

Nov. 16, 1937.

L. O. HEDBLOM

2,099,206

FUEL PUMP

Filed Feb. 18, 1935

2 Sheets-Sheet 1

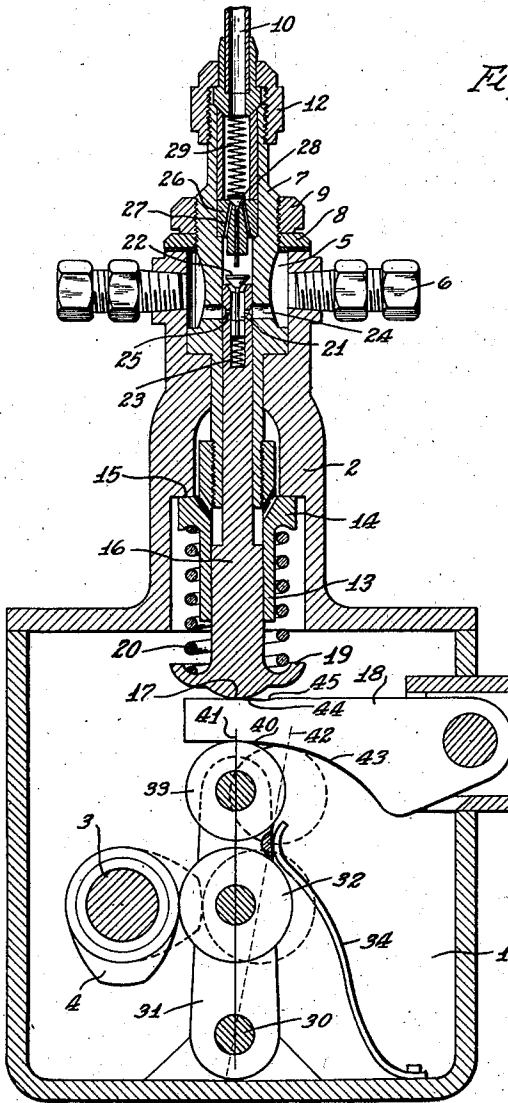


Fig. 1.

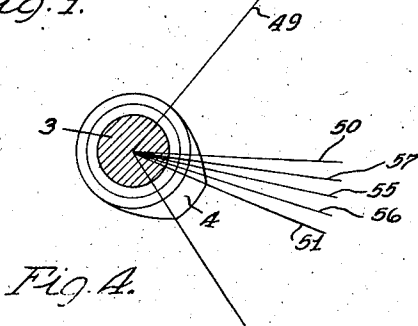


Fig. 4.

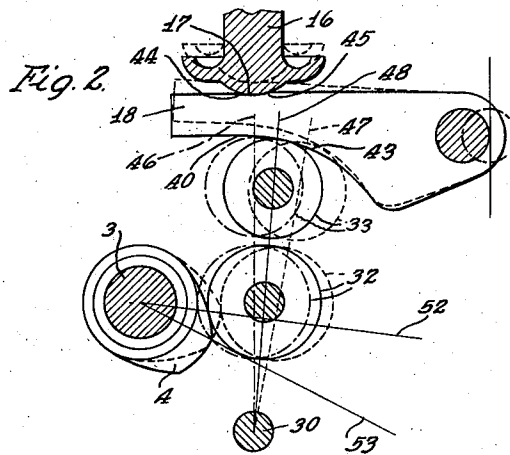


Fig. 2.

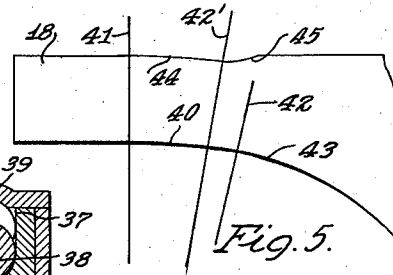


Fig. 5.

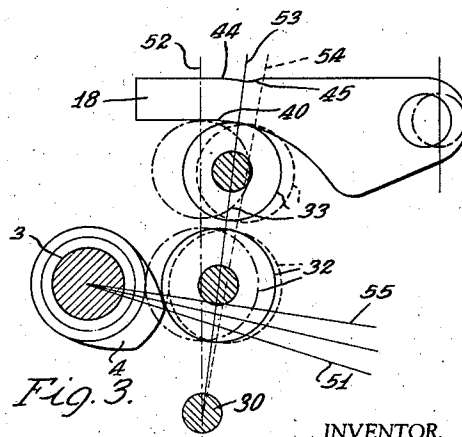


Fig. 3.

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2 Sheets-Sheet 2

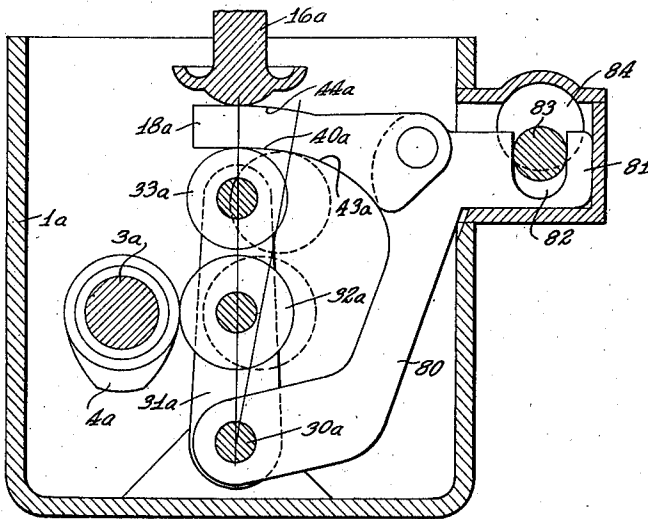


Fig. 8.

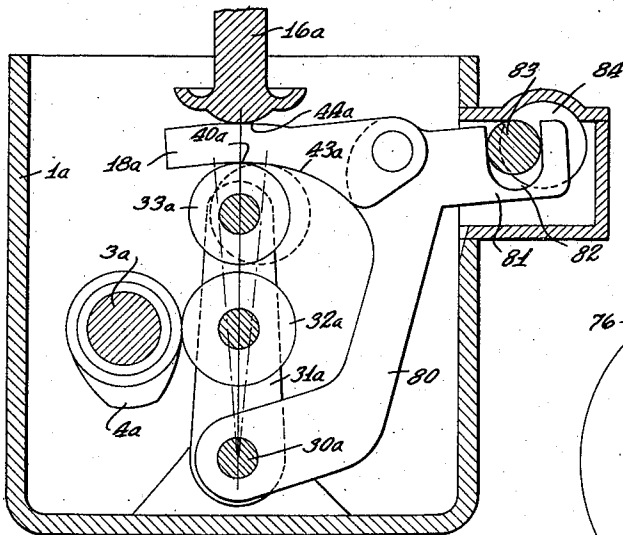


Fig. 9.

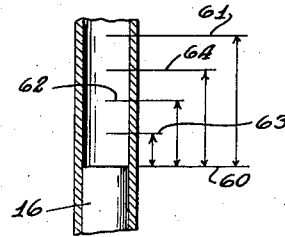


Fig. 6.

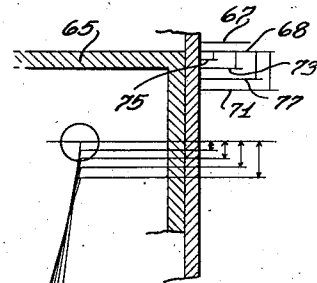
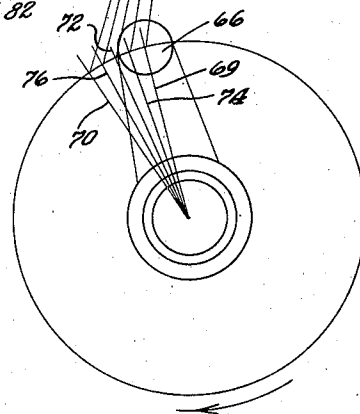


Fig. 7.



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2,099,206

FUEL PUMP

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Application February 18, 1935, Serial No. 6,988

2 Claims. (Cl. 103—38)

The present invention pertains to a novel fuel injector for Diesel engines of the type shown in my co-pending application Serial No. 615,624, filed June 6, 1932, and more particularly to means for regulating the length of the injector stroke to regulate the amount of fuel delivered with each stroke.

The primary object of the present invention is to provide a fuel injector whose operating cam shaft is adapted to be operatively connected to the crank shaft of an engine to rotate in timed relation thereto, and means between the operating cam and an injector mechanism which is subject to manual adjustment to prevent operative performance of the injector mechanism when the engine is running on momentum after the throttle has been closed. To this end, the closing of the throttle effects an instantaneous adjustment in the injector mechanism whereby continued rotation of the cam shaft may take place as a result of momentum of the engine without resulting in a fuel pumping action in the injector.

Another object of the invention is to provide means for controlling successive ejections of fuel from a fuel injector mechanism whereby successive injections of fuel into a cylinder of a combustion engine are definitely timed relative to movement of a piston in the cylinder so that the successive injections of fuel always terminate when the piston reaches a definite point in its travel. The means for ejecting the fuel from the injector comprises a reciprocating plunger which causes fuel to be injected into the cylinder of the engine with each pumping stroke thereof, and the regulating means cooperates with the plunger and provides a means for varying the length of the pumping stroke of the plunger so as to vary the size of the injection. In varying the length of the stroke two important functions are provided for by the invention. The first function is that the reciprocating plunger always starts its pumping stroke at the same point and the length of the stroke is varied by moving it different distances from this constant point. The other function is that the injection of the fuel is always terminated when the piston in the engine cylinder reaches a definite point in relation to its firing point and the length of the injection stroke is varied by starting it at various points in advance of the constant terminating point.

Another object of the invention is to provide a stroke adjuster which co-relates the movement of a plunger with an operating cam so that the

cam may be rotated without imparting movement to the plunger and so that rotation of the cam may be utilized to impart various amounts of movement to the plunger. In this connection, the stroke adjuster functions whereby a short stroke of the plunger requires a short angular movement of the operating cam and a longer stroke of the plunger requires a longer angular movement of the cam. For example, a full stroke of the plunger requires a certain number of degrees of rotation of the cam whereas a half stroke requires movement of the cam through half that number of degrees. The advantage of this function is that the time interval necessary to complete an injection is actually less in connection with a short injection than it is with a longer injection even though the cam is rotating at a slower rate of speed, when the short injections are taking place, than it is when the longer injections are taking place, with the result that the fuel injected at idling speed of the engine does not have sufficient time to expand to the extent that it bucks the engine. In other words, during short injections, the fuel is not injected too far in advance of the firing point to cause unnecessary back pressure on the piston due to the natural tendency of the fuel to expand when it contacts the walls of the heated cylinder and piston whereby the start of the injection automatically advances as the volume of the injection increases.

Still another object of the present invention is to provide a device for synchronizing the movements of an injector plunger, its operating cam and the piston of an engine so that the plunger stroke terminates at a predetermined stage of rotation of the operating cam and so that the predetermined stage of rotation of the operating cam is reached when the piston in the engine cylinder has reached a predetermined point in its travel, and for maintaining the synchronized relationship during adjustments to vary the length of the stroke of the plunger. Thus, three functions remain in constant timed relation, the termination of the actuating movement of the cam with respect to the plunger, the point from which the plunger pumping stroke starts, and the point at which the injection is completed with respect to the travel of the piston in its cylinder. Three functions are variable, the point at which actuating movement of the cam begins, with respect to the point thereon where the actuating movement ends, the point at which the plunger stroke terminates with respect to the point where the stroke starts, and the point at which the injection

into the cylinder begins with respect to the constant point where it ends.

With the above and other ends in view the invention is more fully disclosed with reference to the accompanying drawings, in which

Figure 1 is a vertical cross section of the injector;

Figs. 2 and 3 are diagrammatic views illustrating different stages in operation;

Fig. 4 is a detail of the operating cam;

Fig. 5 is a fragmentary elevation of a detail;

Fig. 6 is a diagrammatic view illustrating the movements of the plunger;

Fig. 7 is a diagrammatic view illustrating the movements of the piston and crank shaft;

Fig. 8 is a vertical cross section of a modified stroke adjuster, and

Fig. 9 is a view corresponding to Fig. 8 and illustrating another stage in operation.

Like characters of reference are employed throughout to designate corresponding parts.

The injector device comprises a crank case 1 having a body 2 secured thereon by any suitable securing means. Rotatably supported in the crank case 1 is a cam shaft 3 having a cam 4 secured or formed thereon. The cam shaft 3 is adapted to be connected to the crank shaft of an internal combustion engine to rotate in unison therewith in the manner well known in the art and therefore not illustrated here.

In the body 2 there is provided a fuel injector mechanism of the type shown and claimed in my copending application Serial No. 615,624, filed June 6, 1932, and allowed October 18, 1934. As illustrated, the body 2 is formed with a fuel reservoir 5 having a fuel supply line 6 connected thereto. A sleeve 7 extends through the top of the body 2, through the reservoir 5, and through a substantial portion of the body 2. The upper end of the reservoir 5 is sealed by a ring 8 clamped by a nut 9 on the exposed portion of the sleeve 7. Attached to the upper end of the sleeve 7 is a line 10, held by a coupling element 12 and leading to the injection nozzle at the cylinder of an engine in a manner well known in the art and therefore not illustrated here.

On the lower end of the sleeve 7 is screwed another sleeve 13 having a flange 14 bearing upwardly against a shoulder 15 formed in the body 2. A plunger 16 is slidably mounted in the lower part of the sleeve 13 and extends upwardly through the sleeve 7 beyond the bottom of the reservoir 5. The lower end of the plunger is rounded at 17 and rests upon an arm 18 which in turn is supported in a manner to be presently described. The lower end of the plunger is further formed with a spring seat 19 receiving the lower end of a spring 20 which has its upper end bearing against the shoulder 14 to hold the plunger normally in engagement with the arm 18.

In the upper end of the plunger 16 is formed a cavity 21 in which is mounted an upwardly opening poppet valve 22 resting on a spring 23. Ports 24 are drilled through the sleeve 7 at the reservoir 5 to register with ports 25 in the plunger 16 and communicating with the cavity 21.

A plug 26 is mounted in the sleeve 7 at a distance above the upper end of the plunger 16 and has a series of passages 27 drilled there-through. A poppet valve 28 is slidably mounted in the plug and is adapted to obstruct the passages 27 when in its lowered position. A spring 29 bearing upon this valve normally holds it in its closed position.

A journal shaft 30 is mounted in the bottom of the crank case 1 in parallel relation to the cam shaft 3, and on the shaft 30 is journaled a follower 31. The follower 31 is preferably in the form of a frame having its sides straddling the cam 4, similar to the showing in the above referred to co-pending application. The follower 31 carries a roller 32 engageable with the cam 4 and in the normal position shown in Fig. 1 the axes of the cam 4 and roller 32 are in the same horizontal plane. The upper end of the follower 31 carries another roller 33, the center of which is normally in a vertical line with the center of the shaft 30. A spring 34 engages the follower 31 and normally urges pivotal movement thereof in a direction to maintain the roller 32 in engagement with the cam 4.

The arm 18 has one end pivotally attached to a slidable block 35, supported in a guide 36, and having a slot 37 therein receiving an eccentric 38 on a shaft 39 so that by rotating the shaft 39 the block may be caused to slide in one direction. Any suitable manual means may be employed to rotate the shaft 39.

The arm 18, on its lower side, is provided with an arcuate surface 40, the ends of which are illustrated in Figs. 1 and 5 by radial lines 41 and 42 which extend from the center of the shaft 30. The surface 40 is therefore concentric with the path of movement of the roller 33 carried by the follower 31 when the arm 18 is in the position shown in Fig. 1, which is the inoperative position. Therefore, when the follower 31 is rocked by the cam 4, from the position shown in full lines in Fig. 1 to that shown in the dotted lines, the roller 33 contacts the arcuate surface 40 and the arm 18 is supported in a stationary position by the moving roller 33.

The lower surface of the arm 18 has an arcuate surface 43 beginning at the terminal 42 of the surface 40 and having a radius considerably less than the radius of the arcuate surface 40. The upper surface of the arm 18 has an arcuate surface 44 engaged by the rounded portion 17 on the plunger and terminating in a shoulder 45. The arcuate surfaces 40 and 44 are concentric and the length of the surface 40, which is longer than the surface 44, is defined by the radial lines 41 and 42 in Figs. 1 and 5. Both arcuate surfaces 40 and 44 start at the radial line 41, the surface 40 terminates at the line 42, and the surface 44 terminates at the line 42' shown on Fig. 5 only. These lines 41 and 42 also serve to designate the length of the rocking movement of the rocking arm 31 on Fig. 1.

As shown in Fig. 2 the arm 18 has been moved to a position which provides for the full length plunger stroke. During such full length stroke the cam 4 engages the roller 32 to rock the follower 31 from the position shown by the dot and dash line 46 to the position indicated by dotted center line 47. During such movement the roller 33 rides against the arcuate surface 40 until it reaches the point indicated by the radial line 48. During this movement no appreciable movement of the arm 18 will take place. However, a very slight movement will be present, due to the fact that the arcuate surface is no longer concentric with the follower 31, but this movement is so small that the check valves do not function and the plunger does not eject any fuel. After the roller 35 passes the position indicated by the line 48 it will ride against the arcuate surface 43 and will cause the arm 18 to pivot to the dotted line position shown in Fig. 2. The full line position

of the plunger 16 in Fig. 2 illustrates it at the limit of its down stroke and the dotted line position illustrates the limit of its upward stroke.

It will be noted that the movement of the arm 18 from the position shown in Fig. 1 to that shown in Fig. 2 does not disturb the plunger 16 due to the fact that during such movement, that part of the arm 18 which is between the roller 33 and the plunger 16 is of uniform thickness because the two surfaces 40 and 44 are concentric. Thus, the plunger 16 always comes to rest at the same point regardless of the position of adjustment of the arm 18.

Referring to Fig. 4 the cam 4 is illustrated in detail. The line 49 designates the point thereon where the rise in the cam begins. Approximately fifty-three degrees from the point 49 is shown a line 50, and approximately twenty degrees from the point designated by the line 50 is shown a line 51. In operation, when the surface of the cam, between the points where the lines 49 and 50 intersect the same, progressively engages the roller 32, the roller 33 and the follower will be moved from the position indicated by the line 46 to the position indicated by the line 48 in Fig. 2. When the surface of the cam between lines 50 and 51 progressively acts upon the roller 32 the roller 33 and the follower will move from the position designated by the line 48 in Fig. 2 to that designated by the line 47, which, as described above results in the ejection stroke of the plunger. Therefore, according to the example shown, twenty degrees of angular movement of the cam 4 is required to cause the full injection stroke of the plunger.

Referring to Fig. 3 line 52 designates the center line of the follower 31 in its normal inoperative position. The arm 18, in this figure, is positioned approximately midway between the positions illustrated in Figs. 1 and 2, which position provides for approximately one half of a stroke of the plunger. With the parts as shown in Fig. 3 the roller 33 will ride against the arcuate surface 40 until it reaches the position shown in full lines and indicated by the line 53. During this movement no appreciable movement of the lever 18 and plunger 16 will take place for the reasons above pointed out. From the position designated by the line 53 to that designated by the line 54 the fuel ejection stroke of the plunger is caused to take place. However, it will be noted that the point on the cam 4 at which movement of the arm 18 starts, designated by the line 55, is approximately ten degrees from the point 51 which represents the end of the injection stroke. It becomes apparent, therefore, that as the mechanism functions to vary the length of the stroke of the plunger 16 the point at which the stroke terminates always remains constant with relation to the position of the cam inasmuch as it terminates when the point 51 engages the roller 32.

The high part of the cam extends through approximately thirty-four degrees in order to hold the plunger stationary at the end of its pumping stroke for a sufficient length of time to permit the check valves in the injector to react.

The length of the plunger stroke may be infinitely varied between the examples illustrated and described, and throughout all these adjustments the plunger always comes to rest at a constant point. In Fig. 6 the plunger 16 is diagrammatically illustrated as being at the point from which the ejection stroke starts, and this point is designated by the line 60. In completing a full

length stroke the plunger 16 moves from the point designated by the line 60 to the point designated by the line 61, and after the cam 4 has been rotated until the low part thereof engages the follower the spring 20 will return the plunger to the point designated by the line 60. In the event that the arm 18 has been positioned as in Fig. 3 the plunger movement will start at the point designated by the line 60 and will terminate at the point designated by the line 62, thus providing for a half stroke. A quarter stroke of the plunger starts at the point designated by line 60 and terminates at the point designated by the line 63, and a three quarter stroke starts at the line 60 and terminates at the line 64.

Referring to the diagram in Fig. 7, 65 designates a piston of an engine and 66 its crank. The line 67 designates the point in the movement of the piston that will be reached when the crank 66 is at its dead center. The line 68 designates the point in the movement of the cam where the injection of fuel into the cylinder is to be completed. This point will be determined by the characteristics of individual engines. When the crank 66 is in the position designated by the line 69 the piston 65 will be at the position indicated by the line 68, the cam 4 will be in a position where the point 51 is engaging the follower, and the plunger 16 will have been moved from the point 60 to the point 61 and the full injection will have been completed. While this full injection is being completed and the cam 4 is moving from the point 50 to the point 51 the crank will have moved from the point designated by the line 70 and the piston will have moved from the point designated by the line 71. In the event of a half injection the injection will start when the crank is in the position designated by line 72 and when the piston is at the point designated by the line 73, and the injection will terminate when the crank is at the point 69 and the piston at the point 68. The quarter injection starting point is indicated by the line 74 relative to the crank and the line 75 relative to the piston. The three-quarter injection point is indicated at 76 on the crank and at 77 on the piston. It becomes apparent, therefore, that all injections end when the crank and piston are at definite points in their travel and that short injections are completed during a shorter travel of the crank and piston than the travel thereof during a full injection.

In Figures 8 and 9 there is illustrated a modified construction of the stroke regulating mechanism. In this form the crank case is designated 1a, the cam shaft 3a, the cam 4a and the plunger 16a. In the crank case is a journal shaft 30a supporting a follower 31a bearing rollers 32a and 33a. These elements are constructed the same as the elements described above in detail and their functions are identical.

Between the roller 32a and the plunger 16a extends an arm 18a having concentric arcuate surfaces 43a and 44a whose centers coincide with the center of movement of the follower. The arm 18a is pivotally connected to a lever 80 having one end pivotally received on the journal shaft 3a. The lever 80 has an arm 81 provided with a slot 82 receiving an eccentric 83 on a shaft 84 so that by rotating the shaft 84 the eccentric moves the lever 80 from the position shown in Fig. 8 to that shown in Fig. 9.

As shown in Fig. 1, the roller 33a in moving from the position shown in full lines to that shown in dotted lines does not cause any movement of

the arm 18a. When the arm 18a is positioned as in Fig. 9 movement of the roller 33a from the position shown in full lines to that shown in dotted lines does not cause any movement of the arm 18a, but the position shown in dotted lines is approximately half the travel of the roller 33a and therefore when the roller continues from this point it engages the arcuate surface 43a to cause pivotal movement of the arm 18a. It will be noted in this form that as the arm 18a moves between the positions shown in Figs. 8 and 9 that the lever 80 supports and guides the same so that the two arcuate surfaces 40a and 44a always remain concentric with the journal shaft 30a. Thus the slight movement presented during the initial movement of the follower 31a does not cause any movement of the arm 18a in the manner of the slight, but inappreciable, movement of the arm 18 due to the fact that when it is moved from its position shown in Fig. 1 the surface 40 no longer remains concentric with the shaft 30.

Although specific embodiments of the present invention are illustrated and described it will be understood that various changes may be made within the scope of the appended claims without departing from the spirit of the invention. For example, the exact number of degrees mentioned during the description, although found to be desirable and practical, were employed for illustrative purposes and the invention is not limited thereto.

What I claim is:—

1. In a fuel injector, a plunger, a rocker arm pivoted at one end, means for rocking said arm to cause swinging movement of the free end thereof through a predetermined arc, an operating arm interposed between the swinging end of said arm and said plunger and adapted to be moved

by said swinging end to impart movement to said plunger, said operating arm having an arcuate portion of uniform thickness with one of the arcuate surfaces thereof engaged by said swinging end and the other arcuate surface engaged by said plunger, the two arcuate surfaces having a common center of curvature, said operating arm having a cam surface merging with the arcuate surface engaged by said rocker arm, means supporting said operating arm, said common center of curvature being coincident with the axis of swinging movement of said rocker arm, and means for adjustably moving said operating arm with respect to said rocker arm.

2. In a fuel injector, a plunger, a rocker arm pivoted at one end, means for rocking said arm to cause swinging movement of the free end thereof through a predetermined arc, an operating arm interposed between the swinging end of said arm and said plunger and adapted to be moved by said swinging end to impart movement to said plunger, said operating arm having an arcuate surface engaged by said swinging end corresponding in length to the arc of swinging movement thereof and an arcuate surface engaged by said plunger and having a common center of curvature with the first named arcuate surface, said operating arm having another arcuate surface at a terminal of the arcuate surface engaged by said rocker arm, the radius of curvature of said last named surface being shorter than the radii of the first two arcuate surfaces, means supporting said operating arm, said common center of curvature being coincident with the axis of swinging movement of said rocker arm, and means for adjustably moving said operating arm with respect to said rocker arm.

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