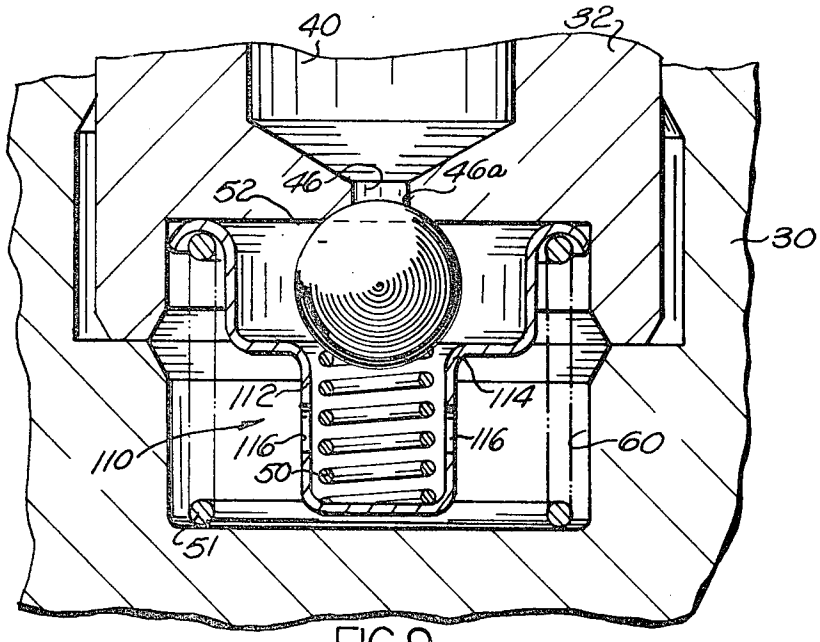


FIG. 9

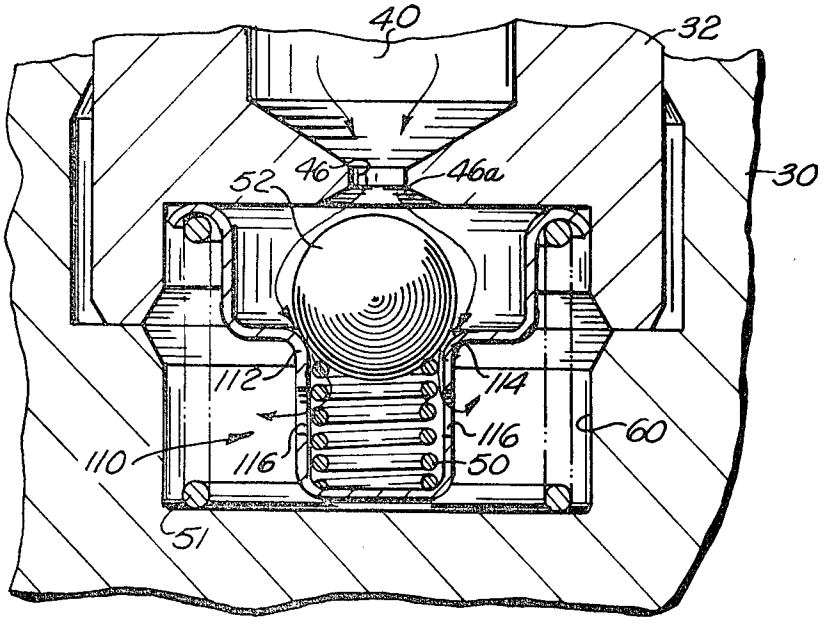


FIG. 10

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HYDRAULIC VALVE LIFTER WITH PUMP-UP PREVENTION MEANS

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Int. Cl. F01l 1/24
U.S. Cl. 123—90.57 1 Claim

ABSTRACT OF THE DISCLOSURE

A hydraulic valve lifter includes body and plunger members which cooperate to define a pressure chamber. The hydraulic valve lifter includes means for preventing "pump-up" of the lifter under the influence of surging of an engine valve spring and for minimizing lash in the valve train at cold engine starting conditions. The means for preventing "pump-up" includes a check valve member, movable between a first limit position in which the valve member blocks a flow of fluid to the pressure chamber and a second limit position in which there is a restricted flow of fluid to the pressure chamber. This restricted flow of fluid prevents "pump-up" of the lifter during surging of the engine valve train and also prevents lash in the valve train during cold engine starting conditions.

The present invention relates to a hydraulic valve lifter, and more particularly to a hydraulic valve lifter having a check valve assembly which prevents "pump-up" of the lifter during valve spring surging which occurs at high vehicle speeds.

A known hydraulic valve lifter used in internal combustion engines includes a valve lifter body and a plunger member slidably received therein and defining a fluid chamber therewith. A check valve is provided to control the flow of fluid to the fluid chamber to thereby control the effective length of the lifter. The check valve assembly of the known lifters allows the effective length of the lifter to increase excessively so that "pump-up" of the lifter occurs during high speed operation of the engine when the valve closing spring for the engine valve reaches critical speeds where the natural frequency of the spring is at a low harmonic of the valve train operating frequency. This condition causes the valve train to surge and allows momentary separation of the valve train. During periods of valve train surge, an intermittent unseating of the check valve occurs permitting a build-up of fluid in the pressure chamber of the known lifter to a point where the hydraulic valve lifter elongates excessively or "pumps-up." This excessive elongation results in continual unseating of the engine valve and a loss of horsepower.

Attempts have been made to correct "pump-up" in conventional hydraulic valve lifters. One attempt to prevent "pump-up" in a hydraulic valve lifter utilizes a check valve that automatically closes and prevents fluid flow to the pressure chamber when surging of the valve train occurs. This type of lifter, illustrated in the Donnelly et al. Patent No. 3,406,668, suffers from the disadvantage that at cold engine starting conditions noise is created in the valve train.

The Donnelly Patent No. 3,406,668 includes a check valve member which controls the flow of lubricant into a pressure chamber which is defined by the plunger and body member of the lifter. The flow of fluid into the pressure chamber controls the elongation of the valve lifter. In order to solve the problem of excessive "pump-up," due to engine valve spring surging, the Donnelly construction provides for the check valve to block the flow of fluid into the pressure chamber at its limit position, to which it

is moved on upward movement of the plunger body. Since the check valve closes off flow to the pressure chamber in this limit position, excessive "pump-up" of the lifter is prevented.

However, since the lubricant in the pressure chamber leaks therefrom when the engine is not operating, a problem of noise at cold engine starting conditions results. The valve lifter, as noted above, will be somewhat in a collapsed condition at cold engine starts. During initial starting, the check valve will move toward its limit position and block the flow of fluid into the pressure chamber. As a result, an amount of fluid will flow into the chamber which is insufficient to take up the lash in the valve train during the cold engine start. Accordingly, noise in the valve train results in the Donnelly construction.

Moreover, since the lubricating fluid has a high viscosity under cold engine starting conditions, the noise problem caused by the check valve blocking fluid flow into the pressure chamber is compounded, since the lubricating fluid will not flow rapidly past the check valve even when it is opened. This further minimizes the amount of fluid flow into the pressure chamber and the time lapse for providing a sufficient volume of fluid in the pressure chamber to take up lash in the valve train.

The present invention is directed to the problem of preventing valve lifter "pump-up" during surging of the valve train and is also constructed to solve the problem of noise during cold engine starts. This is effected in the present invention by, in general, providing a restricted flow of fluid past the check valve member and into the pressure chamber at the limit position to which the check valve member moves from its valve seat. As a result, the check valve member in its limit position does not block or prevent all fluid from flowing into the pressure chamber. However, the flow of fluid that is permitted to flow in this limit position is a restricted or limited flow. This restricted flow is low enough to minimize "pump-up" of the valve lifter during surging of the valve spring, but, yet, is great enough to provide for relative rapid elongation of the lifter to take up lash in the valve train during cold engine starts.

A characteristic of the operation of a lifter having the advantageous flow in accordance with the present invention is that the plunger member will slowly move upward in the lifter, as opposed to the prior art hydraulic valve lifters where the plunger moves upward substantially instantaneously. In fact, as compared to the prior art where the plunger returns instantaneously the plunger of the present construction returns at approximately one-fourth the rate at which the plunger of the prior art returns.

Accordingly, it is an object of the present invention to provide a new and improved hydraulic valve lifter which overcomes the hereinabove noted deficiencies of the prior art by including a check valve assembly which prevents "pump-up" of the lifter during surging of the engine valve train and which minimizes lash in the valve train at cold engine starting conditions.

Another object of the present invention is to provide a new and improved hydraulic valve lifter having a check valve assembly for controlling the flow of fluid into a pressure chamber in the valve lifter and which check valve assembly includes a valve member movable from a first limit position blocking the flow of fluid to the pressure chamber to a second limit position in which the valve member provides for a restricted flow of fluid into the pressure chamber which is sufficiently great to minimize lash in the valve train at cold engine start conditions and is low enough to prevent "pump-up" of the lifter when surging of the engine valve train occurs.

Still another object of the present invention is to provide a new and improved hydraulic valve lifter for use

in an internal combustion engine for opening and closing an engine valve which is biased toward a closed position by an engine valve spring and which lifter includes a body member and a plunger member which cooperate to define a pressure chamber therebetween and means defining a passageway for directing fluid to the pressure chamber, and wherein a check valve member controls the effective cross-sectional area of the passageway to thereby control the flow of fluid into the pressure chamber and wherein the valve member moves from a first limit position blocking the flow of fluid through the fluid passageway through a position in which the passageway has a maximum effective cross-sectional area to a second limit position in which the passageway has a predetermined relatively small cross-sectional area when surging of the engine valve train occurs to thereby restrict the flow of lubricant to the pressure chamber and prevent "pump-up" of the lifter.

A further object of the present invention is to provide a new and improved hydraulic valve lifter, as noted in the next preceding paragraph, wherein the check valve assembly provides for a restricted flow of fluid to the pressure chamber at cold engine starting conditions to thereby prevent lash in the valve train and noisy operation thereof.

Still another object of the present invention is to provide a new and improved hydraulic valve lifter, as noted above, having a pressure chamber and a check valve assembly including a check valve member biased by a spring member toward a first limit position blocking the flow of lubricant to the pressure chamber and movable against the force of the spring member to a second limit position in which the check valve assembly provides for a restricted flow of lubricant to the pressure chamber, the flow of lubricant to the pressure chamber flows through the spaced coils of the spring member so that movement of the check valve member away from the first limit position to the second limit position compresses the spring and reduces the space between the coils thereof to thereby restrict the effective cross-sectional area of the flow path through which the fluid flows to the pressure chamber so that the fluid flow to the pressure chamber is restricted thereby.

A further object of the present invention is to provide a new and improved hydraulic valve lifter, as noted in the next preceding paragraph, further including a check valve retainer member in which the check valve member and the spring member are located and wherein the retainer member includes a projection thereon with which the valve member abuts upon movement to its second limit position to thereby provide a positive stop for the valve member when the spring member is fully compressed so as to prevent damage to the spring member.

Another object of the present invention is to provide a new and improved hydraulic valve lifter for use in an internal combustion engine for opening and closing an engine valve and which includes a check valve assembly for restricting the flow of lubricant to a pressure chamber, the check valve assembly includes a check valve member and a fluted check valve retainer, the check valve member is movable from a first limit position in which it blocks the flow of lubricant to the pressure chamber to a second limit position in which it engages with the fluted retainer member and at which position a restricted flow of lubricant flows to the pressure chamber.

Still another object of the present invention is to provide a new and improved hydraulic valve lifter for use in an internal combustion engine for opening and closing an engine valve and which includes a check valve assembly including a check valve member and a check valve retainer having an opening in the side thereof to provide for fluid flow to the pressure chamber, the check valve member having a first limit position in which it blocks the flow of fluid to the pressure chamber and a second limit position in which the valve member moves toward

the side of the retainer member having the opening to thereby restrict the flow of lubricant to the pressure chamber and prevent "pump-up" of the filter during surging of the valve train and excessive lash in the valve train at cold engine starts.

Further objects of the present invention will be apparent from the following detailed description of a preferred embodiment of the present invention made with reference to the accompanying drawings and forming a part of the specification and wherein:

FIG. 1 is a schematic view of a hydraulic valve lifter and related assemblies in an engine block of a V-type internal combustion engine;

FIG. 2 is a cross-sectional view of an embodiment of the invention taken approximately along the lines **2—2** of FIG. 1;

FIG. 3 is a cross-sectional view of a portion of the valve lifter shown in FIG. 2 and illustrating the check valve member in a position in which the flow of lubricant to the pressure chamber is restricted;

FIG. 4 is an enlarged cross-sectional view of another embodiment of the present invention showing a check valve assembly including a fluted cone shaped retainer;

FIG. 5 is a sectional view taken approximately along the line **5—5** of FIG. 4 and further illustrating the fluted configuration of the retainer member;

FIG. 6 is an enlarged cross-sectional view of still another embodiment of the present invention;

FIG. 7 is an enlarged cross-sectional view of another embodiment of the present invention illustrating a check valve assembly including a check valve retainer having a projection formed thereon for engaging with the valve member and providing a positive stop therefor;

FIG. 8 is an enlarged cross-sectional view of yet another embodiment of the present invention;

FIG. 9 is an enlarged cross-sectional view of another embodiment of the present invention showing a check valve providing for a restricted lubricant flow to the pressure chamber; and

FIG. 10 is another view of the embodiment of FIG. 9 showing the valve member in a flow restricting position.

The present invention provides an improved hydraulic valve lifter, and more particularly an improved check valve assembly in a hydraulic valve lifter which presents "pump-up" of the lifter and also minimizes lash in the valve train at cold engine start-up conditions to thereby provide quiet operation of the valve train. The check valve assembly includes a valve member for controlling the cross-sectional area of a fluid passageway through which the fluid must flow to the pressure chamber to thereby at least partially control the flow of fluid to the pressure chamber. The valve member has a first limit position in which the flow of fluid to the pressure chamber is blocked and is movable to a second limit position in which the fluid passageway has a predetermined minimal effective cross-sectional area which provides for restricted flow of fluid to the pressure chamber. During operation of the lifter, the valve member normally moves from the first limit position and fluid flows to the pressure chamber in a well-known manner. During the occurrence of excessive surging of the engine valve spring and during cold engine starts, the valve member moves to the second limit position in which the cross-sectional area of the passageway has a predetermined effective cross-sectional area which provides for a restricted fluid flow to the pressure chamber to thereby prevent "pump-up" of the lifter under the influence of excessive surging of the engine valve train. The restricted flow when the valve member is in its second limit position is sufficient to substantially minimize lash in the valve train during cold engine starts and thereby prevent noise on cold engine starts.

A valve lifter embodying the present invention may have a variety of constructions. This application discloses different embodiments of the invention, and FIG. 1 illustrates a hydraulic valve lifter **10** embodying the present invention.

The hydraulic valve lifter **10**, as illustrated in FIG. 1, controls the movement of an engine valve **20**. The valve **20** controls the flow of gases into and from the combustion chamber **14** of the cylinder of the engine. The valve member **20** is moved between open and closed positions with respect to a valve seat **20***a* by a valve train, generally designated **21**.

The valve train **21** is actuated by a cam **9** which engages the hydraulic valve lifter **10**. The cam **9** consists of a circular portion **11** and a raised portion **13**, which rotate with a cam shaft **12**. The bottom of the lifter **10** engages with cam **9** which imparts motion to the lifter during rotation thereof. The cam **9** may rotate in either a clockwise or a counterclockwise direction, as viewed in FIG. 1, but for illustrative purposes will be described as rotating in a clockwise direction so that an upward motion is imparted to the lifter **10** as the ramp **13***a* of the cam **9** engages and moves relatively to the lifter **10**. An upward motion of the lifter **10** effects an upward movement of the valve train **21** and opening of the valve **20**. When the ramp **13***b* engages with and moves relatively to the lifter **10**, a downward movement of the lifter **10** and of the valve train **21** is effected. The downward movement of the valve train **21** results in closing of the valve **20**.

The valve train **21** includes a push rod **15** interposed between the lifter **10** and a rocker arm **17**. Movement of the push rod **15** upwardly by the lifter **10** causes the rocker arm **17** to pivot about a bearing **18** and effect opening of the valve **20**. The push rod **15** has a tubular passageway **16** which allows lubricant to flow therethrough from the valve lifter **10** to the bearing **18** of the rocker arm. When the rocker arm **17** is raised by an upward movement of the push rod **15** acting on a shoulder **17***a* thereof, the rocker arm **17** pivots about the bearing **18** and a shoulder **17***b* of the rocker arm **17** exerts a downward force to open the avlve **20**. An engine valve spring **19** biases the shoulder **17***b* upwardly so that when the ramp **13***b* engages with the bottom of the lifter, the spring **19** effects an upward movement on the shoulder **17***b* to engage valve **20** with the valve seat **20***a* and cause the rocker arm **17** to pivot and thereby cause the push rod **15** and valve lifter **10** to move downwardly.

As is known, the hydraulic valve lifter **10** adjusts the valve train **21** to maintain a predetermined relationship between the rocker arm **17** and the cam **9** even though the dimensions of the valve train **21**, rocker arm **17**, valve **20** and the cam **9** may vary due to wear, thermal effects, etc. To this end, the hydraulic valve lifter **10** includes a generally cylindrical cupped shaped body member **30** as illustrated in FIG. 2. The cupped shaped body member **30** has a closed end **31** which is engaged by the cam **9**, as shown in FIG. 1. Disposed within the hollow body member **30** are a plunger member **32** and a push rod socket member **33** having a push rod seat **34**. Seated in the push rod seat **34** is the push rod **15**. A snap ring **41** is disposed in an angular groove **41***a* in an upper portion **35** of the hollow body member **30** to hold the parts of the lifter within the body member **30**.

The plunger member **32** at least in part defines a lubricant reservoir **40**. Lubricant is pumped into a passageway **42** in the portion **35** of the body member **30** by some suitable means, not illustrated, such as a pump. The passageway **42** communicates with an annular groove **43** in the portion **35** of the body member **30** which in turn communicates with a slotted passageway **45** in the socket member **33** to allow lubricant to flow into the reservoir **40**. Therefore, during normal operations the reservoir **40** is filled with lubricant.

The hydraulic valve lifter **10** provides for lubricant flow through the push rod passage **16** to the rocker arm **17**, in any well-known manner. In the illustrated embodiment the socket member **33** has an annular peripheral surface **38** upon which is located an inlet **38***a*. A radially extending passageway **37** is interposed between the inlet **38***a* and a perpendicular passageway **36**. The perpendicular passageway **36** has an outlet **36***a* which is in communication with the push rod seat **34**. The lubricant in the annular groove **43** is directed through the passageways **37** and **36** to the push rod seat. The lubricant then flows through the push rod passageway **16** to the rocker arm **17** to effect lubrication thereof.

The reservoir **40** communicates with a pressure chamber **60** by means of a passageway **46** located in the lower end of the plunger member **32**. Disposed within the pressure chamber **60** is a check valve assembly generally designated **47**. The check valve assembly **47** includes a check valve retainer cup **48**, a check valve spring **50**, and a check valve member **52**. The check valve member **52** is a spherical shaped ball member. The ball **52** is located within the retainer cup **48** which is suitably connected to the plunger member **32** at the shoulder **49**. The check valve spring **50** abuts with the bottom of the check valve retainer cup **48** and biases the ball member **52** upwardly to a first limit position in which the ball **52** engages with a valve seat **46***a* formed at the lower end of the passageway **46**.

The check valve assembly **47** cooperates with the plunger member **30** and the socket member **33** to compensate for dimensional changes in the valve train **21** by varying the axial extent of the hydraulic valve lifter **10** to thereby maintain the predetermined relationship between the cam **13**, rocker arm **17** and valve **20**. To this end, the check valve assembly **47** controls the flow of lubricating fluid to the pressure chamber **60** to thereby control the axial extent of the lifter **10**.

The position of the check valve member **52** is controlled by the spring **50** and fluid pressure forces acting thereon. The pressure within the pressure chamber **60** and the spring **50** exert an upward force on the valve member **52**. This upward force is opposed by the fluid pressure acting on the valve member **52** from the reservoir **40**. When the downward force acting on the check valve member **52** from the reservoir **40** is less than the force acting on the check valve member **52** due to the pressure in the pressure chamber **60** and the force exerted by spring member **50**, the valve member **52** engages the valve seat **46***a* to prevent the flow of lubricant therethrough. When the force acting on the check valve member **52** from the reservoir **40** is greater than the force due to the pressure in the pressure chamber **60** and the force exerted by the spring member **50**, the valve member **52** is moved downwardly and allows lubricant to flow into the pressure chamber **60**.

When the body member **30** is moving in a downwardly direction off the raised portion of the cam **13**, the plunger return spring **51** effects relative movement between the plunger **32** and body member **30** to enlarge the pressure chamber **60** and reduce the pressure therein. As a result, the pressure acting on the check valve member **52** from the reservoir **40** moves the valve member downwardly away from the valve seat **46***a* against the influence of the pressure in the chamber **60** and the check valve spring **50**. This enables fluid to flow from the fluid reservoir **40** into the pressure chamber **60**.

When the body member **30** is again moved upwardly by the cam **13**, the fluid pressure in the chamber **60** is increased. This is due to the upward movement of the body member **30** relative to the plunger member **32** which compresses the plunger return spring **51** and effects a decrease in the volume of the pressure chamber **60**. The increase in pressure in the chamber **60** and the force of the check valve spring **50** combine to overcome the force exerted by the pressure from the reservoir **40** acting on the valve member **52** to allow the member **52** to again seat against the valve seat **46***a* and stop the flow of fluid from the reservoir **40** into the pressure chamber **60**.

When the check valve assembly **47** closes passageway **46** due to an upward movement of the body member **30**, the lubricant in the pressure chamber **60** is essentially sealed therein. The lubricant sealed within the pressure chamber **60** is substantially incompressible and, there-

fore, when the hollow body member **30** is raised the lubricant in the pressure chamber **60** will exert an upward force which resists downward movement of the plunger member **32** relative to the body member **30**. As a result, the plunger member **32** moves in an upward direction thus, opening the valve **20** as described hereinabove.

During each valve opening stroke, small amounts of lubricant trapped in the pressure chamber **60** escape or leak around the plunger **32** through a small space **62** disposed between the body member and the plunger member. The leakage is termed "leak-down" and is necessary in order to insure that the valve **20** can be fully seated on subsequent return strokes which occurs with continued rotation of the cam **9**. Were it not for this "leak-down" during each lifting stroke, if any of the parts of the valve train lengthened, due to an increase in temperature, such greater length would hold the engine valve **20** slightly off its seat **20***a* and effect a decrease in efficiency of the engine.

It should be realized that the check valve assembly **47** controls the effective length of the valve lifter **10**. Thus, if the effective length of the valve train **21** should increase from one revolution of the cam **9** to the next, the distance which the plunger spring **51** moves the plunger **32** and the socket **33** and the amount of replacement fluid which flows into the pressure chamber **60** is decreased to thereby decrease the effective axial length of the lifter **10**. Conversely, if the effective length of the valve train **21** should decrease from one revolution of the cam **11** to the next, the plunger spring **51** moves the plunger member **32** and the socket member **33** outwardly to expand the pressure chamber **60** and enable a relatively large amount of replacement fluid to flow into the pressure chamber to thereby effect an increase in the axial length of the hydraulic valve lifter **10**. In this manner, the check valve assembly **47** cooperates with the plunger member **32** and the socket member **33** to maintain a predetermined relationship between the cam **9**, rocker arm **17** and the valve **20** even though the dimensions of valve train **21** change during operation of the engine.

During high speed operations of the engine, the valve closing spring **19** tends to surge when the valve train reaches critical speeds where the natural frequency of the spring is a low harmonic of the valve train operating frequency. When excessive surging of the spring **19** occurs the effective force of the spring **19** is reduced and momentary separation of the valve train occurs. The temporary slack in the valve train effects an increase in size of the pressure chamber **60** due to the force of the plunger spring **51** located therein.

In known valve lifters, the increase in size of the pressure chamber and the axial length of the hydraulic valve lifter is greater than that necessary to maintain a desired predetermined relationship between the cam, the rocker arm and the valve. This results because the valve lifter tends to expand to take up the temporary slack which is caused by the temporary condition of surging of the entire valve train. When the surging of the valve train continues, a condition known as "pump-up" of the hydraulic valve lifter usually results. This "pump-up" condition results from the inability of known check valves to control the flow of lubricant into the pressure chamber when the surging condition occurs. The "pump-up" condition causes the valve **20** to be held in a partially open condition due to excessive axial extension of the hydraulic valve lifter. When the valve **20** is held in a partial open condition due to a "pumping-up" of the hydraulic lifter, the flow of gases from the combustion chamber of the engine is improperly controlled and a decrease in operating efficiency of the engine results.

In accordance with the present invention, the check valve assembly **47** provides means for metering the flow of lubricant to the pressure chamber **60** upon the occurrence of surging of the valve train **21**. The means for metering the flow of lubricant to the pressure chamber **60** include the check valve member **52**, the check valve spring **50** and the opening **64** located in the lower portion of the check valve retainer member **48**. It should be realized that the flow of lubricant through the fluid passageway **46** into the pressure chamber **60** must flow around the check valve member **52**, through the coils of the check valve spring **50** and through the opening **64** in order to enter the pressure chamber **60**. When the check valve ball member **52** reaches its second limit position, wherein the spring is fully compressed and limits further movement of the ball **52** as shown in FIG. 3, the cross-sectional area of the flow path through which the lubricant must flow into the pressure chamber **60** is substantially reduced so that only a minimal or restricted flow of lubricant flows into the pressure chamber **60**. The restricted lubricant flow to the pressure chamber results due to the fact that compression of the spring reduces the area between the coils of the spring which thereby reduces the cross-sectional area of the flow path of the lubricant to the pressure chamber **60**.

At critical engine operating speeds, when the valve train **21** tends to surge excessively the acceleration of the lifter **10** tends to be rapid and in opposite directions. When a fast upward acceleration of the lifter **10** occurs during surge of the valve train **21**, the inertia of the valve member **52** causes the valve member **52** to move downwardly to its second limit position to compress the spring **50** as shown in FIG. 3 to thereby restrict the flow of lubricant to the pressure chamber. A sudden reversal in the lifter **10** causes the ball member **52** to move upwardly to its first limit position and seat on the valve seat **46***a* thus, blocking the flow of fluid into the pressure chamber **60**. Therefore, it should be realized that a rapid upward movement of the lifter **10** causes the check valve ball **52** to move from its first limit position, shown in FIG. 2, in which it blocks the flow of fluid to the pressure chamber **60**, through a position in which the fluid flow path to the pressure chamber **60** has a maximum effective cross-sectional area through the coils of the spring **50** to the second limit position shown in FIG. 3 in which the fluid flow path to the pressure chamber **60** has a predetermined effective cross-sectional area which is defined as the space between the compressed coils of spring **50**. The predetermined effective cross-sectional area when the spring **50** is compressed is smaller than the maximum effective cross-sectional area which occurs when the ball **52** is in a position intermediate the position shown in FIG. 2 and FIG. 3.

When the valve train **21** starts to surge, it should be realized that the ball member **52** will move rapidly between the position shown in FIGS. 2 and 3 and, therefore, the flow into the pressure chamber **60** will be restricted. This restricted flow of fluid caused by the compression of the valve spring **50** acts as a "pump-up" deterrent and prevents a large flow of fluid into the pressure chamber **60** when surging of the valve train occurs. The restricted flow of the fluid into the pressure chamber allows the plunger member **32** to move upwardly slowly and does not allow sufficient fluid to flow into the pressure chamber **60** to pick any lash that is introduced into the valve train during erratic valve train motions. The restricted flow of fluid into the pressure chamber provides for slow upward movement of the plunger member to its normal operating condition by controlling the fluid flow into the pressure chamber so as to create a vacuum in the pressure chamber which opposes rapid upward movement of the plunger member. While the vacuum does not prohibit the upward movement of the plunger member, it does slow the upward movement substantially so as to eliminate problems of "pump-up" during erratic valve train motions.

When the lifter **10** is allowed to sit in an engine that is not running for a period of time, the fluid in the pressure chamber **60** tends to leak out through the space **62** between the body member **30** and the plunger **32**. This

causes the pressure chamber **60** to be substantially void of lubricating fluid at cold engine starts, and the valve member **52** moves to its second limit position under the influence of the fluid pressure in the pressure chamber **60** when the engine is started. The absence of a substantial amount of lubricant in the pressure chamber **60** when the engine is started causes the lifter **10** to have a reduced axial extent. This reduced axial extent introduces lash in the valve train which causes noisy operation of the valve train. Therefore, to prevent noisy operation of the valve train, it is desirable to allow the lubricant to flow into the pressure chamber **60** to thereby increase the axial extent of the lifter and take up the lash in the valve train. Providing lubricant flow to the pressure chamber **60** is complicated at cold engine starts due to the fact that lubricating fluids generally have a relatively high viscosity at cold temperatures and, therefore, flow slowly to the pressure chamber when the engine is cold.

The present invention prevents noise at cold engine starts by providing for a restricted flow of lubricant into the pressure chamber **60** when the check valve ball **52** compresses the spring **50**. If the check valve ball **50** were to prevent the flow of lubricant into the pressure chamber **60** at cold engine start conditions, a much longer period of time would elapse before the chamber **60** could expand by the flow of lubricant therein. As a result, a longer period of time would elapse before lash in the valve train would be taken up. Thus, the provision of a check valve means which allows a restricted flow of lubricant into the pressure chamber **60**, rather than completely blocking the flow of lubricant into the chamber **60** when the check valve member **52** compresses the spring **50**, eliminates lash in the valve train and a noisy valve train upon cold start ups. This results in the advantage over the prior art valve lifters, such as illustrated in the Donnelly et al. patent, in that an effective anti-pump check valve is provided which does not result in noise in the valve train during cold engine start up conditions. Thus, it should be apparent that the restricted flow of fluid to the pressure chamber is great enough to eliminate lash in the valve train at cold engine starts and yet is small enough to prevent "pump-up" of the lifter during surging of the engine valve train.

For the purposes of providing a more complete understanding of the invention, several modified forms of the invention are shown in FIGS. 4–9. In these modified forms or embodiments of the invention numerals like those used on conjunction with the embodiment of FIGS. 1–3 have been used to designate like parts.

The check valve assembly **75**, illustrated in FIG. 4, provides for a restricted flow of lubricant to the chamber **60**. The check valve assembly **75** includes a check valve ball **52** and a check valve retainer member **70**. The ball **52** is biased by the check valve spring **50** to a first limit position in which it seats against the check valve seat **46***a* to prevent flow of lubricant to the pressure chamber **60**. Downward movement of the check valve ball **52** against the bias of the check valve spring **50** causes the check valve ball **52** to engage with the sides of the check valve retainer **70**.

The retainer member **70** has substantially a conical configuration and has flutes **74** disposed in the side thereof. The flutes **74**, more fully illustrated in FIG. 5, have a cross-sectional area which provides for a predetermined restricted flow of lubricant to the pressure chamber **70** when the ball **52** moves to its second limit position in which it engages with the sides of the retainer **70**. It should be realized that when the ball reaches its lowermost position, as illustrated by the dotted lines in FIG. 4, the flow of lubricant to the pressure chamber **60** will not be entirely blocked. Rather, the lubricating fluid will flow around the ball member **52** through the flutes **74** and through the openings **72** disposed in the side of the retainer member **70**. Thus, it should be apparent that the check valve assembly **75** illustrated in FIG. 4 functions to provide a restricted lubricant flow to the pressure chamber **60** when the check valve ball **52** moves to its limit position in which it engages with the retainer member **70**. This restricted flow of fluid prevents "pump-up" of the lifter and also prevents noisy operation of the valve train by minimizing lash therein in substantially the same manner as the check valve means **47** illustrated in FIG. 2. While the flutes are illustrated at the limit position of the check valve member, it should be apparent that the same results could be obtained by providing the flutes at the top of the retainer where it butts against the plunger member. This construction would also provide a restricted fluid flow to the pressure chamber and prevent "pump-up" of the lifter.

The check valve assembly illustrated in FIG. 6 functions in a manner similar to the check valve **47** illustrated in FIG. 2 with the exception that a flat check valve **82** is provided rather than a check valve ball. It should be apparent in this embodiment that the flow of lubricant into the pressure chamber **60** flows from the passageway **46** around the flat check valve member **82** through the spring member **50** and through the orifice **64** located in the bottom of the retainer **48**. Thus, when the member **82** compresses the spring **50**, the flow of lubricant to the pressure chamber **60** will be restricted as the cross-sectional area of the flow path will be decreased and "pump-up" of the lifter and lash in the valve train will be prevented as discussed hereinabove.

Another embodiment of the check valve assembly for a hydraulic valve lifter is illustrated in FIG. 7. In this embodiment, the check valve means **90** includes a check valve retainer **92**, a check valve spring **50**, a check valve ball member **52**, and a pair of orifices **94** located in the bottom of the retainer **90**. Movement of the ball member **52** in a downwardly direction causes compression of the spring **50** and the spring meters the lubricant into the pressure chamber **60**, as described hereinabove in connection with the embodiment of FIG. 2.

The orifices **94** are disposed on a projection or stop member **96** located on the bottom of the retainer member **92**. The projection **96** provides a positive stop for the check valve ball **52** when the ball moves to its second limit position. In other words, downward movement of the check valve ball member **52** will effect engagement of the ball member **52** with the projection **96** to thereby prevent further downward movement of the ball member **52**. The ball member **52** will engage with the stop member **96** when the spring is compressed so as to meter the flow of lubricant through the orifices **94** to the pressure chamber **60**. The provision of the positive stop **96** prevents damage to the check valve spring **50** that might occur if the spring member is compressed more than necessary. It should be realized, however, that the check valve means **90** functions in substantially the same manner as the check valve means **47** illustrated in FIG. 2 in that compression of the spring **50** provides for the restricted flow of lubricant into the pressure chamber **60** when the check valve ball **52** reaches its lowermost or second limit position, and that the flows are such as to prevent "pump-up" during engine valve train surging and yet minimize noise during cold engine starts.

The embodiment of the invention illustrated in FIG. 8 includes a check valve ball member **52** and check valve spring **50** located in a check valve retainer **98**. The check valve retainer **98** has an orifice **100** located in the side thereof which provides for flow of fluid to the pressure chamber **60**. In this embodiment when the check valve member **52** moves downwardly, the flow of the lubricant through the orifice **100** results in movement of the ball member **52** against the side of the retainer **98**, as illustrated by the dotted line, to thereby restrict the flow of lubricant into the pressure chamber **60** through the orifice **100**. It should be apparent that during the surging of the engine valve train, the ball **52** cooperates with the orifice **100** to provide a restricted flow of lubricant to the pressure chamber **60**. Moreover, at cold engine start

conditions the ball **52** will also move sidewardly to provide for a restricted flow of lubricant to the pressure chamber **60**. Thus, the embodiment of FIG. 8 functions in essentially the same manner as the previous embodiments by providing a restricted flow of lubricant to the pressure chamber **60** to prevent "pump-up" of the lifter during engine valve train surge and minimize lash in the valve train at cold engine starts.

Another embodiment of the present invention, illustrated in FIGS. 9 and 10, includes the check valve assembly **110**. The check valve assembly **110** includes a check valve retainer **112** which supports the check valve spring **50** and the ball member **52**. The check valve retainer **112** has a pair of orifices **116** through which lubricant flows to the pressure chamber **60**. The retainer **112** also has an upper relatively large diameter portion in which the ball member **52** is located, and a relatively small diameter lower portion connected with the upper portion to provide a shoulder **114** which has a substantially circular configuration and a diameter less than that of the ball member **52**.

When the ball member **52** moves in a downwardly direction to the position shown in FIG. 10, the outer surface of the ball **52** cooperates with the shoulder **114** to restrict the flow of lubricant through the orifices **116** to thereby control the flow of lubricant to the pressure chamber **60**. Movement of the ball **52** downwardly restricts the cross-sectional area of the flow path to the pressure chamber **60** which includes the space between the shoulder **114** and the ball member **52**. Thus, downward movement of the ball member **52** restricts the flow of lubricant to the pressure chamber as described hereinabove.

In this embodiment, it has been discovered that the flow dynamics result in forces acting on the ball **52** so that the ball does not seat on the shoulder **114** but rather moves downwardly to a position where the ball and the shoulder **114** assume a spaced apart relationship which provides for a restricted flow of lubricant to the pressure chamber **60**. It should be noted that a modification of this embodiment could be constructed so that the ball would seat on the shoulder **114**. In the modified form where the ball **52** seats on the shoulder **114**, the shoulder **114** could have a number of flutes disposed therein similar to the flutes of the embodiment of FIG. 4 or the flutes could be disposed on the top of the retainer where it butts against the plunger member. The flutes would provide for a restricted flow to the pressure chamber when the ball engaged with the shoulder **114**.

Since, due to the particular construction of the check valve of the embodiment shown in FIG. 9, the check valve ball member **52** will not engage the shoulder **114**, a flow passageway will be continually maintained therebetween. As a result, a restricted flow of fluid to the chamber **60** will occur, even though the ball is in its limit position, illustrated in FIG. 10. This restricted flow of fluid, as in the other embodiments described above, is slow enough to prevent pump-up of the valve lifter during valve train surging but, yet, is large enough to minimize lash in the valve train during cold engine starts and thereby prevent noise resulting therefrom.

It has been observed that the plunger member **32** will return at a very slow rate to its normal operating position during operation of the valve lifter. This should be compared with the normal rate of return of valve lifters which is substantially instantaneous. In the valve lifter construction of FIG. 9, the plunger member **32** will return to its normal operating position in the lifter at about one-fourth the rate at which the plungers of the prior art will return to the positions.

From the foregoing, it should be apparent that a new and improved hydraulic valve lifter has been provided which prevents "pump-up" of the lifter under the influence of surging of the engine valve train and also which minimizes lash in the valve train during cold engine starts. The valve lifter includes a body member and a plunger member which cooperate to define a pressure chamber therebetween. A check valve assembly is provided to restrict the flow of lubricant into the pressure chamber. The check valve assembly includes a valve member which is movable from a first limit position blocking the flow of lubricant into the pressure chamber to a second limit position in which the valve member restricts the flow of fluid to the pressure chamber. This restricted flow of fluid to the pressure chamber prevents "pump-up" of the valve lifter during surging of the engine valve spring. Moreover, the anti-pump up means provided in the present invention also provides for quiet operation of the valve train during cold engine starts by providing a restricted flow of lubricant to the pressure chamber when the valve member is in its second limit position to thereby minimize lash in the valve train. This provides a distinct advantage over known anti-pump up devices which prevent lubricant flow to the pressure chamber at cold engine starts and thereby cause excessive lash in the valve train.

Having described my invention, I claim:

1. A hydraulic valve lifter for use in a valve train of an engine valve of an internal combustion engine and which engine valve is biased closed by an engine valve spring which surges at critical operating speeds and effects surging of the valve train, said valve lifter comprising a body member, a plunger member located in said body member, said body member and said plunger member defining a chamber therebetween, said plunger member defining a fluid reservoir, a fluid passageway means providing for fluid flow between said reservoir and said chamber, said means for preventing pump-up of the lifter during the surging of the engine valve train, said means including a spherical valve member for controlling the flow of fluid to said chamber and movable from a first limit position in which said valve member blocks the passageway through a position in which the passage has a maximum effective cross-sectional area to a second limit position in which the passageway has a predetermined cross-sectional area smaller than said maximum effective cross-sectional area, a spring member biasing said valve member to said first limit position, said valve member being movable to said second limit position against the force of said spring member during engine valve train surging, and a retainer member, having a substantially frustoconical configuration and including fluted passages disposed thereon, for containing said valve member and said spring, said valve member engaging said retainer member in the second limit position and said fluted passages allowing fluid flow into said fluid chamber when said valve member is in said second limit position.

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