Nov. 21, 1961 H. H. ENGEMANN 3,009,450

AUTOMATIC CLEARANCE REGULATOR

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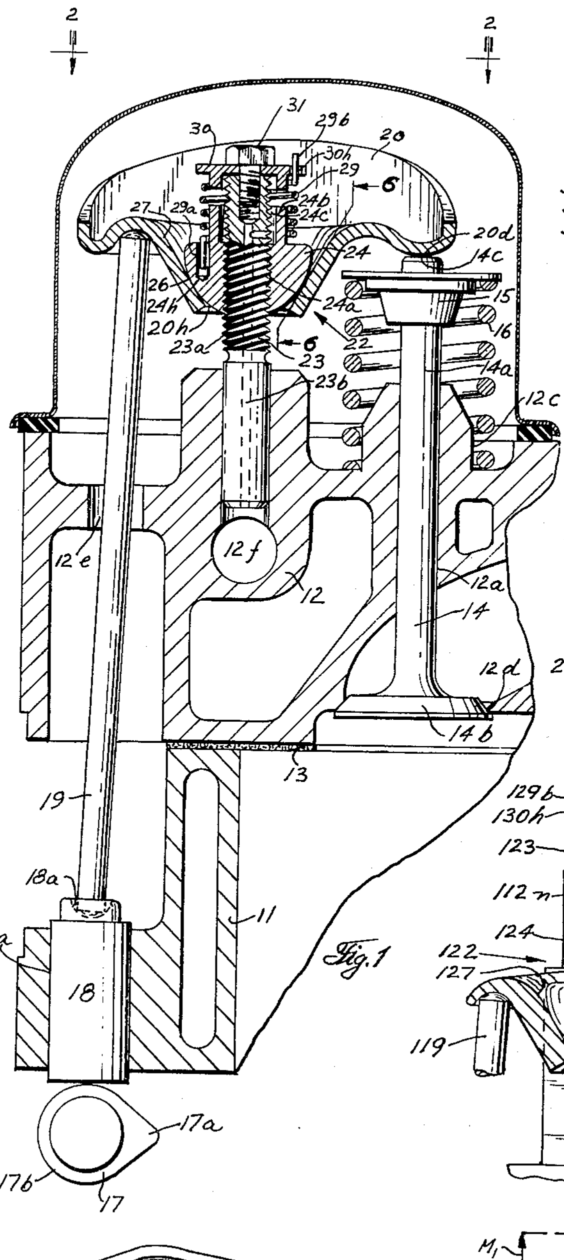

Fig. 1

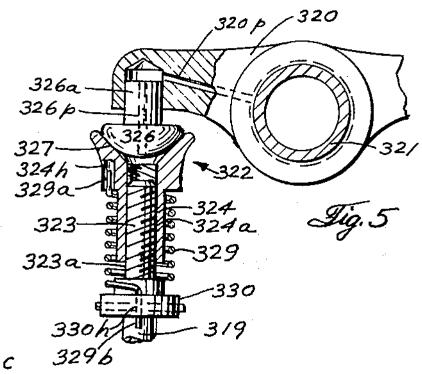

Fig. 5

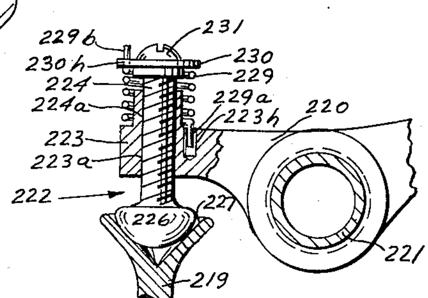

Fig. 4

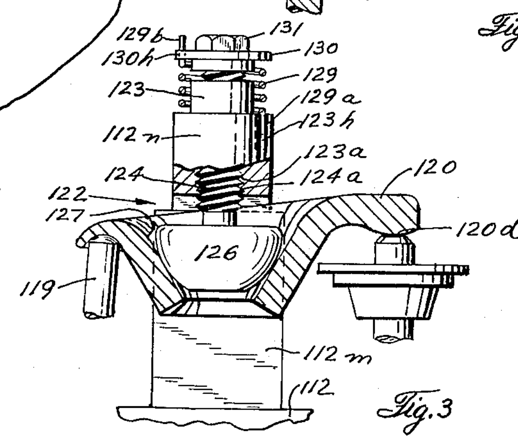

Fig. 3

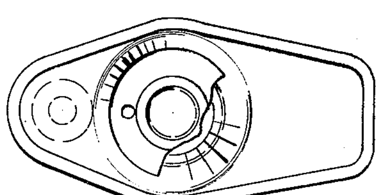

Fig. 2

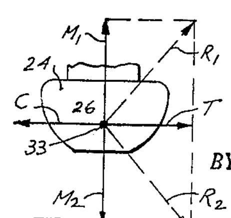

Fig. 6

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AUTOMATIC CLEARANCE REGULATOR

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This invention relates to improvements in a mechanical mechanism and more particularly to a mechanical mechanism with a clearance regulator for operating a valve head in an internal combustion engine.

One of the objects of the present invention is to provide means for maintaining effective operating length in a linkage having reciprocating and oscillating parts to which an operating force is intermittently applied, especially wherein one of said parts is a rocker arm for actuating a valve head in an internal combustion engine.

A further object of the present invention is to provide a clearance regulator for a rocker arm of an internal combustion engine with the regulator located either at the oscillation mounting of the rocker arm to the engine block or at one end of the rocker arm.

A further object of the present invention is to provide a clearance regulator for the valve head actuating linkage of an internal combustion engine wherein the regulator is easily accessible for servicing requirements; may be checked visually for correct functioning; provides accurate, positive and reliable clearance regulation with a controlled back-off; and/or has a minimum number of working parts.

Another object of the present invention is to provide in a mechanism a clearance regulator located at the oscillation point of a link member with its mounting frame member, adding no extra weight to the moving mass of the linkage members, and/or having its working parts fastened to the non-moving member of the mechanism.

A further object of the present invention is to provide a clearance regulator not requiring pre-assembly before installation in a mechanical mechanism.

A further object of the present invention is to provide a connecting means between an oscillating link member and a base member in a mechanical mechanism with said connecting means providing the dual functions of clearance regulation and oscillatory mounting of the link member to the base member of the mechanism.

A further object of the present invention is to provide a clearance regulator characterized by its structural simplicity, economy of manufacture, ease of assembly, operating efficiency, and its strong and sturdy nature.

Other features of this invention reside in the arrangement and design of the parts for carrying out their appropriate functions.

Other objects and advantages of this invention will be apparent from the accompanying drawings and description and the essential features will be set forth in the appended claims.

In the drawings,

FIG. 1 is a vertical sectional view through a valve head and its operating mechanism in a first and preferred form of the invention with said mechanism including a clearance regulator located intermediate the ends of a rocker arm member and at its oscillation mouting;

FIG. 2 is a top plan view of the rocker arm in FIG. 1 with parts cut away, taken along the line 2—2 of FIG. 1;

FIG. 3 is a side elevational view, partially in section of a second form of the invention;

FIG. 4 is a side elevational view partially in section of a third form of the invention with a clearance regulator located at one end of a rocker arm;

FIG. 5 is a side elevational view partially in section of a fourth form of the invention; while

FIG. 6 is a force diagram of the forces acting on the female screw threaded nut element in FIG. 1 taken along the line 6—6 of FIG. 1.

Before the mechanism here illustrated is specifically described, it is to be understood that the invention here involved is not limited to the structural details or arrangement of parts here shown since mechanisms or clearance regulators embodying the present invention may take various forms. It also is to be understood that the phraseology or terminology herein employed is for purposes of description and not of limitation since the scope of the present invention is denoted by the appended claims.

While the present invention might be adapted to various types of mechanical mechanisms and adapted to various uses in addition to valve head operation for an internal combustion engine, it has been chosen to show the same as a mechanical mechanism for valve head operation in an internal combustion engine. Four different forms of the invention are illustrated and all operate in a similar manner. Similar parts in different forms are labeled with corresponding reference numerals of different hundreds series. The following description will refer throughout to the form in FIG. 1 but the description generally applies with equal force to the other forms unless specific differences are noted.

FIG. 1 illustrates the complete mechanical mechanism for valve head operation in an internal combustion engine including a base member and a plurality of linkage part members making up the valve head operating linkage. FIGS. 2 to 5 inclusive each disclose only a portion of the mechanism including a clearance regulator and part of a rocker arm member.

In FIG. 1, the base member includes the conventional cylinder block member **11** having a cylinder head member **12** secured thereto with a gasket **13** sandwiched therebetween. In FIG. 3, cylinder head member **112** includes an upwardly extending arm of generally inverted L-shape with vertically and horizontally extending portions **112***m* and **112***n*.

Valve **14** includes a valve stem member **14***a* and a valve head **14***b* adapted to move into and out of engagement with valve port **12***d* of cylinder head **12** as valve stem member **14***a* reciprocates in guide bore **12***a* in cylinder head **12**. Spring cap **15**, keyed to the upper end of the valve stem member **14***a* in the conventional manner, is shaped on its underside for concentrically positioning the upper end of valve spring **16** while the lower end of said spring is supported on the cylinder head by boss **12***c*. Valve spring **16** is biased to hold valve head **14***b* tightly against the valve port **12***d* when the component parts are in the position shown in FIG. 1.

A plurality of linkage part members are operatively connected to the base member and arranged in series for opening and closing operation of valve head **14***b*. These include a tappet **18** mounted for reciprocable vertical movement in bore **11***a* of cylinder block **11** with a socket **18***a* at its upper end pivotally supporting a push rod **19** guided through elongated slot **12***e* in the cylinder head **12**. Slot **12***e* is elongated in the plane of the drawings so that push rod **19** can oscillate in the plane of the drawings to provide the geometry of motion required but is prevented from oscillating at right angles to the plane of the drawings by the sliding fit of push rod **19** in the narrow width of slot **12***e*. Corresponding push rods are shown at **119**, **219** and **319** in FIGS. 3, 4 and 5 respectively. A rocker arm member **20**, **120**, **220** or **320** is mounted for oscillation movement on its associated cylinder head and operatively connects its associated push rod member and valve stem member **14***a* so that these three members form three members of the valve head operating linkage. The slot **12e**, used in the FIGS. 1 and 3 constructions, prevents the rocker arm **20** or **120** from swinging about a vertical axis and thus preserves good alignment of the rocker arm tip **20d** or **120d** on the valve stem member tip **14c**. In FIGS. 4 and 5, rocker arms **220** and **320** are mounted for oscillation on pivot shafts **221** and **321** secured to their respective cylinder heads and slot **12e** is not required because these rocker arms can swing only about a horizontal axis. The oscillation mounting of rocker arms **20** and **120** in FIGS. 1–3 will be described in more detail hereinafter. Valve head actuating linkage members **14a** and **18** are mounted for reciprocation, member **20** is mounted for oscillation, and member **19** has primarily a reciprocation movement.

Means is provided for applying operating force in cyclic fashion to the mechanism members to cause intermittent relative movement of the linkage members and movement of the valve head **14b** during mechanism operating portions of the cycle. Here, conventional cam shaft cam **17** is provided with a cam lobe **17a** and a base circle **17b** of uniform radius contour. As the cam **17** rotates about its central axis, lobe **17a** applies the operating force during operating portions of the cycle to linkage members **18**, **19**, **20** and **14a** to open and close valve head **14b**. When tappet **18** rests on base circle **17b**, the cycle is in its non-operating portion, no valve head opening force is applied, and valve head **14b** remains in its closed position illustrated in FIG. 1 under the bias of spring **16**.

In each form of the invention, a connecting means operatively connects two members of the mechanism for permitting relative oscillation movement therebetween and for providing valve head movement during operating portions of the cycle. These connecting means are shown as **22**, **122**, **222**, and **322** and connect respectively members **12** and **20**, **112** and **120**, **219** and **220**, and **319** and **320**. In FIGS. 4 and 5, these members **219**, **220** or **319**, **320** are two adjacent parts in the series of linkage parts. Members **220** and **320** are mounted for oscillation relative to members **219** and **319** which in turn are mounted for reciprocation on the base members. In FIGS. 1 and 3, rocker arms **20** and **120** are linkage parts while members **12** and **112** are parts of the bases upon which they are mounted for oscillation.

In each form of the invention, the connecting means serves a duel function. It provides an operative connection between two adjacent members in the mechanism and serves as a clearance regulating means in the mechanism.

The connecting means in each form of the invention includes two coacting screw threaded elements **23**, **24**; **123**, **124**; **223**, **224**; or **323**, **324**. An element of each pair is fixed with respect to one of the mechanism members, either secured thereto as a separate component or formed integrally therewith. For example, element **23** in FIG. 1 is formed as a stud to be fastened by a press fit or other suitable method to the cylinder head **12** while elements **123**, **223**, and **323** are formed integrally with members **112n**, **220** and **319** respectively. The screw threads **23a**, **24a**; **123a**, **124a**, **223a**, **224a**; and **323a**, **324a** on these respective members are non-locking upon the application of only an axial force, whether it be static or vibrating, under actual working conditions. In other words, the threads in each pair are free running under actual working conditions because the helix angles of the threads are steep enough so that the frictional engagement between the threads is not sufficiently great to prevent rotation of one element relative to the other upon the application of only an axial force under actual working conditions. The minimum helix angle may vary with different working conditions. It should be noted that a low helix angle may be sufficient under actual working conditions in an internal combustion engine wherein the friction between the threads is low because: (1) a film of lubricating oil is located between the threads from the oil bath within which the engine operates, (2) the axial vibration of the screw threads relative to each other breaks their frictional contact by the axial vibrational force imposed thereon by the engine, and (3) lower dynamic friction exists between the threads as they rotate relative to each other instead of higher static friction. Although a higher helix angle might be required for non-locking in other type apparatuses under actual working conditions wherein a static (non-vibrating) axial force is applied and no oil lubricates the threads, it should be noted the mechanism herein disclosed will operate properly and will still be non-locking with this higher helix angle even though subjected to vibration and being well lubricated under actual working conditions in an automobile engine. In each form, both elements of a pair are carried by the same mechanism member, namely member **12**, **112**, **220**, or **319** wherein **12** and **112** are base members, **220** is a rocker arm linkage member, and **319** is a reciprocating push rod member of the linkage.

In FIGS. 1 and 3, at least one of the elements forms part of the oscillation mounting of the rocker arm. In FIG. 1, element or stud **23** extends through the hole **20h** in the rocker arm **20** so that portions of it are located on opposite sides of rocker arm **20**. FIG. 3 has a support construction above the rocker arm with both elements **123** and **124** located above the rocker arm **120**.

The connecting means include two surfaces in each form of the invention with one being a spherically contoured surface **26**, **126**, **226** or **326** and the other being an annular and conically contoured surface **27**, **127**, **227** or **327** serving as a supporting surface, coacting with, and arranged in a circle around its spherically contoured surface to form an operative connection therewith for permitting relative oscillation movement between the adjacent members of the mechanism. One of the surfaces is carried by one of the mechanism members and the other of the surfaces is carried by one of the elements by being either integrally formed therewith or carried by a separate component secured thereto. In FIG. 1, surface **26** is carried by element **24** and surface **27** is carried by rocker arm member **20**; in FIG. 3, surface **126** is carried bv element **124** and surface **127** is carried by rocker arm member **120**; in FIG. 4, surface **226** is carried by element **224** and surface **227** is carried by push rod member **219**; and in FIG. 5, surface **327** is carried by element **324** while surface **326** is carried by plug **326a** secured to and carried by rocker arm member **320**. Each pair of these surfaces engage with approximately line contact of circular formation to provide some degree of wedging and clutching action between the element and member by which they are carried. It is readily seen that as the linkage is moved back and forth to open and close the valve head **14b**, relative oscillation will take place at these surfaces during the operating portions of the cycle with the center of curvature of the spherically contoured surface in each form being generally located along the axis of oscillation.

Each connecting means includes a torsion spring **29**, **129**, **229** or **329** and axial limit stop member **30**, **130**, **230** or **330**. Bolts **31**, **131**, and **231** are provided in FIGS. 1–4 to secure the associated stop members on their associated elements. The torsion springs have respectively opposite ends **29a**, **29b**; **129a**, **129b**; **229a**, **229b**; and **329a**, **329b** secured respectively in element holes **24h**, **123h**, **223h**, and **324h** and in stop member holes **30h**, **130h**, **230h** and **330h**. Each torsion spring is biased to turn its associated element in the direction to take up any existing slack in the mechanism. The torsion spring tends to rotate by its bias in FIG. 1 the element **24** toward cylinder head **12**, in FIG. 3 element **124** downwardly toward the main portion of cylinder head **112**, in FIG. 4 element **224** toward push rod **219**, or in FIG. 5 element **324** toward rocker arm member **320**. The torsion spring in each form operatively connects the elements (one end is connected to an element and the other end is connected to a stop member which in turn is connected to the other element) so as to rotate one element relative to the other in this manner. In FIGS. 1, 3 and 4, the stop members take the form of stop caps 30, 130 and 230 secured by bolts 31, 131 and 231 screwed into internally threaded holes in the element 23, 124 or 224 with the hands of these internal threads being opposite to the hands of the threads between the elements, such as threads 23*a* and 24*a*, to prevent loosening of the caps. In FIG. 5, stop member 330 is pinned or otherwise suitably secured to the push rod member 319. In each form of the invention, the axial limit stop member is not only adapted to hold one end of the torsion spring but is also adapted to abut against the element, which moves axially with respect thereto, to serve as a safety limit stop to limit the travel thereof.

The present invention is concerned with the clearance regulator found in this mechanism. A satisfactory mechanical type clearance regulator generally meets three requirements. First, it transmits the operating force and motion without slippage or collapse of the effective length of the linkage. Second, it provides a very small amount of back-off or controlled reduction of effective linkage length during the operating portions of the cycle so that a corrective adjustment in length may be made during the non-operating portions of the cycle. Third, it removes any undesirable slack or lash during the non-operating or no-load portions of the cycle to increase the effective length of the linkage, if necessary.

The mode of operation of each form of the invention is basically the same so that only the forms shown in FIGS. 1 and 2 will be described in detail unless specific reference is made to one of the other forms. In each form, the spherically contoured surface acts as a fulcrum for oscillation, transmits the operating forces and motion of the valve head operating linkage of the mechanism, and provides functions in the clearance regulating action. Each form of construction provides the three requirements desired in a mechanical type clearance regulator.

First, the construction in FIG. 1 transmits the operating force and motion without slippage or collapse of the effective length of the linkage as the operating force is applied during operating portions of the cycle. As mentioned before, the screw threads 23*a* and 24*a* are free running or non-locking upon application of only an axial force. In other words, an axial force exerted upwardly on element 24 in FIG. 1 may be resolved into a force component T at point 33 on surface 26 in FIG. 6 tending to rotate element 24 and to advance it in the upward direction. The helix angle of the thread is steep so that under any conditions of thread friction which may be encountered during operation, element 24 will not support the operating load but will permit rocker arm member 20 to move upwardly away from members 19 and 14 unless assisted by some other frictional lock, taking the form in the present disclosure of a friction clutch exerting with spring 29 a force C in FIG. 6 equal and opposite to force T.

In other words, element 24 must spin upwardly on the threads 23*a* when the operating load is axially imposed thereon if clutching force C is not applied. Let us assume for only illustrative purposes and in no sense of limitation some numerical values and calculations. Threads 23*a* and 24*a* may have a maximum coefficient of friction of 0.12 if the pitch diameter of 60 degree thread is assumed at 0.32 inch. Calculations would give the thread helix angle with slipping impending at approximately 7¾ degrees. When torsion spring 29 is included with a torque of 0.5 inch pounds in the FIG. 1 position and when 500 pounds of operating force is exerted on element 24 when cam lobe 17*a* is moving valve head 14*b*, the thread helix angle may be slightly steeper, or approximately 8¼ degrees, because torsion spring 29 opposes the upward spinning of element 24. Since the highest probable value for thread friction has been assumed and the helix angle with slipping impending has been calculated, it is obvious that if the coefficient of friction becomes less than 0.12, an axial force on element 24 will cause an unbalanced torque to be exerted thereon to spin it upwardly to result in excess operating clearance in the linkage.

However, clutching means is provided at the coacting surfaces 26 and 27 for counteracting under operating force the unbalanced torque (shown as force T) of the non-locking screw threads 23*a* and 24*a* exerted on element 24 so that the effective length of the linkage will not slip or collapse but will transmit the operating force and motion. The lowest probable screw thread friction coefficient for polished threads will be about 0.02. With an operating force of 500 pounds being imposed on the element 24 and a coefficient of friction of only 0.02 assumed on the 8¼ degree helix angle threads, the unbalanced torque tending to rotate element 24 upwardly will be about 9 inch pounds. In order to stop the element 24 from being spun upwardly by the operating force, a clutching action must take place between the surfaces 26 and 27 for counteracting this unbalanced torque. The radius at the line of contact of the surfaces 26 and 27 must be properly calculated to produce sufficient frictional torque resistance, along with the torque exerted by spring 29, to balance this unbalanced 9 inch pounds of torque being exerted by the free running screw threads. If one assumes the seat angle for surface 27 of 45 degrees with respect to the central axis (90 degree included cone angle) and a coefficient of friction between the surfaces of 0.04, the frictional contact radius between the surfaces should be about 0.33 inch with 500 pounds of operating force on element 24, a helix thread angle of 8¼ degrees, screw thread friction of 0.02 and a torsion spring of 0.5 inch pounds. The coefficient of friction between the ball seat surfaces 26 and 27 has been assumed higher than the friction of the threads 23*a* and 24*a* because of the near line contact between the surfaces may result in even higher probable friction. These are only assumed and theoretical values to prove that a practical device exists; it is intended that even though these values may vary considerably in working devices, the devices will come within the scope of the present invention since these values are given only for illustrative purposes. A line contact between these surfaces is desirable because it has been found in practice that the high specific loading in the small area of a line contact results in a fairly high and uniform coefficient of friction. High friction is desirable on this contact because it insures that no unwanted slippage of threads 23*a*, 24*a* will open up the operating clearance of the valve head operating linkage. However, it should be clearly understood that this invention is not limited to only line contact but covers all practical devices coming within the scope of the claims.

It should be noted that this device will operate satisfactorily under variations in or with different operating forces in the same or different installations. The unbalanced torque exerted on element 24 and the clutching or braking effect exerted by surfaces 26 and 27 will each be very nearly proportional to the operating load or force exerted by rocker arm member 20 on element 23. Hence, the device will work satisfactorily under variations in and with different operating forces.

Second, controlled back-off, reduction or decrease in the effective length of the linkage of the valve head operating mechanism takes place during the operating portions of the cycle when the operating force is applied. This reduction in length occurs automatically in response to the rubbing contact under operating force of coacting surfaces 26 and 27 in the spherical pivot between the members; this rubbing contact is caused by the relative oscillation movement of the members. This oscillation movement of the members causes a limited and controlled slipping action which in turn causes relative rotation of element 24 with respect to the fixed element 23 so that element 24 will advance in the upward direction in FIG. 1 to decrease the effective linkage length.

Let us consider the forces acting at point 33 on surface 26 of element 24 during the oscillation movement, as shown in FIGS. 1 and 6. Under static friction conditions the force T, tending to rotate nut element 24, will not be sufficient to rotate the nut element. However, as oscillation occurs with dynamic friction conditions, a rubbing action between surfaces 26 and 27 will occur and will cause by this movement a force M1 or M2 to be exerted at point 33, depending upon the direction of oscillation. Thence, the force acting upon nut element 24 at point 33 will be resultant R1 or R2, each of which will be sufficient to cause a controlled amount of back-off, with these resultants composed respectively of component forces T and M1 or T and M2. As oscillation occurs in either direction, element 24 will be rotated in the direction of the arrow T so as to move axially in the upward direction in FIG. 1. However, this will be a controlled movement depending upon the extent of oscillation so that only controlled reduction in length will occur but there will be no collapse of the linkage.

This phenomena may be readily explained. "Compound sliding" has been defined in Marks Hand Book (fourth edition, page 234) as the phenomena wherein a body sliding across another may be deflected crosswise from its original direction by a small force. This explains the ease with which an automobile may skid on a road or with which a plug gauge may be inserted into a hole if it is being rotated while being pushed in. This principle may be explained in another manner. If frictionally contacting surfaces 26 and 27 are moved with respect to each other in a given direction by a force (M1 or M2) and these surfaces are also free to move in some other direction, and then if another force (T) is applied in this other direction during motion of these surfaces, one surface (26) will move with respect to the other surface (27) in this other direction (in the direction of force T). The amount of movement in this other direction depends upon the amount of movement in the given direction (in the direction of force M1 or M2) and the relative forces (M1 or M2 and T) applied in the given and other directions.

This last principle may be demonstrated by holding frictionally between two fingers a flat, long stick, such as a yardstick, near one end while letting the stick hang vertically downwardly therefrom. If the stick is now swung back and forth in pendulum fashion, it will gradually slip downwardly between the two fingers. The fingers, pinching the yardstick, represent frictionally contacting surfaces. The surfaces of the yardstick are free to move in a given direction as rotational motion is applied through the pendulum action; gravity applies the force in the other direction; and the yardstick moves in the other direction between the fingers in accordance with this principle.

In the valve head operating mechanism of the present disclosure, the application of this principle should be readily apparent. When tappet 18 rides on the cam base circle 17*b* in FIG. 1, all of the undesirable lash or clearance in the linkage has been removed as shown in FIG. 1. As the cam lobe 17*a* lifts and lowers tappet 18, this motion is transmitted to the valve head 14*b*. During this action, surface 27 will oscillate on surface 26 and a slight amount of back-off of the element 24 on threads 23*a* will occur.

Several factors in this design should be noted. First, since force T acting at point 33 and the corresponding force acting on the surface 26 diametrically opposite point 33 will both be oriented in the same rotational direction about the longitudinal axis of element 23, the rotational forces acting upon element 24 will be additive, instead of in opposition, to cause the linkage shortening

action. Second, the linkage shortening action occurs both during to and fro oscillation during both the valve head opening and valve head closing portions of the cycle because force T is always exerted in the same direction and resultant R1 or R2 always has a component in the horizontal direction even though forces M1 and M2 are exerted in opposite directions. Third, the orientation of the axis of the unbalanced torque exerted on nut element 24 with respect to the orientation of the axis of oscillation of the lever member 20 is important. In the present disclosure, these axes are always mutually perpendicular in all positions of lever 20 since in FIG. 1 one extends along the longitudinal axis of element 23 in the plane of the drawing and the other extends perpendicular to the plane of the drawing. However, as long as the axes are non-parallel, a net decrease to some extent in the effective length of the linkage will occur during elapse of the full operating cycle. In the parallel position, forces T, M1 and M2 either would be parallel or would coincide. Fourth, the non-locking or free running feature of adjusting screw threads 23*a* or 24*a* is important. Self-locking screw threads would make the device inoperative. Fifth, back-off action is obtained smoothly and in proportion to the extent of oscillation; the back-off action does not require impact, vibration or periodic clutching or unclutching for its operation. Sixth, the amount of back-off per valve cycle can be controlled by the proper proportioning of the various parts, especially the helix angle of the threads 23*a* and 24*a*, and the dimensions and shapes of the surfaces 26 and 27, especially spherically contoured surface 26. A desirable amount of back-off per valve cycle would be in the range of 0.0005 to 0.002 inch per valve head operating cycle measured at the valve tip 14*c*.

Third, the mechanism removes any undesirable lash, slack or clearance from the valve head operating linkage during the non-operating or no-load cycle portions (when tappet 18 travels on cam base circle 17*b*) to increase the effective linkage length, if necessary. Here, restoring means, taking the form of torsion spring 29, is provided and tends to rotate element 24 relative to element 23 in a direction opposite to that of force T in FIG. 6 so as to move element 24 downwardly in FIG. 1 during non-operating portions of the cycle. When tappet 18 returns to the base circle 17*b*, a small amount of excess clearance may and probably does exist in the valve linkage with no operating force being exerted on the linkage. Torsion spring 29 now becomes active and rotates element 24 downwardly to remove this clearance until the clutching force between surfaces 26 and 27 prevents further rotation. Then, the valve head operating linkage is in perfect adjustment for the next cycle. The operating torque exerted by torsion spring 29 is of a small magnitude, just sufficient to overcome any slight amount of remaining friction between threads 23*a* and 24*a* and also to act fast enough during high engine speeds to take up undesirable operating lash in the valve head operating linkage during the non-operating cycle portion.

The present invention has many advantages. First, the clearance regulator is of a mechanical type instead of a hydraulic type. Therefore, it is not sensitive to the type of oil used in the engine. Second, the clearance regulator can be placed on top of the engine where it is readily accessible for servicing, such as replacement of parts or adjustment. Third, it can be easily checked visually for correct functioning. Fourth, it provides an accurate, positive and reliable clearance regulation with controlled back-off. Fifth, it has a minimum number of working parts and is inexpensive to manufacture. Sixth, it does not have to be preassembled before installation on the engine.

The construction in FIGS. 1 to 3 inclusive also has other advantages. First, no additional weight or mass is added to the linkage members so as to increase their inertia during movement. For example, in FIG. 1, rocker arm member 20 carries therewith only surface 27 while all of the rest of the clearance regulator components are secured to the stationary cylinder head 12. The linkage inertia is not increased because the component parts are located at the oscillation mountings. Second, the clearance regulator of the present invention is a compact unit providing a plurality of functions including clearance regulations and an oscillation mounting for the rocker arm member 20.

The construction in FIGS. 4 and 5 may be used where added inertia weight in the valve head operating linkage can be tolerated. Also, these constructions may be desirable where the rocker arm member 220 or 320 is mounted on a rocker arm shaft 221 or 321.

Alternate constructions readily suggest themselves as being within the scope of the present invention. First, the clearance regulator may be mounted in any suitable location in the linkage where oscillation or any other suitable relative movement occurs. For example, the clearance regulators in FIGS. 4 and 5 may be mounted on the valve stem tip end of the rocker arm instead of the push rod end since the valve stem member is part of the valve head operating mechanism. Second, the surfaces may be interchanged on the members. For example in FIG. 5, spherically contoured surface 326 may be carried by element 324 and conical surface 327 may be carried by plug 326*a*, and the mode of operation will be the same. Third, the spherically contoured surface and coacting conically contoured surface are respectively disclosed as being external and internal surfaces. However, the spherical surface may be an internal spherically contoured surface coacting with a circular line contacting surface associated therewith.

Lubrication may be suitably provided for any of the disclosed forms of the present invention. In FIG. 1, the upper part of nut element 24 has a counterbored boss 24*b* through which the upper end of the threaded portion of stud element 23 projects. Boss 24*b* has a counterbored cavity 24*c* serving as an oil reservoir which is fed oil through communicating channel 23*b* in element 23 by the oil gallery 12*f* in cylinder head 12. In FIGS. 3 and 4, no lubrication construction is illustrated but any suitable construction may be used. In FIG. 5 an oil passage is provided from the hollow rocker arm shaft 321 through passages 320*p* and 326*p*.

Various changes in details and arrangement of parts may be made by one skilled in the art without departing from either the spirit of this invention or the scope of the appended claims.

What I claim is:

1. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means responsive to a rubbing contact in zones in said connecting means between said members for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle, said means for decreasing the effective length including two coacting screw threaded elements, said rubbing contact zones being located on a circle concentric with the screw thread axis on at least one of said elements.

2. A mechanical mechanism adapted to operate an internal combustion engine valve head, said mechanism including two members; connecting means operatively connecting said members for permitting relative oscillation between them; and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative oscillation of said members; said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle; said means for decreasing the effective length including a spherically contoured surface, a conically contoured surface coacting with and arranged in a circle around said spherically contoured surface to form a connection for relative oscillation between said members, one of said surfaces being carried by one of said members, and means operatively connecting said other surface to the other of said members for relative rotation in one direction of said other surface relative to said other member during relative oscillation of said members for decreasing the effective length of the valve head operating mechanism; said means for taking up any existing slack in the mechanism during the non-operating portions of the cycle comprising means tending to rotate said other surface relative to said other member in the opposite direction during non-operating portions of the cycle.

3. In a clearance regulator wherein a surface is coactable with a surface on a valve head operating linkage member, two coacting screw threaded elements, said screw threads being non-locking upon application of only an axial force, one of said surfaces being a spherically contoured surface and the other of said surfaces being a supporting surface coacting with an arranged in a circle contacting said spherically contoured surface, one of said surfaces being carried by said member and the other of said surfaces being carried by one of said elements, and torsion spring means operatively connecting said elements for rotating one element relative to the other toward said member.

4. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members; connecting means operatively connecting said members for permitting relative oscillation between them for valve movement; means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative oscillation of said members and intermittent movement of said valve head by the mechanism during mechanism operating portions of the cycle; said connecting means including means for regulating the clearance in said valve head operating mechanism, said clearance regulating means including means responsive to a rubbing contact between said members for decreasing the effective length of the valve head operating mechanism during both to and fro oscillation when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the valve head operating mechanism during non-operating portions of the cycle; said means for decreasing the effective length including two coacting screw threaded elements with one element having relatively oscillatable contact with one member during the operating portions of said cycle and the other element fixed with respect to the other member, said screw threads being non-locking upon application of only an axial force under actual working conditions, a spherically contoured surface, and a conically contoured surface coacting with and arranged in a circle around said spherically contoured surface to form a connection for relative oscillation between said members to counteract as a clutch under operating load the unbalanced torque of the non-locking screw threads but to have limited slipping under operating load during relative oscillation of said members, one of said surfaces carried by said one mem-

ber and the other of said surfaces carried by said one element, whereby relative rotation in one direction of said one element relative to said other element occurs during relative oscillation of said members for decreasing the effective length of the valve head operating mechanism; said means for taking up any existing slack in the mechanism during the non-operating portions of the cycle comprising restoring means tending to rotate one element relative to the other in the opposite direction during non-operating portions of the cycle.

5. The combination of claim 4, wherein said mechanism includes a base and a plurality of linkage parts operatively connected to said base and arranged in series for valve head operation, wherein said base includes said other member and one of said parts includes said one member, wherein said one member has a through hole, wherein said other element extends through said hole, and wherein portions of said other element are located on opposite sides of said one member.

6. The combination of claim 4, wherein said mechanism includes a base and a plurality of linkage parts operatively connected to said base and arranged in series for valve head operation, wherein said base includes said other member and one of said parts includes said one member, and wherein both said elements are located on the same side of said one member.

7. The combination of claim 4, wherein said mechanism includes a base and a plurality of linkage parts operatively connected to said base and arranged in series for valve head operation, and wherein said two members are two of said adjacent parts in the series with said other member mounted for oscillation on said base and said one member mounted for reciprocation on said base, and wherein both elements are carried by said other member.

8. The combination of claim 4, wherein said mechanism includes a base and a plurality of linkage parts operatively connected to said base and arranged in series for valve head operation, and wherein said two members are two of said adjacent parts in the series with said one member mounted for oscillation on said base and said other member mounted for reciprocation on said base, and wherein both elements are carried by said other member.

9. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members, an element, means operatively connecting said element by one of its surfaces to one of said members to provide a mechanism shortening action by movement in one direction and a lengthening action in an opposite direction, means operatively connecting said members together for relative movement with said element in frictional contact on another of its surfaces with said other member, means for intermittently applying operating force to said mechanism to cause intermittent relative movement of said members in another direction by sliding contact at said other surface, said one end other directions being angularly disposed whereby relative movement in said other direction causes shortening movement in said one direction, one of said surfaces being a threaded surface, said first mentioned one surface being said threaded surface and being non-locking with said one member at all times.

10. A mechanical mechanism adapted to operate an internal combustion engine valve head, said mechanism including two members, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle, said means for decreasing the effective length including two coacting screw threaded elements with the screw threads thereof being non-locking upon application of only an axial force under actual working conditions and including a clutch means for one of said elements having limited slipping under operating load during relative movement of said members.

11. A mechanical mechanism adapted to operate an internal combustion engine valve head, said mechanism including two members, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle, said means for decreasing the effective length including two coacting screw threaded elements and including clutch means operatively connecting one of said members and one of said elements by any amount of friction great enough to prevent relative rotation of said elements when relative movement does not occur.

12. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members comprising a movable member and a stationary member, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle, said clearance regulating means including two screw threaded elements with at least one of said element being fixed against movement relative to said stationary member.

13. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members comprising a movable member and a stationary member, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means responsive to a rubbing contact in said connecting means between said members for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle.

14. A mechanical valve head operating mechanism with a clearance regulator for an internal combustion engine, said mechanism including two members, connecting means operatively connecting said members for permitting relative movement between them, and means for applying operating force in cyclic fashion to the mechanism to cause intermittent relative movement of said

members, said connecting means including means for regulating the clearance in said mechanism, said clearance regulating means including means for decreasing the effective length of the mechanism when said operating force is applied during operating portions of the cycle without collapse of said effective length and including means for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle; said clearance regulating means including two coacting screw threaded elements telescopically threaded together, means biasing said elements for relative rotation in one direction for taking up any existing slack by increasing the effective length of the mechanism during non-operating portions of the cycle, the coacting threads on said elements having a thread helix angle sufficiently great to cause during relative movement of said members an unbalanced torque in the opposite of said one direction to be transmitted to the contacting surfaces of one of the threaded elements and one of the members having said relative movement between said members for urging said one element for relative rotation in said opposite direction for decreasing the effective length of the mechanism, one of said contacting surfaces being spherical and the other of said contacting surfaces providing sufficient torsional clutching capacity with said spherical surface to exceed said unbalanced torque to prevent uncontrolled relative movement of said one element in said opposite direction but permitting a controlled movement in said opposite direction by said unbalanced torque during relative rubbing movement at said surfaces during relative movement between said members.

15. In combination with a rocker having an opening extending therethrough in the thrust direction, clearance regulator supporting means for the rocker comprising a first threaded member extending through said opening with sufficient clearance to accommodate rocking movement of said rocker, a second threaded member telescopically associated with said first member and threaded thereon through which said first member extends, said rocker and said second member having coacting bearing surfaces with a spherical bearing surface on said rocker with said surfaces defining the rocking axis of said rocker, resilient means acting between said members tending to relatively rotate them in one direction for taking up any existing slack by increasing the effective length of the mechanism, and means operatively connecting said members and rocker and responsive to the motion of said rocker so that the rocking action of said rocker on said second member through said spherical bearing surface causes relative axial adjustment between said members tending to relatively rotate said members in the opposite of said one direction for decreasing the effective length of the mechanism during rocker movement.

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