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INJECTION OF FUEL IN INTERNAL COMBUSTION ENGINES.

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1,265,799. Patented May 14, 1918.

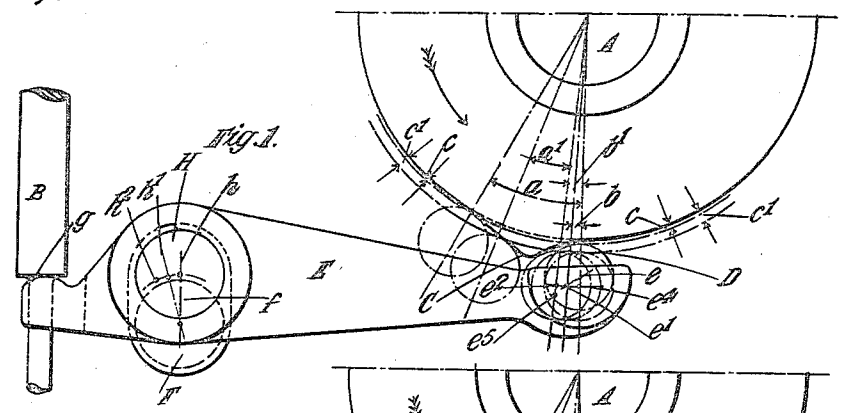


Fig. 1.

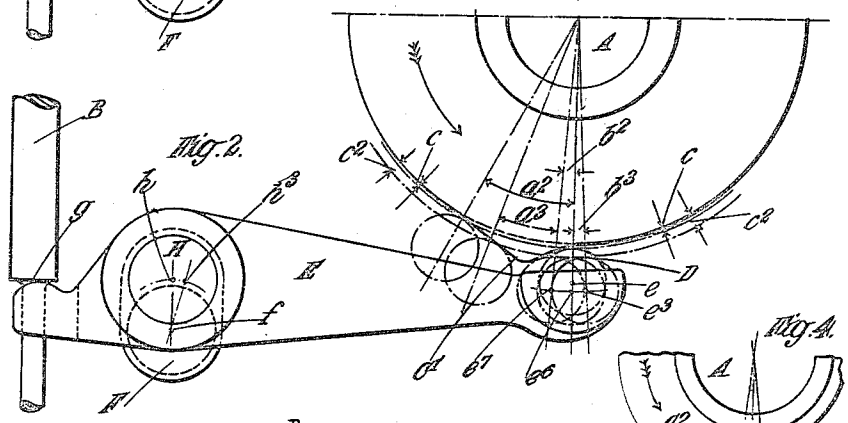


Fig. 2.

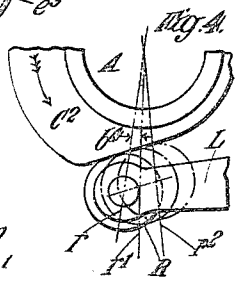


Fig. 4.

Fig. 3.

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UNITED STATES PATENT OFFICE.

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INJECTION OF FUEL IN INTERNAL-COMBUSTION ENGINES.

1,265,799. Specification of Letters Patent. Patented May 14, 1918.

Application filed December 2, 1916. Serial No. 134,642.

To all whom it may concern:

Be it known that I, JAMES McKECHNIE, a subject of the King of Great Britain, residing at Naval Construction Works, Barrow-in-Furness, in the county of Lancaster, England, have invented certain new and useful Improvements in or Relating to the Injection of Fuel in Internal-Combustion Engines, of which the following is a specification.

This invention relates to the injection of fuel in internal combustion engines, more especially fuel mechanically injected in the form of a liquid spray, and its chief object is to provide simplified means by which the operation of the fuel injection valve may be properly performed for varying engine load and speed.

According to this invention an adjustable valve lever controlling the fuel injection is operated by a cam the outline of which is so formed with relation to the path given by variation of the lever adjustment to the extremity of the lever that, for all clearances between the cam and lever and resulting variation in duration of fuel injection and engine power, the valve is timed to open at the correct point at which injection should take place, without the introduction of special timing mechanism. For this purpose the displacement of the lever for varying the fuel injection must be so chosen that a cam surface giving the correct timing for the variable speed and quantity of fuel is one of practicable form.

A convenient method of adjusting the lever is to mount its fulcrum upon an eccentric partially rotatable so as to move the cam roller at the end of the lever toward or away from the cam and also usually to displace it forwardly or rearwardly of the cam. It has not hitherto been realized that a lever adjustment and the cam outline could be so related as to give the best timing of the valve opening for all variations in engine power, but it is now found that by suitably choosing the size of the eccentric upon which the fuel lever fulcrum is mounted, the direction of partial rotation of the eccentric and the portion of the path of the eccentric during which regulation of the fuel valve is effected, the necessary movement of the fuel valve lever roller away from the cam can be accomplished by any desired movement of the lever roller in or against the direction of rotation of the cam, and it is thus possible to obtain the required opening and closing of the fuel valve at all adjustments without departing to any material extent from the cam profile most suitable for any particular duty of the engine.

The following edge of the cam is of course shaped in accordance with the form of the leading edge to give the proper duration of injection for all adjustments of the valve lever. This duration in an engine using mechanical injection and fuel supplied at constant pressure (for example by a battery of pumps passing any surplus fuel through a relief valve) will determine the charge of fuel at each firing stroke and will therefore depend upon the purpose of the engine. Thus in a marine engine of this type the angle of duration for a given reduced charge will, owing to the greater time of opening at lower speed, be less than in a constant speed dynamo engine. In an engine in which mechanical injection is used and a measured quantity of fuel is supplied at each firing stroke the angle of duration of opening will be so arranged that the spraying pressure is maintained at a high level even at low powers of the engine. In an engine using compressed air for the pulverization and spraying of the fuel the reduction of duration will be such as to prevent wastage of air owing to the valve remaining open longer than is necessary for the injection of the fuel.

The partial rotation of the eccentrically mounted fulcrum bearing of the fuel valve lever may be effected simultaneously with the control of the fuel pump. Thus in a constant speed engine with a surplus fuel supply at constant pressure the amount of fuel to be passed by the relief valve on the fuel pump does not become excessive as the power decreases. In the case of an engine where the charge of fuel is determined by a fuel measuring pump the simultaneous adjustment of pump and injection valve can, by suitably arranging the linkwork connecting the two adjusting gears, be made to give to the injection valve the correct functions for the power as determined by the quantity delivered by the fuel pump. For this purpose, we may mechanically operate the suction valve of the pump by means of a

cam and adjustable lever with variable clearance on the lines described above for the injection valve lever. The displacement of the lever and the cam profile will in this case be so correlated that the suction valve may open early in the suction stroke of the pump at all adjustments and will close, according to the adjustment, at any point within the desired range of the delivery stroke of the pump, a sufficient lift of the valve being given at all adjustments.

In order that the said invention may be clearly understood and readily carried into effect the same will be described more fully with reference to the accompanying drawings, in which:—

Figure 1 shows the application of the invention to the fuel injection valve operating device of a constant speed internal combustion engine, such as a dynamo engine.

Fig. 2 shows the application of the invention to the fuel injection valve operating device of a variable speed engine such as a marine engine.

Fig. 3 shows the application of the invention to the gear operating the suction valve of the high pressure fuel pump of an internal combustion engine; and

Fig. 4 is an enlarged view of a detail shown in Fig. 3.

A is the cam shaft of the engine upon which are mounted the injection valve cams C or C′ and, in Figs. 3 and 4, the pump cam C^2. B is the valve spindle of the fuel injection valve. E is the injection valve operating lever mounted on the eccentric or crank H of the fulcrum pin F, which can be partly rotated about its center f, and so move the center h of the eccentric H. The lever E oscillates about this center h and, as the fulcrum pin F is partly rotated, the eccentric center h moves in an arc about the pin center f. D is the cam roller on the end of the lever E, revolving about its center e. g shows the position at which the valve end of the lever E touches the valve spindle B when the valve is closed. h is the center of the eccentric H in maximum power position, and c is the corresponding clearance between the roller D and cam C (Fig. 1) or cam C′ (Fig. 2).

Referring to Fig. 1, which shows the application of the invention to a constant speed engine, in which it is desirable to admit fuel at an early stage at all ranges of power, the angle a is the duration of opening of the injection valve when the center of the eccentric H is in its maximum power position h. Upon partial rotation of the fulcrum F in a direction which causes the roller D to move opposite to the direction of motion of the cam C, the center h moves in an arc to, say, position h', causing both a tangential and a radial displacement of the roller D in respect to the path of cam C (the position g of the valve end of the lever E remaining the same, that is, the valve is still closed), so that the center e of the roller D moves to the position e', increasing the clearance between the cam C and the roller D to c'. The duration of opening of the injection valve is now given by the angle a'. Owing to the radial component $e\,e^4$ of the displacement of the roller D, which now works on the higher part of the cam C, the opening of the fuel valve is delayed by an amount represented by the angle b' between the points e and e^2, e^2 being the center of a circle of the same diameter as D and touching the circle of clearance c' and the cam C. But in moving from center e to center e' the roller D has had imparted to it a tangential or angular displacement b partly compensating for the delay in the opening of the fuel valve due to the roller working on the higher part of the cam. The net delay in the opening of the valve is therefore the small angle represented by $b'—b$, *i. e.* the angle subtended at the center of the cam shaft by the distance $e'—e^2$.

In the extreme case in which the opening of the fuel valve has to take place at the same point for all powers the path through which the center c of the roller D is moved by the partial rotation of the pin F would be made to follow as closely as possible the contour of the leading face of the cam C, making the angle $b'—b$ zero. This may in certain cases entail inconvenient proportions of the eccentric H and in order to avoid this the leading edge of the cam may be made as steep as practicable so as to reduce the delay in opening of the fuel valve due to the roller working on the higher part of the cam. In practice a slight retardation of the admission of fuel is desirable at reduced powers and this retardation is effected by gradually sloping the leading edge of the cam C as shown in Fig. 1.

The position e^5 shows the center of the roller D for the cut out position h^2 of the eccentric H when the roller is quite clear of the cam C.

Referring now to Fig. 2, which shows the application of the invention to a variable speed engine in which as the power falls it is desirable to retard the fuel injection to a considerably greater extent than in a constant speed engine, the angle a^2 is the duration of opening of the fuel injection valve when the center of the eccentric H is in its maximum power position h. Upon partial rotation of the fulcrum pin F, in a direction such that the roller D moves in the same direction as the cam C′, the center h moves to, say, position h^3. This causes both a tangential and radial displacement of the roller D relatively to the path of the cam C′ (the position g of the valve end of the lever E remaining the same, that is, the valve is

still closed), the center of the roller D moving to the position e^3 increasing the clearance c between the cam C′ and the roller D to c^2 so that the duration of opening of the fuel injection valve becomes a^3, owing to the radial displacement $e—e^6$ of the roller D, which now works on the higher part of the cam C′, and, due to this radial displacement only, the opening of the fuel valve is delayed by an amount represented by the angle b^2, extending from e^6 to e^7, e^7 being the center of a circle of the same diameter as D and touching the circle of clearance c^2 and the cam C′. But in moving from the center e to center e^3 the roller D has had imparted to it a tangential displacement b^3 so that the timing of the opening of the fuel injection valve is delayed by this amount in addition to the delay due to the roller working on the higher part of the cam. The total delay in opening is therefore represented by the angle $b^2—b^3$.

It is evident that by suitably choosing the eccentricity of the eccentric or crank H, the direction of partial rotation of the fulcrum pin F during regulation and the mean position of the line f, h, it is possible to give, during the desired radial motion of the center e, a tangential motion to the lever E of any desired amount in either direction, so that with a cam of practicable shape it is possible at all powers to obtain a close approximation to the desired point of opening of the fuel valve.

The path during regulation of the roller D and the leading edge of the cam C or C^1 having been designed conjointly to obtain the required variation of timing of the first admission of fuel at various powers, the following edge of the cam is arranged relatively to the leading edge so that the angle of duration a' (Fig. 1) or a^3 (Fig. 2) will, in an engine arranged for mechanical injection of fuel at constant pressure, correctly determine the quantity of fuel admitted at each firing stroke, or, alternatively, will, in an engine arranged with fuel measuring pumps, maintain the injection pressure at a high level at all powers. In a constant speed engine the angle of duration of injection will obviously be greater for a given power than in, say, a marine engine.

In carrying the invention into effect it will be necessary to insure that the practical area for flow through the injection valve is normally considerably greater than the practical area through the pulverizing orifices, as is usual, otherwise at intermediate powers there will occur undue restriction before the fuel reaches the pulverizer, thus affecting the spraying of the fuel. At very low powers partial throttling by the injection valve may be adopted.

Fig. 3 shows the invention arranged for the control of a pump supplying high pressure fuel oil, where separate fuel pumps are fitted to each cylinder, the control to be effected simultaneously with, and at all adjustments of, the fuel injection valve as already set forth.

P is the fuel oil pump, with suction port S, and suction valve V, which is controlled by the cam C^2 on the cam shaft A through the cam roller R on the end of the lever L and the push rod v. This push rod v keeps the lever L hard up to the cam C^2 by means of the spring v^2 through the guide v'. Y is the fuel injection valve body in the cylinder cover Z, the fuel oil being delivered from the pump P to the fuel injection valve Y by means of the pipe O, in which may be fitted a pressure accumulator T. M is the hand or governor controlled rock shaft carrying the eccentric N upon which the lever L is mounted. Upon this shaft is also mounted the lever l' controlling the adjustment of the fuel injection valve Y through the link l^2 and the lever l on the eccentric fulcrum pin F.

Fig. 4 is an enlarged view of part of the cam C^2 and the roller R on the end of the lever L. The cam C^2 is shown just opening the suction valve V when the rock-shaft M is in its maximum power position, and the plunger p of the fuel pump P, which is driven from the cam shaft A by an eccentric X, is just commencing to ascend on its suction stroke, so that n is the position of the center of the eccentric N when h is the position of the center of the eccentric H, and r is the position of the center of the roller R. Upon the rock-shaft M being partly rotated so as to bring the center h of the eccentric H to say h', the center n of the eccentric N moves in an arc about the center of the rock-shaft M to the position n', and in doing so moves the lever L so as to displace the roller R both tangentially and radially relatively to the path of the cam C^2, the point g' of the lever L remaining in the same position throughout the movement, so that the center r of the roller R takes up the position r' shown in Fig. 4. The angular displacement is shown at b^4 and this is so proportioned in conjunction with the leading or opening edge of the cam C^2 that the valve V opens at an early point in the suction stroke of the pump at all adjustments.

The radial displacement of the roller R causes the valve to open with more or less lift according to the direction of displacement, and in the position r the valve obtains its minimum lift while in position r^2 it remains completely open, corresponding to the cut-out position.

The cam C^2 has its remaining contour so formed that the suction valve V is held open till the downward stroke of the plunger p begins and then is allowed to close, the point of closing, depending upon the position of

the center of the eccentric N, being represented by the angular positions Q, Q_1, Q_2 for the positions n, n_1, n_2 of the said center. The curve of the closing edge of the cam may be arranged so that the effective discharge of the pump bears any desired ratio to the duration of opening of the valve B. It is thus possible to maintain a high spraying pressure at all powers.

What I claim and desire to secure by Letters Patent is:—

1. Fuel injecting mechanism for internal combustion engines, comprising an injection valve, a valve lever, a lever operating cam, and an adjustable eccentric fulcrum for the said lever, so positioned that its path of adjustment is approximately tangential to the cam and causes both radial and tangential adjustment of the cam end of the lever, the outline of the cam being so formed with relation to the path of adjustment of the lever end that correct timing of the point at which the valve opens is obtained for all adjustments.

2. Fuel injecting mechanism for internal combustion engines, comprising an injection valve, a valve lever, a lever operating cam and an adjustable fulcrum for the lever so positioned that on adjusting the fulcrum for power regulation the cam end of the lever moves along a path substantially following the contour of the leading edge of the cam, whereby the opening of the injection valve begins at practically the same point in the engine stroke for different positions of the lever.

3. Fuel injecting mechanism for internal combustion engines, comprising an injection valve, an adjustable valve lever, a lever operating cam having the outline of its leading surface so related to the path of adjustment of the lever as to time the valve opening for all adjustments of the lever, a fuel pump including a suction valve, a suction valve cam, an adjustable cam lever through which the suction valve is operated and means for effecting the simultaneous adjustment of the injection and suction valve levers.

4. Fuel injecting mechanism for internal combustion engines, comprising an injection valve, a valve lever, an adjustable eccentric fulcrum on which the said lever is mounted, a lever operating cam having the outline of its leading surface so related to the path of adjustment of the lever as to time the valve opening for all adjustments of the lever, a fuel pump including a suction valve, a suction valve cam, a cam lever operating the suction valve, an adjustable eccentric fulcrum for the said cam lever, and an operative connection between the two adjustable fulcrums by which simultaneous adjustment of the two levers is effected.

In testimony whereof, I hereto affix my signature.

JAMES McKECHNIE.