This invention relates to lash adjusting mechanism such as is adapted for use with engine valve operating trains, and more particularly to an extremely simplified system for compulsorily creating potential lash while the train is loaded so that a lash take-up device may preclude actual lash as the load on the train is relieved.

The modern high compression overhead valve type of automotive engine customarily utilizes valve trains of the rocker arm type which valve trains, being fairly long, are frequently provided with automatic lash adjusting devices. Such devices, as heretofore utilized commercially, are almost entirely of the hydraulic type; however, the sensitivity of hydraulic valve lifters to varnish and dirt has led designers to seek improved reliability in automatic lash adjusters through the use of purely mechanical devices.

Hereinafter, mechanical lash adjusters, loaded by a lash take-up spring, have repeatedly been proposed which depend for their operational success upon a critical frictional requirement between contacting surfaces to create potential lash whenever the valve is actuated. Frequently this is exemplified by use of a force-multiplying mechanism, such as a wedge, eccentric or a helix utilized at or near the critical friction angle. While such devices may operate under ideal conditions, unavoidable small changes in the friction co-efficient which arise under actual operating conditions render such sensitive devices inherently unreliable. For this reason, it has been proposed to use a force-multiplying type lash adjuster with angles safely below the critical frictional angle have depended upon critical frictional requirements elsewhere, either in the driving or the reaction connection, or both, with the means for operating the force-multiplying arrangement. Again, such connections may hold and release at the proper times under specific conditions, but are similarly subject to diverse environmental factors during engine operation that render them not entirely satisfactory.

It has recently been proposed to shift an inherently self-locking force-multiplying lash adjusting device relative to the valve train in a manner of fully compulsive driving and reaction connections not dependent upon critical friction angles. This is accomplished by providing a positive grip clutch which coaxes itself during the valve opening stroke and then positively grips the force-multiplying mechanism during the valve closing stroke to move the mechanism to introduce potential lash into the train, a separate releasing device becoming operative before the valve seats to disengage the clutch so that the lash take-up spring may function upon valve seating. While such devices are certainly operative during actual use in automotive engines, the expense of providing the various component parts which comprise the clutch driver and clutch releaser tend to make the initial and repair costs prohibitive for mass production use.

Accordingly, it is an object of the present invention to provide a spring-loaded mechanical lash adjuster utilizing an inherently self-locking force-multiplying mechanism which is shifted in the direction of increased lash by positive means including fully compulsive driving and reaction connections and which is extremely simple and desirably inexpensive to manufacture, adjust and maintain.

More particularly, it is an object of the present invention to provide a mechanical lash adjuster comprising an eccentric pivoted in one end of a rocker arm to form a portion of the valve actuating train, which eccentric is positively driven about its pivot on the valve opening stroke in the direction of increased lash by means of a fixed abutment positioned on the engine itself, such potential lash being removed after the valve seats by a biasing spring connected to pivot the eccentric back in the direction of decreased lash.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein several forms of the present invention are illustrated.

FIGURE 1 is a purely diagrammatic illustration of the operational theory of the present invention.

FIGURE 2 is a developed diagram of valve stem travel as compared with cam configuration.

FIGURE 3 is a cross-sectional elevational view of a rocker arm pivoted about an upright stud and including the lash adjusting arrangement of this invention.

FIGURE 4 is a fragmentary top view of the valve actuating end of such rocker arm.

FIGURE 5 is a cross-sectional elevational view of a rocker arm pivoted about a longitudinal shaft and including the lash adjusting arrangement of this invention.

FIGURE 6 is a fragmentary top view of the valve actuating end of such a rocker arm.

The invention has been illustrated in embodiments suitable for use with valve trains which employ fulcrumed rocker arms. Regarding FIGURE 1, such valve trains ordinarily comprise a valve 10 having a stem 12 and a flared head 14 which is biased against an annular seat 16 in the engine 18 by means of a heavy valve seating spring 20. The valve is mounted for limited longitudinal reciprocatory motion by means of a tubular valve guide 22 positioned in the engine 18 whereby force applied to the end of the valve stem 12 compresses the spring 20 and shifts the head 14 of the valve away from the fixed seat 16. Such a valve is operated by means of a cam 24 rotated by a camshaft 26 journalled in the engine 18.

Motion is transmitted from the cam surface to the valve by means of a valve actuating train which ordinarily may comprise a cam follower or tappet 28, a push rod arrangement 30, and a rocker arm assembly 32. The rocker arm may be fulcrumed at 34 intermediate its ends to a pivot fixed on the engine 18, and may have means 36 at one end thereof forming a push rod abutment and means 38 at the other end thereof forming a valve stem abutment. As the rotating cam 24 presents a rising face to the tappet 28, it will be clear that upward motion of the push rod arrangement 30 will oscillate the rocker arm 32 clockwise (FIGURE 1) about the fixed pivot 34 to open the valve 10; as the cam 24 presents a falling face to the tappet 28, the valve closing spring 20 maintains a counter-bias on the entire valve actuating train forcing such linkage members back in response to the falling cam contour.

It has long been appreciated that because of temperature requirements and wear conditions, the valve actuating train varies in effective length. When the train is too long, for instance, the valve will be too open a seat even when the cam presents its base circle to the follower, a very undesirable condition resulting in burned valves. When the train is too short, on the other hand, such lash in the system creates noisy operating conditions. This invention provides means for controlling the effective length of the valve actuating train by introducing potential lash into the train each cycle so that the valve may seat properly, and then eliminating all actual lash from the train prior to the next valve opening so that undesirable noise will be eliminated.

Such a result may be accomplished by the elements illustrated purely schematically in FIGURE 1. There, the push rod arrangement 30 is shown composed of several segments, the two lowermost of which are guided for rectilinear motion in bushings 40 which form fully
compulsive reaction connections for lateral forces. These two push rod segments are interconnected by a wedge device \(2 \) which may be shifted laterally relative to the valve train to vary the effective length \( \text{44,56,68} \). The slope of the wedge surface is well below the critical friction angle, whereby such device may be termed self-locking; that is, the force of valve train load created by the valve seating spring \(20 \) is unable to squeeze the wedge laterally to the left in the direction of increased lash.

The force-multiplying wedge is biased relative to the valve train in the direction of decreased lash by means of a lash take-up spring \(44 \). This spring is not strong enough to shift the wedge relative to the train while the train is under valve spring load; consequently, its acts only after the valve has seated and the cam approaches its base circle whereupon such lash take-up spring may shift the wedge to remove slack from the train prior to the next valve opening stroke.

This invention provides positive means for shifting the force-multiplying wedge \(42 \) in the direction of increased lash each time the valve is actuated to insure proper seating thereof. Such positive means may include a fully compulsive one-way drive which will completely disengage with the force-multiplying mechanism by the time the valve seats so that the lash take-up spring may operate. Such a drive may include a single pair of abutments sliding relative to one another in response to motion of the valve train itself. Such a pair of abutments will come together from spaced positions to an engaged position of driving contact; the engaged position may include driving contact of either the direct variety involving no further relative shifting, or the camming or "wedge" variety involving relative shifting while engaged which may be smoothed by the addition of a roller or other wear inhibiting device. For instance, a roller abutment \(46 \) associated with the self-locking force-multiplying mechanism \(42 \) is positioned to approach and engage a camming abutment \(48 \) fixed on the engine \(18 \).

On the valve opening stroke, as the push rod arrangement is being lifted by the rising face of the cam \(24 \), the abutments \(46 \) and \(48 \) will come together forming a fully compulsive driving connection and shift the wedge \(42 \) to the left in the direction of increased lash to create potential lash in the train. During the entire valve closing motion, it will be obvious that the two abutments \(46 \) and \(48 \) move steadily apart because the wedge is held in its shifted position by the locking angle thereof. After the valve seats, the lash take-up spring \(44 \) may then become operative to bias the wedge to the right in the direction of decreased lash through the distance required to take up any actual lash that may have existed in the train. Thus, as the cam begins to lift the push rod arrangement on the next valve opening stroke, all lash will be removed from the train and silent operation will be insured.

In FIGURE 2, there is shown by the line \(50 \) a horizontal plot of cam motion, but showing only the portion of the action when the lobe of the cam is effective. The upper line \(52 \) plots the corresponding movement of the valve stem to show the differences which are introduced by the lash adjuster mechanism. It will be seen from FIGURE 2 that the cam motion and the valve stem motion correspond exactly during the initial portion of the rising part of the cam ramp due to the non-slipping quality of the wedge. After point \(54 \), the one-way drive begins to shift the force-multiplying member \(42 \) in the direction of increased lash. This motion introduces an increment of potential lash into the valve train. At a time after maximum cam rise is completed at point \(56 \), the two abutments \(46 \) and \(48 \) will engage each other and thereafter no further lash is introduced into the train, and the valve stem follows the motion of the cam until a point such as \(58 \) is reached where the valve seats. Thus, the valve stem comes to rest with the valve head on its seat earlier than the cam has allowed the operating members of the train to reach the end of their return travel. The lash take-up spring \(44 \) is then able to shift the member \(42 \) since that member is now entirely free of the one-way abutment drive and the locking force of the valve spring. As the cam recedes further, the member \(42 \) is driven to the right by spring \(44 \) to such lengths that the train as fast as the contour of the cam will permit.

The lash take-up spring \(44 \) is kept free of lash by the one-way drive becomes wiped out and the parts come to rest with no lash in the system.

In FIGURES 3 through 6, two operative embodiments of the lash adjusting system of this invention are illustrated. In FIGURES 3 and 4, an embodiment is disclosed for use with an upright rocker arm pivot supporting stud. In FIGURES 5 and 6, an embodiment is shown for use with a longitudinal rocker arm pivot shaft.

In FIGURES 3 and 4, a rocker arm \(132 \) of the trough shaped or dished variety is individually pivoted about a semi-spherical fulcrum \(134 \) fixed on the engine and includes means forming a push rod abutment \(136 \) at one end thereof to receive a push rod \(130 \) and a valve stem abutment \(138 \) at the other end thereof. Semi-permanent adjustments in the length of the valve actuating mechanism may be obtained by means of an adjusting nut \(140 \) of the self-locking variety which effects an upward or downward positioning of the fulcrum \(134 \).

The valve stem actuating end of the rocker arm \(132 \) includes lash adjusting mechanism according to this invention. An eccentric roller \(142 \) may be trunnioned on a shaft \(143 \) for oscillatory motion in the bifurcated end of the rocker arm. A lash take-up spring \(144 \) connected to the eccentric at \(145 \) may bias the high side of the eccentric towards the valve stem to wipe out potential lash after the valve seats. An abutment cam surface \(146 \) on the eccentric may be designed to engage a fixed abutment comprising a rollable sleeve \(147 \) on a shaft \(148 \) suitably mounted on the engine during the valve opening stroke to oscillate the eccentric about its trunnel \(143 \) in the direction of increased lash. The distance between the center of the eccentric and the center of its trunnion mounting in the rocker arm is large enough to provide the desired distance differential for the required amount of potential lash, yet is small enough to provide a moment arm arrangement which is so short so as to be completely self-locking against the valve spring load on the actuating train.

In FIGURES 5 and 6, a rocker arm \(232 \) is mounted for oscillation about a pivot shaft \(234 \) fixed on the engine and includes means forming a push rod abutment \(236 \) at one end thereof to receive a push rod \(230 \) and a valve stem abutment \(238 \) on the other end thereof. Semi-permanent adjustments in the effective length of the valve actuating mechanism may be obtained by means of an adjusting screw \(240 \) threaded in the rocker arm and associated with the push rod abutment \(236 \) thereof.

A self-locking eccentric roller \(242 \) may be trunnioned on a shaft \(243 \) for oscillatory motion in the bifurcated valve stem actuating end of the rocker arm. A shoulder \(245 \) of the eccentric is biased in the direction of decreased lash by means of a lash take-up spring \(244 \). An abutment cam surface \(246 \) on the eccentric may be designed to engage a fixed abutment comprising a rollable sleeve \(247 \) on a fixed shaft \(248 \) mounted on the engine during the valve opening stroke to turn to the low side of the eccentric towards the valve stem to positively introduce potential lash into the train.

In operation, both the FIGURE 3 and the FIGURE 5 embodiment function similarly and upon the theory illustrated in FIGURES 1 and 2. As the rocker arm is oscillated in a clockwise direction, the lower edge of the eccentric is turned the low side of the eccentric towards the valve stem to positively introduce potential lash into the train. However, if the eccentric is turned the high side of the eccentric towards the valve stem to positively introduce potential lash into the train.
the engine and oscillate the eccentric in a counter-clockwise direction relative to the rocker arm to a given point to introduce potential lash into the valve operating train. On the valve closing stroke, as the rocker arm oscillates back in a counter-clockwise direction about its fulcrum, such potential lash will be retained in the valve actuating train by the self-locking design of the eccentric to insure proper seating of the valve. As the valve seats and before the rocker arm has completed its increment of return motion following the falling contour of the cam, the lash take-up spring which is too weak to operate while the train is loaded becomes effective to oscillate the eccentric in a clockwise direction relative to the rocker arm about its trunnion to wipe out any potential lash that had been introduced into the train. Thus, all lash is removed from the valve actuating train and, on the next valve stroke, the eccentric will act as an integral part of the linkage until the abutment cam surface thereon comes into contact with the fixed abutment to again introduce an increment of potential lash into the train.

While the embodiments of the invention herein disclosed constitute preferred forms, it is to be understood that other forms might be adapted, all coming within the scope of the claims which follow.

I claim:

1. A lash adjusting system of the mechanical type for a valve operating train of an engine comprising in combination therewith:
   - force-multiplying means shiftable in one direction and return through a limited stroke to decrease and increase, respectively, the effective length of the train by a predetermined amount,
   - a single pair of abutments movable toward and away from one another between spaced and engaged relationships in response to valve opening and valve closing motion of the train, respectively, one of the abutments being associated with the force-multiplying means and the other abutment being located to engage the one abutment part way through the valve opening motion of the train and thereafter compulsively rotate the force-multiplying means in the one direction from a mid-stroke position through the distance required to reach the limit of its stroke to create a corresponding amount of potential lash in the train, the force-multiplying means being inherently self-locking against the force of valve train load to retain such amount of potential lash in the train during valve closing motion of the train as the abutments disengage and move away from one another,
   - yieldable biasing means having insufficient force to shift the force-multiplying means while the train is loaded and connected to shift the force-multiplying means in the return direction away from its stroke limit to a mid-stroke position through the distance required to remove actual lash from the train as the load on the train is relieved by seating of the valve.

2. A lash adjusting system of the mechanical type for a valve operating train of an engine comprising in combination therewith:
   - a rocker arm means intermediate the ends of the rocker arm forming a fulcrum,
   - means on one end of the rocker arm forming a push rod connection,
   - means on the other end of the rocker arm forming a valve stem connection,
   - one of the means including rotary wedge type force-multiplying means rotatable in one direction and return through a limited stroke to decrease and increase, respectively, the effective length of the train by a predetermined amount,
   - a single pair of one-way drive abutments movable toward and away from one another between spaced and engaged relationships in response to valve opening and valve closing motion of the train, respectively, one of the abutments being associated with the force-multiplying means and the other abutment being located to engage the one abutment part way through the valve opening motion of the train and thereafter compulsively rotate the force-multiplying means in the one direction from a mid-stroke position through the distance required to reach the limit of its stroke to create a corresponding amount of potential lash in the train,
   - the force-multiplying means being inherently self-locking against the force of valve train load to retain such amount of potential lash in the train during valve closing motion of the train as the abutments disengage and move away from one another,
   - and a lash take-up spring having sufficient force to rotate the force-multiplying means while the train is loaded and connected to rotate the force-multiplying means in the return direction away from its stroke limit to a mid-stroke position through the distance required to remove actual lash from the train as the load on the train is relieved by seating of the valve.

3. A lash adjusting system of the mechanical type for a valve operating train of an engine comprising in combination therewith:
   - an eccentric rotatable in one direction and return through a limited stroke to decrease and increase, respectively, the effective length of the train by a predetermined amount,
   - a single pair of one-way drive abutments movable toward and away from one another between spaced and engaged relationships in response to valve opening and valve closing motion of the train, respectively, one of the abutments being associated with the eccentric and the other abutment being located to engage the one abutment part way through the valve opening motion of the train and thereafter compulsively rotate the eccentric in the one direction from a mid-stroke position through the distance required to reach the limit of its stroke to create a corresponding amount of potential lash in the train, the eccentric being inherently self-locking against the force of valve train load to retain such amount of potential lash in the train during valve closing motion of the train as the abutments disengage and move away from one another,
   - and a lash take-up spring having insufficient force to rotate the eccentric while the train is loaded and connected to rotate the eccentric in the return direction away from its stroke limit to a mid-stroke position through the distance required to remove actual lash from the train as the load on the train is relieved by seating of the valve.

4. A lash adjusting system of the mechanical type for a valve operating train of an engine comprising in combination therewith:
   - a rocker arm means intermediate the ends of the rocker arm forming a fulcrum,
   - means on one end of the rocker arm forming a push rod connection,
   - means on the other end of the rocker arm forming a valve stem connection,
   - one of the means including rotary wedge type force-multiplying means rotatable in one direction and return through a limited stroke to decrease and increase, respectively, the effective length of the train by a predetermined amount,
   - a single pair of one-way drive abutments movable toward and away from one another between spaced and engaged relationships in response to valve opening and valve closing motion of the train, respectively, one of the abutments being associated with the force-multiplying means and the other abutment being located to engage the one abutment part way through the valve opening motion of the train and thereafter compulsively rotate the force-multiplying means in the one direction from a mid-stroke position through the distance required to reach the limit of its stroke to create a corresponding amount of potential lash in the train,
the force-multiplying means being inherently self-locking against the force of valve train load to retain such amount of potential lash in the train during valve closing motion of the train as the abutments disengage and move away from one another, and a lash take-up spring having insufficient force to rotate the force-multiplying means while the train is loaded and connected to rotate the force-multiplying means in the return direction away from its stroke limit to a mid-stroke position through the distance required to remove actual lash from the train as the load on the train is relieved by seating of the valve.

5. A lash adjusting system of the mechanical type for a valve operating train of an engine comprising in combination therewith

a rocker arm,

means intermediate the ends of the rocker arm forming a fulcrum and means on one end of the rocker arm forming a push rod connection,

means on the other end of the rocker arm forming a valve stem connection including a trunion mounting,

an eccentric trunnioned thereon with its surface engageable with the end of a valve stem and being rotatable in one direction and return through a limited stroke to decrease and increase, respectively, the effective length of the train by a predetermined amount, a single pair of one-way drive abutments movable toward and away from one another between spaced and engaged relationships in response to valve opening and valve closing motion of the train, respectively, one of the abutments being associated with the eccentric and the other abutment being located on the engine to engage the one abutment part way through the valve opening motion of the train and thereafter compulsively rotate the eccentric in the one direction from a mid-stroke position through the distance required to reach the limit of its stroke to create a corresponding amount of potential lash in the train, the eccentric being inherently self-locking against the force of valve train load to retain such amount of potential lash in the train during valve closing motion of the train as the abutments disengage and move away from one another, and a lash take-up spring having insufficient force to rotate the eccentric while the train is loaded and connected to rotate the eccentric in the return direction away from its stroke limit to a mid-stroke position through the distance required to remove actual lash from the train as the load on the train is relieved by seating of the valve.

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