

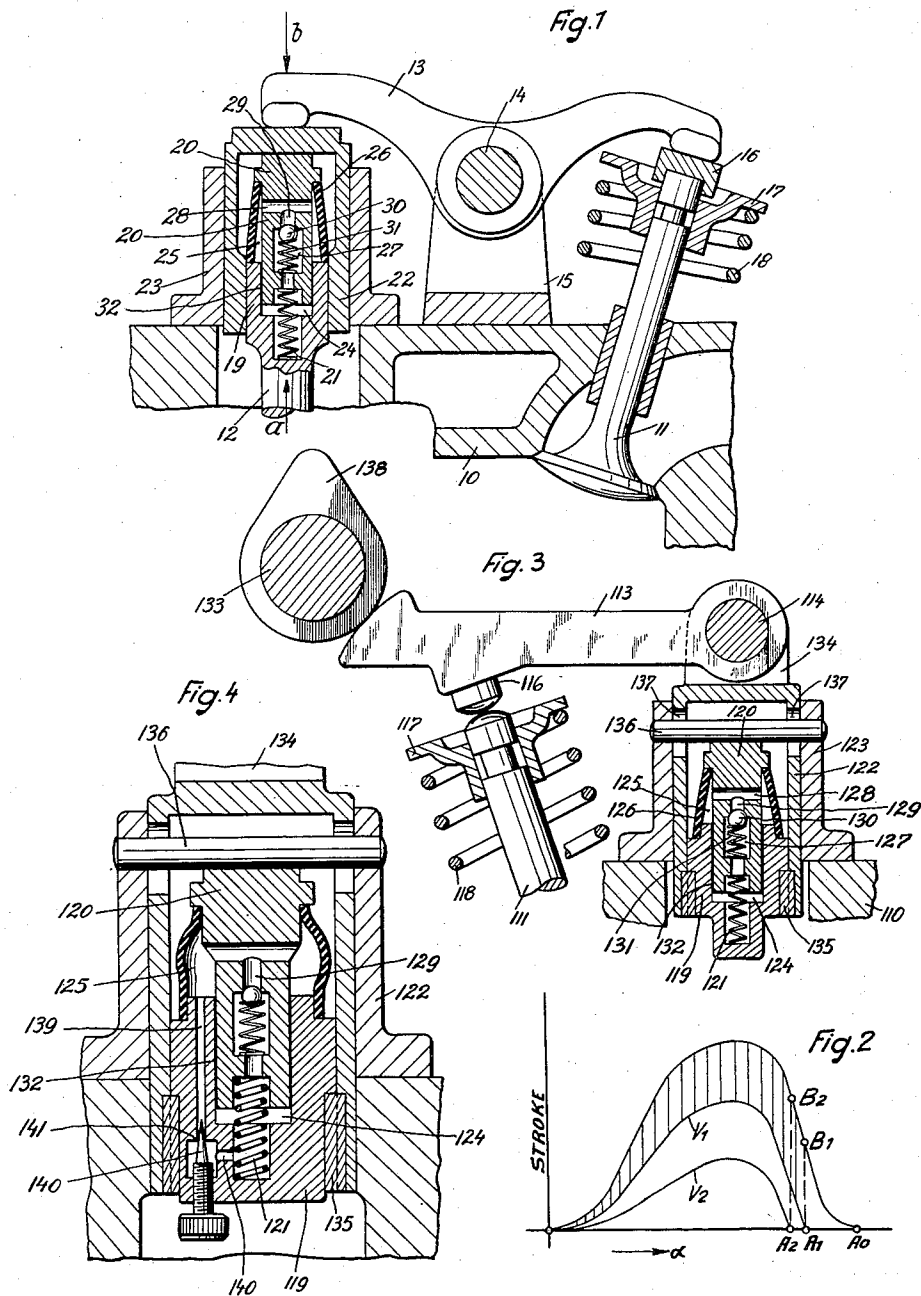
May 6, 1958

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2,833,257

VALVE CONTROL MECHANISM FOR INTERNAL COMBUSTION ENGINES

Filed July 5, 1955



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1

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VALVE CONTROL MECHANISM FOR INTERNAL COMBUSTION ENGINES

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Application July 5, 1955, Serial No. 520,020

8 Claims. (Cl. 123—90)

The present invention relates to a valve control mechanism for internal combustion engines.

It is the object of the present invention to provide an improved valve control mechanism in which the valve actuation is varied in dependence on the speed of operation of the engine. More specifically, objects of the invention are to increase the valve stroke as the engine is sped up and to reduce same as the engine is slowed down; to vary the timing of the closing of the valve in dependence on the speed of operation of the engine; to close the valve earlier in the cycle of operation at a low speed of the engine and later in the cycle of operation at a higher speed of the engine; to provide simple and reliable means for effecting the aforesaid valve control; and to provide an improved valve control mechanism in which both the valve stroke and the timing of the closing of the valve will be varied in dependence on the speed of operation of the engine without varying the timing of the opening of the valve.

Further objects of the present invention will appear from a detailed description of a number of preferred embodiments thereof following hereinafter with reference to the drawings, and the features of novelty will be pointed out in the claims. It is to be clearly understood, however, that such detailed description serves the purpose of illustrating the invention rather than that of restricting or limiting the same. In the drawings,

Fig. 1 is a sectional elevation of the upper portion of the cylinder head of an internal combustion engine showing part of an inlet valve and part of the linkage for the actuation thereof, the linkage including a hydraulic link forming part of the cam-controlled push rod,

Fig. 2 is a control diagram of the valve actuation,

Fig. 3 is a sectional elevation of the valve control mechanism mounted on the cylinder head of an internal combustion engine showing part of the inlet valve, a cam for controlling the same, and an interposed linkage including a hydraulic link, and

Fig. 4 is a sectional view similar to that of Fig. 3, but on an enlarged scale, of a modification of the hydraulic link shown in Fig. 3.

A cylinder head 10 of an internal combustion engine is provided with an inlet port for air or a gaseous air-fuel mixture and with an outlet port for the exhaust gases, each port being controlled by a poppet valve, the stem 11 of the poppet valve controlling the inlet port being shown in Fig. 1. A cam shaft (not shown) which is geared to the crankshaft of the engine, is provided with a plurality of cams, each cam being adapted to actuate one of the valves. The cam acts on a reciprocating member and such member is connected with the associated valve by a linkage to transmit the reciprocatory motion to the valve. The linkage includes a push rod 12 slidably mounted for up-and-down motion and a two-armed lever 13 acting on stem 11 of the valve. The two-armed lever 13 is pivotally mounted on a stud 14 fixed to a bracket 15 secured to the cylinder head 10. One of the arms of lever 13 engages a cap 16 fixed to the valve stem 11, and the latter carries a flanged member 17 on which a helical spring 18 acts. The spring 18 is supported on the

2

cylinder head 10 in the orthodox manner and tends to keep the valve closed resisting the opening movement imparted thereto by lever 13. Thus the opening stroke is imparted to the valve stem 11 by the lever 13 and the closing stroke is imparted thereto by the spring 18 in opposite direction.

For the purpose of the present invention the upper end of the cam-actuated push rod 12 is formed integral with a coaxial cylinder 19 in which a piston or plunger 20 is slidably guided. A helical pressure spring 21 inserted between the push rod 12 and the plunger 20 and extending into axial recesses thereof urges the plunger 20 into contact with a cup-shaped member 22 which, in its turn, engages the left arm of lever 13 at the bottom thereof and is slidably guided by its internal cylindrical face on the cylinder 19 and by its external cylindrical face in a flanged guide bushing 23 which is suitably secured to the cylinder head 10 by a plurality of bolts extending through bores of its flange.

The cylinder 19 and the plunger 20 are movable elements and constitute a hydraulic link confining, as they do, a chamber 24 which is filled with a suitable liquid, such as oil.

The variable chamber 24 is connected with a liquid reservoir by each of two ducts. In the embodiment shown, the liquid reservoir is formed by a chamber 25 which surrounds the plunger 20 and is formed by a sleeve 26 of flexible material, such as rubber, which has its lower end sealed against cylinder 19 and its upper end sealed against an external collar provided on plunger 20. One of the ducts which connects the chamber 24 with the reservoir 25 is permanently open and has a restricted cross section. In the embodiment shown in Fig. 1 this duct is simply formed by the gap 32 provided between the cylinder 19 and the plunger 20, such gap having preferably a width of from about 0.1 millimeters to about 0.2 millimeters. The other duct which connects the chamber 24 with the reservoir 25 is formed by a transverse bore 28 of the plunger and by axial bores 27 and 29 thereof which open into the chamber 24. This duct is controlled by a check valve 30 mounted to open towards the variable chamber 24. The check valve is formed by a ball urged by a helical spring 31 upon a valve seat surrounding the lower end of bore 29.

It is the purpose of the flexible sleeve 26 to prevent oil from leaking through between the elements 22 and 19 and from thus getting lost.

The operation of the novel valve control mechanism is as follows: When the push rod 12 is lifted in the direction of arrow *a* by the cam to thereby open the valve contrary to the force exerted by spring 18, the volume of liquid included in the variable chamber 24 transmits the upward motion to the plunger 20 which, in its turn, rocks the lever 13 to thereby depress stem 11 opening the valve. However, a variable part of such motion is absorbed in the hydraulic link, because part of the liquid in the variable chamber 24 will escape through the gap 32 into the reservoir 25 thereby reducing the distance of upward travel of the plunger 20 with respect to the upward travel of the rod 12. The absorbed part of the lifting motion *a*, however, depends on the duration of the period for which the liquid in the variable chamber 24 will be subjected to the pressure of the spring 18. The period, in its turn, however, depends on the speed of operation of the engine. When the engine is running at a very high rate of speed, the liquid hardly finds time to escape from the chamber 24 through the gap 32 when the push rod 12 is lifted so that a very small part only of the upward motion of push rod 12 is absorbed. When the engine is slowed down, however, a greater quantity of liquid will escape through gap 32 during the valve-opening period and,

3

therefore, a larger part of the lifting motion in the direction of arrow *a* will be absorbed thereby reducing the lifting stroke transmitted to valve stem 11.

When the valve closes, the spring 18 will move the two-armed lever 13, the cup-shaped member 22 and the plunger 20 to the position shown in Fig. 1. When that position has been reached continued rotation of the cam will relieve the liquid included in chamber 24 from pressure and will permit spring 21 to further depress push rod 12 to its initial position thus increasing the volume of the variable chamber 24. During this increase oil will be freely sucked into chamber 24 from the reservoir 25 through the bores 28, 29, 27 past the check valve 30.

Hence, it will appear that the volume of liquid included in the variable chamber 24 will prevent the check valve 30 from opening as long as the liquid is held under pressure by forces exerted either by the push rod 12 in the direction of arrow *a*, or by forces exerted on the plunger 20 by spring 18 through the lever 13 in the direction of arrow *b*. Any backlash in the linkage, for instance any backlash between the cup-shaped member 22 and the two-armed lever 13, will be taken up by action of the spring 21 urging the plunger 20, the cup-shaped member 22 and the lever 13 into engagement with one another, outward motion of the plunger 20 from the cylinder 19 in the direction towards the lever 13 being rendered possible by the provision of the check valve 30 permitting liquid to be sucked into the chamber 24 from the reservoir 25. Since the sleeve 26 consists of a rubber-like material, it will be always completely filled with liquid and may extend or contract in conformity with the variable volume of liquid stored in the reservoir 25.

The diagram illustrated in Fig. 2 shows how the stroke imparted to the valve and the timing of the closing of the valve are dependent upon the speed of operation of the engine. In Fig. 2 the stroke imparted to the valve stem 11 is shown as a function of the time, the latter being expressed by the angular position α of the actuating cam which, in cooperation with spring 18, reciprocates the linkage including the push rod 12, the cup-shaped member 22 and the two-armed lever 13. When the engine is operated at its maximum speed the quantity of liquid that escapes from the variable chamber 24 during the valve-opening phase is negligible. Therefore, the stroke imparted to the cup-shaped member 22 equals practically the stroke imparted to the push rod 12 by the cam. The resulting stroke imparted to the valve stem 11 is represented by the top curve showing that the valve will be closed at the instant A_0 . When the engine operates at the speed v_1 a variable part of the reciprocatory motion imparted by the cam to the push rod 12 will be absorbed, such part being indicated by the cross hatching. Therefore, the stroke imparted to the valve stem 11 will be indicated by the curve v_1 , and it will be noted that the stroke is considerably reduced and that the valve will close at the instant A_1 already, that is to say much earlier than during top speed operation of the engine. When the engine is further slowed down to a rate v_2 of speed, the valve stroke will be further reduced and the valve will be closed as early as at A_2 .

Let it be assumed for the purpose of explanation that the two arms of lever 13 be of equal lengths and that, therefore, the top curve in Fig. 2 represents the position of push rod 12 in dependence on the angular position α of the cam. On the basis of this assumption it will be clear that after the valve has been closed, the push rod 12 will continue its downward motion through a distance which for the speed v_1 amounts to the length A_1-B_1 and for the speed v_2 amounts to A_2-B_2 indicated in Fig. 2. During this continued downward motion of push rod 12 the valve stem 11 remains stationary and backlash will be prevented by the spring 21 pushing plunger 20 outwardly holding this plunger, the cup-shaped member 22, the two-armed lever 13, the cap 16

4

and the stem 11 in engagement, thus preventing any backlash from forming.

The variable part of the stroke of push rod 12 which will be absorbed depends on the cross section of the gap 32. This cross section will be so dimensioned that the desired reduction of the valve stroke will be obtained. Preferably, the cross section is so chosen that at idling speed the valve stroke will be reduced to one fourth or one third of the full normal stroke.

A modified embodiment of the present invention is illustrated in Fig. 3 showing an engine of the type in which the cam shaft 133 is mounted above and adjacent the cylinder head, the cam imparting a reciprocatory motion to a linkage connected with the valve. The linkage comprises a one-armed lever 113 and a hydraulic link serving to connect the lever 113 with the cylinder head 110. The one-armed lever 113 is provided with a knob 116 which acts on the valve stem 111 which, in its turn, is subjected to the force of a valve-closing spring 118 braced against the cylinder head and acting on a plate 117 secured to the valve stem 111.

The hydraulic link which is connected with the lever 113 by a pivot pin 114 is similar to the hydraulic link described with reference to Fig. 1. It comprises a cup-shaped member 122 which has an external peripheral surface slidably guided in a flanged guide bushing 123 suitably fixed to the cylinder head 110 and having an internal cylindrical face slidably guiding a cylindrical element 119. In distinction to the afore-described embodiment, however, the cup-shaped member 122 is provided with a pair of upstanding ears 134 in which the pivot pin 114 is held and a ring 135 which is screwed into internal threads at the lower end of the member 112 and serves to hold the cylinder member 119 in place. A plunger 120 is slidable in the cylindrical member 119 protruding from the top thereof and is provided with a transverse bore 128 and with longitudinal bores 127 and 129 through which the variable chamber 124 confined by the cylinder 119 and the plunger 120 communicates with the reservoir 125. The latter surrounds the plunger 120 and is formed by a flexible sleeve 126 of a rubber-like material. A spherical check valve 130 is held on a seat surrounding the lower end of bore 129 by a helical spring 131. Another helical spring 121 inserted between the cylindrical element 119 and the plunger 120 serves to urge the latter in outward direction.

In further distinction from the embodiment shown in Fig. 1 the plunger 120 engages a horizontal pin 136 which is fixed in the guide bushing 123 and extends through slots 137 of the cup-shaped member 122. In this embodiment, the spring 121 urges the cylindrical element 119 downwardly into engagement with the ring 135 fixed to the cup-shaped member 134. Thus a downward pressure is exerted on the member 122 and the pivot pin 114 tending to take up any backlash between the lever 113, the cam 138 of cam shaft 133 and the valve stem 111. When the cam 138 depresses the lever 113 to thereby depress the valve stem 111 and to open the valve, the valve spring 118 tends to rock lever 113 anti-clockwise exerting an upward pull upon the cup-shaped member 122. As the plunger 120 remains stationary in contact with the stationary pin 136, the liquid included in the variable chamber 124 is subjected to pressure and will gradually escape through the gap 132 provided between the cylindrical element 119 and the plunger 120. This gap has a width of from 0.1 millimeters to 0.2 millimeters. Consequently, a part of the reciprocatory motion imparted to the linkage will be absorbed. The effect will be the same as that described with reference to Fig. 1.

A third embodiment of the invention is illustrated in Fig. 4. This embodiment is similar to that shown in Fig. 3 differing therefrom in that the permanently open duct connecting the variable chamber 124 to the reservoir 125 is formed by two communicating bores 139 and

140 provided in the cylindrical element 119. An adjustable throttle valve 140 having a threaded stem and a knurled knob engages a threaded bore provided in the cylindrical element 119 and cooperates with a valve seat 141 provided at the bottom end of the bore 139 to thereby determine the cross section of the communication between the variable chamber 124 and the reservoir 125. In this embodiment, the plunger 120 may have a sealing fit in the cylindrical bore of the element 119. By suitable adjustment of the valve 140 the function of the hydraulic link may be so controlled as to meet the specific requirements of any particular engine. If desired, the plunger 120 may be so fitted in the cylindrical element 119 that a narrow gap 132 is left therebetween which has a smaller cross section than the gap 32 in Fig. 1.

From the afore description it will appear that by the means described the lifting stroke of the valve may be controlled without the necessity of providing any control mechanism outside of and in addition to the linkage. While it has been assumed hereinabove that the stem 11, or 111 respectively, is the stem of the inlet valve, it is obvious that the linkage controlling the outlet valve may be likewise provided with a hydraulic link and, more particularly, with a hydraulic link that is leaky and, therefore, absorbs a variable part of the valve-lifting motion.

In the operation of the valve control mechanism movement of the linkage in the valve-opening direction causes the hydraulic fluid to be displaced through the restricted duct, such as 32, or 132, or 139, 140, whereby a comparatively small relative displacement of the linkage elements will be produced when the engine runs at a high rate of speed, and a comparatively large relative displacement of the linkage elements will occur when the engine is operated at a low rate of speed, such relative displacement reducing the valve-opening stroke. The restricted cross section of the duct through which the hydraulic fluid escapes from the variable chamber 24, or 124 respectively, is preferably provided by a loose fit of plunger and cylinder. The provision of the check valve, such as valve 30, or 130 respectively, provided between the variable chamber and the liquid reservoir which are separated by the restricted cross section, offers the advantage that when the linkage moves in valve-closing direction the elements of the linkage may be easily restored to the initial normal position permitting the liquid that had previously escaped from the variable chamber to quickly return to the same through the check valve.

The application of the invention to the inlet valve of an internal combustion engine offers the advantage that the gas or air stream entering the cylinder may be given a high speed, even if the engine operates at a low number of revolutions per minute. This is particularly desirable in engines of the type in which the fuel is injected into the cylinder during the suction stroke of the piston and is subsequently ignited by a spark plug.

Moreover, the invention may be used with great advantage in an internal combustion engine in which the periods during which the inlet valve and the outlet valve are open overlap each other. While during operation of the engine at a high speed the valves remain open for a longer period of time thus ensuring a high charge of the cylinder, it is desirable when the engine is operated at a low speed that the opening periods of the valves overlap little or not at all in order to avoid a loss of the gas charge through the outlet valve. The novel valve control mechanism complies with that requirement.

Moreover, the novel valve control mechanism ensures a smoother idling and a better starting of the engine.

While the invention has been described in connection with a number of preferred embodiments thereof, it will be understood that it is capable of further modification, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such

departures from the present disclosure as come within known or customary practice in the art to which the invention pertains, and as fall within the scope of the invention or the limits of the appended claims.

What I claim is:

1. In an internal combustion engine, the combination comprising a valve, a reciprocating linkage connected to said valve, and a rotating cam coordinated to and adapted to impart to said linkage a reciprocatory motion transmitted to said valve, said linkage including means responsive to the rotary speed of said cam and adapted to absorb a variable part of said motion, said speed-responsive means being provided with a passage of definite size forming a hydraulic link, said variable part increasing as said rotary speed decreases, whereby the valve stroke will increase as the engine is sped up and will decrease as the engine is slowed down.

2. In an internal combustion engine, the combination claimed in claim 1 in which said means comprises a cylinder, a piston movable therein, and a volume of liquid therebetween, a passage of definite cross section being provided in said means permitting said liquid, when said linkage is subjected to pressure, to gradually escape.

3. In an internal combustion engine, the combination claimed in claim 1 in which said means comprises a cylinder, a plunger guided therein, a volume of liquid filling the space between said cylinder and said plunger, a stop rigidly connected with said cylinder and adapted to limit the outward stroke of said plunger, and a spring tending to urge said plunger out of said cylinder into contact with said stop, said cylinder being provided with a passage of definite cross section for discharge of said liquid when said linkage is subjected to pressure.

4. In an internal combustion engine, the combination claimed in claim 3 in which said passage of definite cross section is provided between said plunger and said cylinder.

5. In an internal combustion engine, the combination comprising a valve, a reciprocating linkage connected to said valve, a rotating cam coordinated to and adapted to impart a reciprocatory motion to said linkage, the latter transmitting said motion to said valve, said linkage including relatively movable elements confining a chamber of variable volume, a liquid filling said chamber, and a liquid reservoir, two ducts being provided each connecting said variable chamber to said reservoir, and a check valve adapted to control one of said ducts being mounted to open towards said variable chamber, the other one of said ducts being permanently open and having a restricted cross section.

6. In an internal combustion engine, the combination claimed in claim 5 in which an adjustable throttle valve is coordinated to said other one of said ducts and adapted to adjust said cross section.

7. In an internal combustion engine, the combination claimed in claim 5 in which said relatively movable elements are constituted by a cylinder and a plunger movable therein, said other one of said ducts being formed by a gap of a width of from about 0.1 millimeters to about 0.2 millimeters provided between said cylinder and said plunger.

8. In an internal combustion engine, the combination claimed in claim 5, in which the other one of said ducts enables said liquid to pass back and forth between said chamber and said reservoir.

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