Sept. 11, 1951

J. L. H. BISHOP ET AL
CAM FOR OPERATING VALVES OF
INTERNAL-COMBUSTION ENGINES

2,567,690

Filed Nov. 2, 1948

2 Sheets-Sheet 1

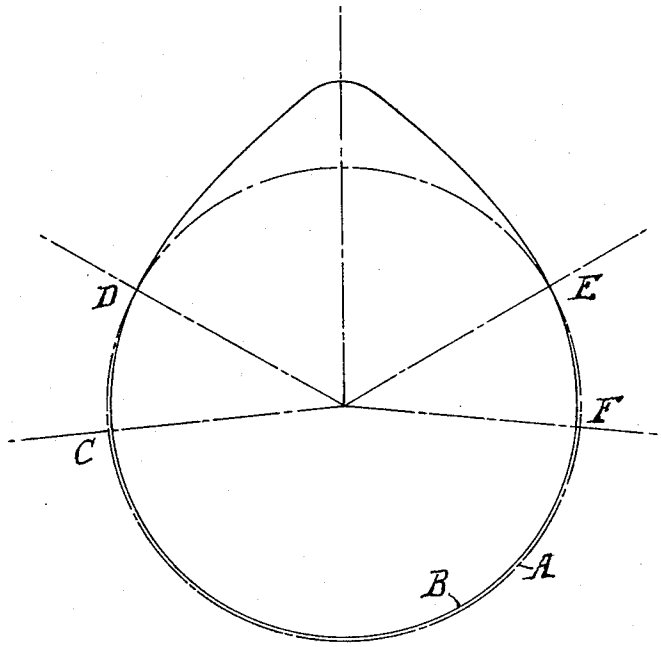


Fig. 1.

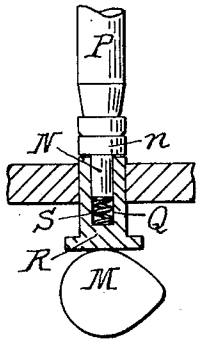


Fig. 8.

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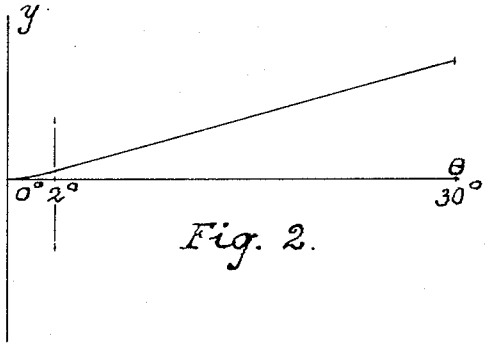


Fig. 2.

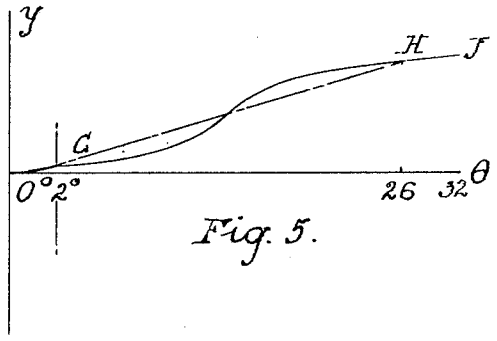


Fig. 5.

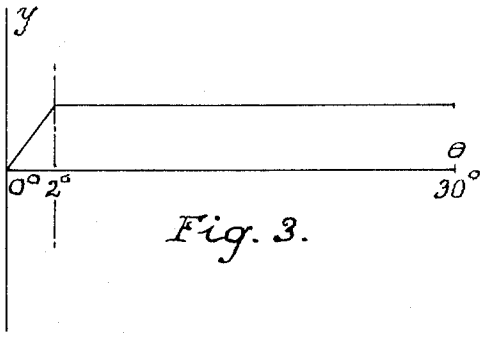


Fig. 3.

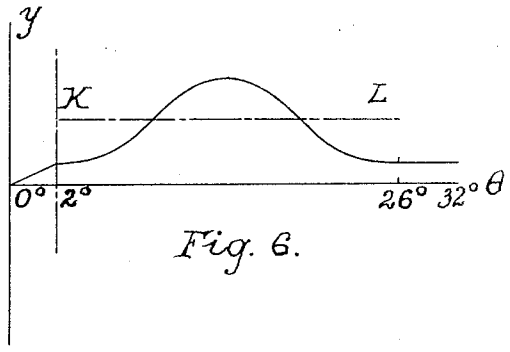


Fig. 6.

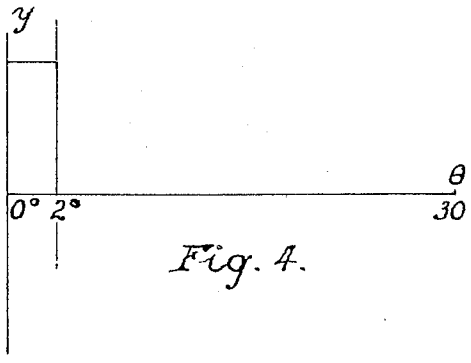


Fig. 4.

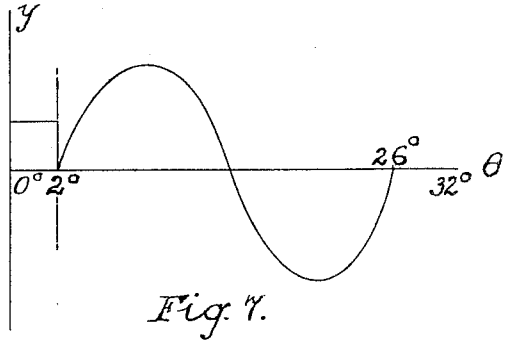


Fig. 7.

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CAM FOR OPERATING VALVES OF INTERNAL-COMBUSTION ENGINES

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Application November 2, 1948, Serial No. 57,873
In Great Britain November 8, 1947

3 Claims. (Cl. 123—90)

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The invention relates to cams for the operation of valves for internal combustion engines, and more particularly to improvements in the opening and closing ramps arranged for taking up the tappet clearance between the clearance circle and the base circle of the cam.

An object of the present invention is to provide opening and closing ramps which result in minimum initial and final velocities of an actuated member such as a valve tappet while taking up tappet clearance to reduce the tappet and valve noise and still provide a relatively short ramp and thus avoid the obvious disadvantages of a long ramp. In an ordinary cam it is quite usual to arrange curves so that the first small part of the lift, which is from the clearance circle to the base circle, for taking up tappet clearance, takes the form of a constant eccentricity ramp on the opening side and a similar ramp on the closing side, the two slopes being, however, often made unequal. The slope of the opening ramp determines the velocity at which the valve will be lifted off its seat and the closing ramp its seating velocity; the slope also determines the actual opening period of the valves. It will therefore be apparent that a slope of less inclination improves the valve seating conditions but would have the disadvantage of increasing the opening period and causing the valve to open too soon.

It is quite common that an opening ramp may have a length of approximately 30 degrees of the camshaft rotation, the first 2 degrees of lift being effected by an eccentric radius to accelerate the tappet from zero velocity to the constant velocity of the remainder of the ramp.

In a ramp designed in accordance with the present invention, after effecting about the first 2 degrees of lift by an eccentric radius to impart a velocity to the tappet of approximately half that produced by the usual constant eccentricity ramp, the next or main part of the ramp, say 26 degrees of camshaft rotation, is represented by the full period of a negative sine curve combined with an ascending straight line curve, the combined curve ending preferably in a straight line curve of approximately 6 degrees of camshaft rotation, and the inclination of this latter straight line curve is preferably arranged to be approximately half that of the usual constant eccentricity ramp.

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The invention is explained by reference to the accompanying drawings of which:

Figure 1 is a somewhat diagrammatic view of a cam of conventional form.

Figures 2, 3 and 4 illustrate, respectively, the lift curve, velocity curve and acceleration curve of an opening ramp of the conventional or usual forms.

Figures 5, 6 and 7 illustrate, respectively, the lift curve, velocity curve and acceleration curve of an opening ramp designed in accordance with the invention.

Figure 8 is a somewhat diagrammatic detail view to illustrate a special form of spring-loaded tappet used with the cam.

Referring first to Figure 1, A indicates the usual base circle of the cam shown by a chain line, and B the usual clearance circle. The part of the cam surface between C and D is the opening ramp during which the tappet is lifted from the clearance circle B to the base circle A, to take up valve clearance. The part of the cam surface between E and F is the closing ramp.

Referring to Figure 2, which illustrates the lift curve of an opening ramp of conventional form, the lift is measured along the vertical ordinate y and the angle of rotation of the cam is measured along the horizontal ordinate θ. It will be seen that, for the first 2 degrees, the tappet is lifted with increasing velocity while between 2 degrees and 30 degrees it is lifted at constant velocity.

Referring to Figure 3, which is the velocity curve the velocity is measured along the vertical ordinate y. It will be seen that between 0 and 2 degrees the velocity increases constantly, and that between 2 degrees and 30 degrees the velocity remains constant.

Referring to Figure 4 in which acceleration is measured along the vertical ordinate y, it will be seen that, between 0 and 2 degrees, the acceleration first rises instantly to maximum value and then remains constant, and that at 2 degrees it falls instantly to zero value. Between 2 degrees and 30 degrees it remains at zero value.

The sudden changes in velocity and acceleration are objectionable and tend to noisy operation.

Referring to Figure 5 which illustrates the lift curve of a ramp designed according to this invention it will be seen that between 0 degrees

and 2 degrees the tappet is lifted for a very short distance at increasing velocity, and that between 2 degrees and 26 degrees it rises in accordance with a full negative sine curve plotted on an ascending straight line G, H. Between 26 degrees and 32 degrees the shape of the ramp is represented by line H, J. The valve clearance is arranged so that the valve is lifted from its seat at some point on the line H, J. The velocity of the valve on opening will be in accordance with the tappet velocity between H and J.

It will be seen from Figure 6, which is the first differential of the lift curve that, between 0 degrees and 2 degrees, the velocity rises constantly. Between 2 degrees and 26 degrees the velocity changes in accordance with a full negative co-sine curve plotted on the line K, L which is the first derivative of the straight line G, H on which the lift curve of Figure 5 is plotted. It will also be seen that between 26 degrees and 32 degrees the velocity remains constant to the end of the ramp.

Referring lastly to Figure 7, which is the second derivative of the lift curve it will be seen that, at 0 degrees, the acceleration rises instantly to a maximum but only to a relatively small value, that it remains constant between 0 degrees and 2 degrees and falls instantly at 2 degrees to zero value. Between 2 degrees and 26 degrees the acceleration curve varies in accordance with a full positive sine wave. Between 26 degrees and 32 degrees it remains constant at zero acceleration to the end of the ramp F.

It will be seen, by reference to Figures 5 and 6, that there are no violent changes in the curves, and that in Figure 7 the curve makes no violent change except the small sudden change at the beginning of the ramp.

Referring to the sine curve combined with an ascending straight line curve shown in Figure 5, it is the slope of the straight line curve which determines the actual total lift of the tappet over the full period of the sine curve. By suitable choice of the slope of the ascending straight line curve, it can be arranged that, at the end of the period of the sine curve, the actual lift could be the same amount as that obtained with a common constant eccentricity ramp, and yet ending with a much less velocity.

The closing ramp may have the same features as the opening ramp but in the reverse order.

In a ramp designed as above described it will be apparent that, provided the tappet is maintained in contact with the ramp, the motion of the tappet is harmonic. Furthermore the main part of the velocity curve will be a full negative co-sine curve and the main part of the acceleration curve will be a full period positive sine curve.

Referring to the lift curve of Figure 5, for the first half of the period of the negative sine curve, the tappet will be subjected to a positive acceleration and for the second half of the period of the negative sine curve, the tappet will be subjected to a negative acceleration.

For this reason it will be necessary to keep the tappet in contact with the cam while traversing the ramps. A form of tappet which may be used for such purpose is shown in Figure 8 in which M indicates the cam. The tappet is formed in two parts, an upper part N, which bears upwardly against the valve stem P, and enters at its lower end, as a sliding fit, in a bore Q formed in from the top of a lower part R of the tappet. A light coil spring S is inserted between the lower end of the part N and the bottom of the bore Q. A collar *n* is formed on the upper end of the part N and the normal distance between such collar and the top of the part R is the valve clearance. As the tappet traverses the opening ramp it presses up the part R against the force of the spring S, while the valve remains closed until the gap is taken up.

Having fully described our invention, what we claim and desire to secure by Letters Patent is:

1. An operating mechanism comprising a movable member, an element actuated by said movable member, and a rotary cam having a peripheral surface adapted to engage said member, said surface having a lifting portion and a circular portion of smaller radius than the base circle of said cam whereby clearance is provided between said member and element, a ramp portion connecting said lifting portion and said circular portion, the contour of the major part of said ramp portion being represented by a lift curve consisting of two functions in series, the first function consisting of a negative sine curve combined with an ascending straight line, whereby said member is accelerated from a predetermined velocity to a positive maximum velocity with the acceleration represented by a positive one half period sine curve and is decelerated from said maximum positive velocity to another predetermined constant velocity with the acceleration represented by a negative one half period sine curve, and the second function consisting of a straight line curve tangent to the end of said negative sine curve whereby said member is moved at a minimum constant velocity with zero acceleration prior to contact with said lifting portion.

2. An operating mechanism comprising a movable member, an element actuated by said movable member, and a rotary cam having a peripheral surface adapted to engage said member, said surface having a lifting portion and a circular portion, a ramp portion connecting said lifting portion and said circular portion, the contour of the major part of said ramp portion being represented by a lift curve consisting of two functions in series, the first function consisting of a negative sine curve combined with an ascending straight line, whereby said member is accelerated from a predetermined velocity to a positive maximum velocity with the acceleration represented by a positive one half period sine curve and is decelerated from said maximum positive velocity to another predetermined constant velocity with the acceleration represented by a negative one half period sine curve, and the second function consisting of a straight line curve tangent to the end of said negative sine curve whereby said member is moved at a minimum constant velocity with zero acceleration prior to contact with said lifting portion.

3. An operating mechanism comprising a movable member, an element actuated by said movable member, and a rotary cam having a peripheral surface adapted to engage and move said member, said surface having a lifting portion and a circular portion, a ramp portion connecting said lifting portion and said circular portion, the contour of the major part of said ramp portion being represented by a lift curve consisting of a negative sine curve combined with an ascending straight line whereby said member is accelerated from a predetermined velocity to a positive maximum velocity with the accelera-

tion represented by a positive one half period sine curve and is decelerated from said maximum positive velocity to another predetermined constant velocity with the acceleration represented by a negative one half period sine curve.

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JOHN H. WEAVING.

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