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PISTON INJECTION PUMP
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Fig. 3.

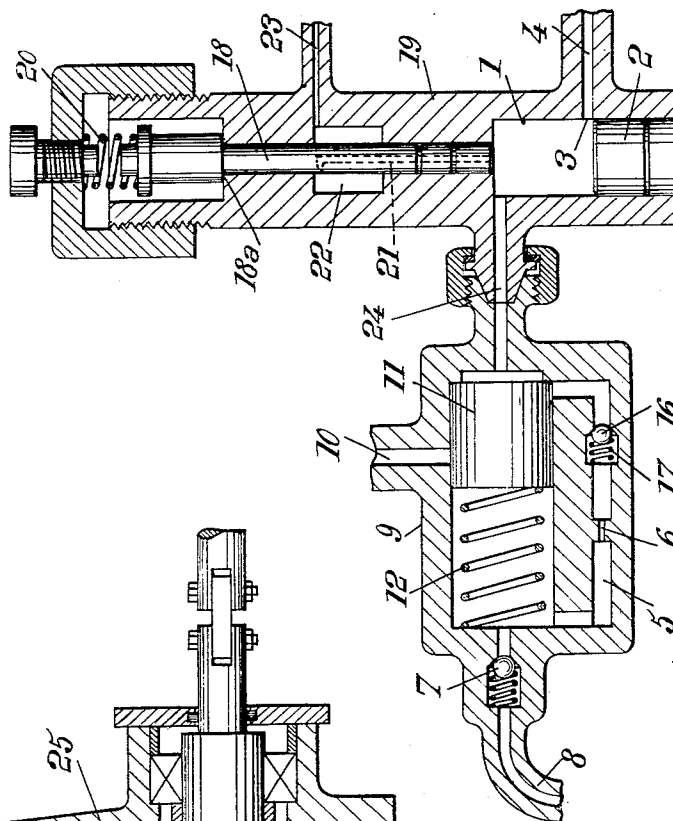
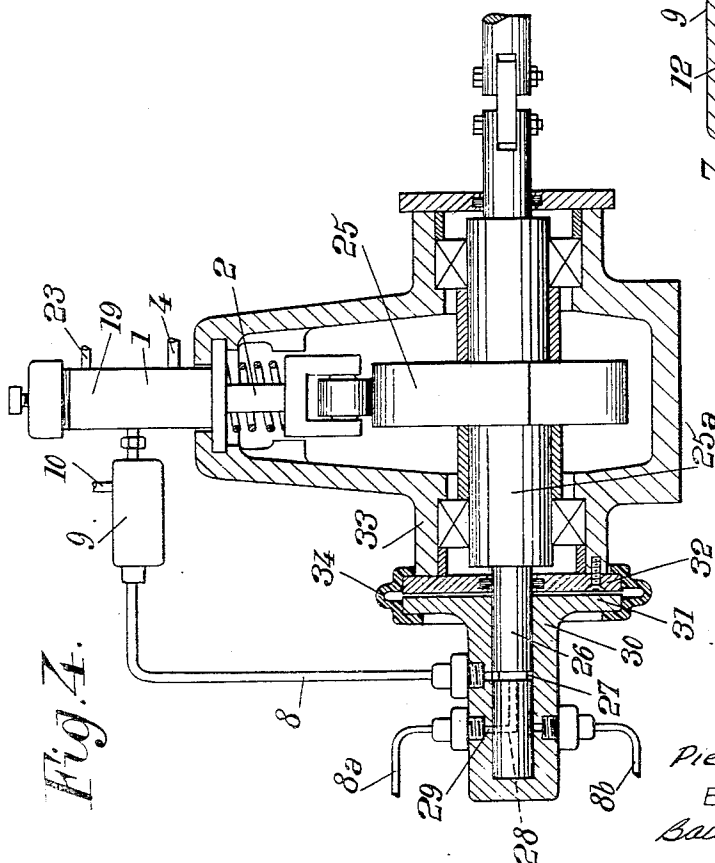


Fig. 2.



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INJECTION DEVICES INCLUDING A RECIPROCATING PISTON INJECTION PUMP

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7 Claims. (Cl. 123—139)

The present invention relates to injection devices, and in particular fuel injection devices for internal combustion engines, including an injection pump of the reciprocating piston type the output of which is connected with at least one injector through a feed conduit having a throttled portion, this device including a liquid outlet conduit arranged, when placed in communication with the output of said pump, to stop the feed of liquid to said injector, this last mentioned communication being controlled by a valve member constantly urged by resilient means toward a position of rest for which said valve member being respectively subjected to the pressures existing in said feed conduit upstream of said throttled portion and downstream thereof respectively, whereby said valve member is moved away from said position of rest toward a position for which it opens the above mentioned communication when the difference between said upstream pressure and said downstream pressure exceeds the force of said resilient means.

The object of my invention is to provide an injection device of this kind which is better adapted to meet the requirements of practice than those existing at the present time, in particular concerning automatic adjustment of the delivery thereof.

According to my invention, the above mentioned elements of the device are determined so that the displacement of said valve member from its position of rest to its position where it opens said communication starts practically at the beginning of injection and is performed in a time the variation of which (this time variation being more important than the variation of the reciprocal of the number of revolutions per minute of the engine due to a variation of the load thereof) automatically ensures the desired regulation of the amount of fuel effectively delivered, said outlet conduit being closed as soon as said valve member is returning toward said position of rest and remaining closed as long as said valve member occupies this position.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

Fig. 1 diagrammatically shows, in axial section, the cylinder of an injection pump provided with automatic regulating means according to the invention.

Fig. 2 is a similar view showing a modification of the device of Fig. 1.

Fig. 3 also diagrammatically shows, in axial section, an injection pump including both means for automatic adjustment of the lead to injection and means for automatically adjusting the delivery of the pump.

Fig. 4 diagrammatically shows the application of a device such as illustrated by Fig. 3 to an injection pump feeding, from a single pump cylinder, a plurality of injectors through a rotating distributing valve.

Fig. 5 is a view similar to Fig. 1 but showing a modification.

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Referring to the drawings and especially to Fig. 1, the injection pump includes a cylinder 1 in which is slidably mounted a piston 2 driven in any suitable way, for instance by means of a cam. This piston controls a port 3 through which the feed conduit 4 opens into cylinder 1. Fuel, after this orifice 3 is closed, is discharged from cylinder 1 during the upward stroke of piston 2 through a feed conduit 5 provided with a throttled portion 6. Downstream of this throttled portion, the fuel that is delivered flows past a valve 7 to arrive into a conduit 8 which conveys said fuel to an injector or the like.

In order automatically to regulate, as a function of a variation of the speed of the engine due to a variation of the load thereof, the effective delivery rate of the pump, that is to say the flow rate of fuel fed through conduit 8 to the injector, I connect a cylinder 9 across the ends of feed conduit 5 (which are located respectively on opposite sides of the throttled portion 6 of said conduit). Therefore, one of the ends of this cylinder 9 communicates either directly with the inside of the pump cylinder 1, or with the portion of feed conduit 5 located upstream of the throttled portion 6 thereof, whereas the other end of said cylinder 9 communicates with the portion of feed conduit 5 located downstream of the throttled portion 6 thereof and upstream of valve 7. An outlet conduit 10 opens into the side wall of said cylinder 9, said conduit 10 being for instance connected to the fuel tank. In cylinder 9, there is provided a piston 11 slidable axially therein and subjected to the action of a spring 12 which urges it into a position of rest (as shown by Fig. 1) in which the under face of piston 11 is applied against a shoulder 13 of cylinder 9, the outlet conduit 10 being closed by piston 11 when said piston is in said position of rest.

According to my invention, the orifice of conduit 10 in cylinder 9 is located at a point of the side wall of said cylinder such that piston 11 must move through a relatively long distance a in order to pass from its position of rest (shown by Fig. 1) to the position for which the under face of piston 11 clears the orifice of outlet conduit 10 and thus places this conduit in communication with the inside of cylinder 1. As soon as this orifice of conduit 10 has been cleared by piston 11, the delivery of fuel from the pump toward the injector ceases and the fuel which, after this time, is driven out from cylinder 1 by the upward movement of piston 2, flows through the outlet conduit 10.

The flow rate regulating effect obtained by means of such a device is due to the following phenomena.

It is clear that piston 11 remains applied against shoulder 13 as long as the difference between the pressures, acting on the opposed faces of said piston is lower than the force of spring 12. This pressure differential depends on the one hand upon the cross-section of the throttled portion 6, and on the other hand upon the velocity of the pump piston 2. By giving spring 12 a suitably low value, it is possible to obtain that the beginning of the movement of piston 11 against the action of spring 12 coincides at least approximately with the beginning of the injection. However, due to the distance a existing between shoulder 13 and the orifice of outlet conduit 10, the beginning of the movement of piston 11 does not immediately permit the outflow of the discharged fuel through conduit 10 and therefore does not immediately stop the effective delivery of fuel toward the injector.

The time taken by piston 11 to cover distance a is variable with the velocity of piston 2 in accordance with a non-linear law. This is due to the fact that this time decreases when the velocity increases, but the decrease

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of this time is more important than the increase of the velocity of piston 2. In other words, said time varies according to the formula

$$k \cdot \frac{1}{v_n}$$

k being a constant, v being the mean velocity of piston 2 or the speed of revolution of the engine, and n being a number ranging between 1 and 2. Consequently, the higher the speed of piston 2, the sooner the time when piston 11 clears the orifice of conduit 10, in relation to the upward movement of piston 2 and the smaller the amount of fuel delivered on every stroke of piston 2 toward the injector past valve 7 and through conduit 8. Thus, the higher the velocity of piston 2 the sooner the injection is stopped in respect to the movement of piston 2 so that an automatic regulation of the delivery is obtained which depends upon the time taken by control piston 11 to cover distance a .

According to a first modification, shown by Fig. 5, I provide a second outlet conduit 14 branching off from cylinder 9 and, in piston 11, a bent conduit 15 one of the ends of which opens into the upper face of piston 11, whereas the other end thereof opens into the side wall of said piston on a generatrix thereof which passes through the orifice through which conduit 14 opens into cylinder 9. When piston 11 is in its position of rest, the distance between the orifice of conduit 15 in the side wall of piston 11 and that of conduit 14 in the side wall of cylinder 9 is also equal to a . Consequently, in this modification, the chamber of cylinder 9 located above piston 11 is placed in communication with the outlet conduit 14 at the same time as the chamber of said cylinder 9 located under piston 11 and the inside of cylinder 1 are placed in communication with the outlet conduit 10. In this way, the two opposed faces of piston 11 simultaneously undergo the pressure drop which stops injection.

The modification shown by Fig. 2 differs from the embodiment of Fig. 1 by the fact that piston 11, when it is in its position of rest, cuts off the communication between the pump cylinder 1 and the feed conduit 5. Consequently, the time when piston 11 starts moving upwardly is, in this case, independent of the strength of spring 12 and of the cross-section of the throttled portion 6.

Another difference between the construction of Fig. 2 and that of Fig. 1 lies in the fact that a valve 16 is inserted in conduit 5, said valve being applied against its seat by a spring 17. This valve 16 is intended to prevent piston 11 from sucking in, during its downward movement, some fuel from cylinder 1 and from thus drawing this amount of fuel into the chamber of cylinder 9 located above said piston 11. For this purpose, spring 17 must exert upon valve 16 a force sufficient to prevent the opening of this valve when piston 11 is producing this suction effect. Said suction effect, if it were not checked, would have a perturbing effect upon the automatic regulation obtained by means of the device according to my invention.

As shown by Fig. 2, valve 16 may be constituted by a mere ball cooperating with a suitable seat provided in conduit 5.

The automatic regulating mechanism according to the present invention may advantageously be used with a device for automatically regulating the lead to injection in accordance with the variations of the speed of the engine as described in my U.S. patent application filed May 20, 1957, under Ser. No. 660,362 for "Improvements Brought to Fuel Injection Devices." In this case, the device for regulating the lead to injection must be placed between the outlet of the pump cylinder and the mechanism for the automatic regulation of the delivery, as shown on the appended Fig. 3. As illustrated by this figure, the device for automatically regulating the lead

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to injection is mounted directly on the cylinder 1 of the injection pump and includes a rod 18 mounted in the head 19 of the cylinder 1 of the pump so as to be able to slide under the effect of the pressure of the fuel delivered by the pump piston 2 when this pressure exceeds the force of spring 20 which tends to keep rod 18 in its lowermost position where its shoulder 18a is applied against a shoulder of the pump cylinder head.

Furthermore, a leak circuit 21 is provided in rod 18 and extends from the lower end of said rod up to a level which is located slightly below the top wall of a chamber 22 provided in the pump cylinder head, said chamber communicating with an outlet conduit 23.

As described in the patent application Ser. No. 660,362 of May 20, 1957, the leak circuit constituted by conduit 21, chamber 22 and conduit 23 is closed, due to an upward movement of rod 18, the quicker and permits an earlier beginning of the injection as the speed of piston 2, which itself depends upon the speed of the engine, is higher.

The mechanism for automatically regulating the delivery, which is for instance of the kind illustrated by Fig. 2, is mounted downstream of the pump cylinder 1 on the delivery conduit 24 thereof.

If the device for automatically regulating the delivery is located as above stated, the lead to injection is regulated without modifying the total amount of fuel that is effectively injected. If, on the contrary, the device for regulating the lead to injection were placed downstream of the output of the mechanism for automatically regulating the delivery, there would be a partial neutralizing of the effect of this mechanism by the device for adjusting the lead to injection.

It should be noted that the automatic regulating mechanism according to my invention, whether or not it is used in combination with a device for automatically regulating the lead to injection as described in patent application Ser. No. 660,362 of May 20, 1957, is not necessarily to be mounted immediately upon the injection pump cylinder. It may be placed at any suitable point of the conduit means extending from the pump cylinder to the injector mounted on the engine cylinder.

In the particular case where a single cylinder is used for delivering fuel successively to several injectors, a single mechanism for the automatic regulation of the delivery made according to the invention may be used to regulate the amount of fuel supplied by the respective injectors, provided that this mechanism is inserted in the conduit extending between said pump cylinder and the point from which the various individual conduits leading to the respective injectors branch off.

Fig. 4 shows an injection pump including a single cylinder 1 and the piston 2 of which is driven by a cam 25 having for instance four projections, this cam being mounted on a shaft 25a driven in such manner that, for a complete revolution of shaft 25a, cam 25 produces four reciprocations of the pump piston 2. On the top of cylinder 1 there is provided a device for automatic regulation of the lead to injection as shown by Fig. 3 and the mechanism for the automatic regulation of the fuel delivery according to the present invention is mounted downstream of the pump cylinder 1 in the feed conduit 8. This delivery conduit connects cylinder 1 to a distributing valve constituted by a shaft 26 rigid with shaft 25a and coaxial therewith. Shaft 26 includes a circular groove 27 into which opens the end of delivery conduit 8. Groove 27 communicates with a channel 28 provided in shaft 26 and opening into the surface of this shaft, at 29, at a distance from groove 27. This orifice 29 of channel 28 communicates successively, during the rotation of shafts 25a and 26, with the respective individual delivery conduits 8a, 8b, etc., which lead to the respective injectors (not shown) which are thus fed successively, from pump 1.

The end of conduit 8 which cooperates with circular

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groove 27, and the ends of conduits 8a, 8b, etc., which communicate successively with channel 28, 29 are mounted in a cylindrical sleeve 30 which surrounds the distributing shaft 27 and is fixed by its flange 31 to the end plate 32 of the casing 33 of the pump through a slit resilient element 34 which, once set in position, keeps sleeve 30 applied against plate 32 of the pump casing while absorbing the slight differences which may exist between the centering of distributing shaft 26 and that of camshaft 25a.

Of course, the rotating distributor might be replaced by a system such as described in the U.S. patent application Ser. No. 635,219, filed by me on January 22, 1957, now patent 2,863,437, issued Dec. 9, 1958, for "Improvements Brought to Fuel Injection Devices for Multi-Cylinder Engines," this system being characterized in that every injector is provided with locking means, preferably of an electromagnetic type the successive release of which permits injection of fuel successively into the engine cylinders on which said injectors are mounted.

When the mechanism for automatically regulating the delivery according to the present invention is used in connection with an injection device comprising two or more injection pump cylinders each of which includes, at the outlet thereof, a check valve, said cylinders being connected with a chamber from which branch off the individual conduits which lead fuel to the various injectors the number of which is a multiple of the number of pump cylinders, the automatic regulation mechanism is advantageously mounted on said chamber so that a single automatic regulating mechanism can be used on the whole of said injectors.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What I claim is:

1. A liquid injection device which comprises, in combination, an injection pump including a cylinder and a piston reciprocable in said cylinder, a feed conduit leading from the output of said pump cylinder, said conduit including a throttled portion, a discharge conduit, passage means leading from said pump cylinder output to said discharge conduit to establish a communication between said pump cylinder output and said discharge conduit, a valve member movable in said passage means between a position of rest in which it closes said communication and a position in which it opens said communication, resilient means for urging said valve member toward said position of rest, means for exerting on said valve member a force urging it away from said position of rest and proportional to the difference between the pressures in said feed conduit respectively upstream and downstream of said throttled portion thereof, said above mentioned elements being determined so that said valve member starts moving away from said position of rest thereof substantially at the beginning of liquid injection, and that the variation of the time taken by said valve member to move from said position of rest to said second mentioned position thereof is such as to achieve self-regulation of the amount of liquid fed from said pump to through said fuel conduit, a plurality of injectors, with individual conduits provided between each of said injectors and the portion of said feed conduit located downstream of said throttled portion thereof, and distributor means for successively connecting said individual conduits with said last mentioned portion of said feed conduit.

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2. A liquid injection device which comprises, in combination, an injection pump including a cylinder and a piston reciprocable in said cylinder, a feed conduit leading from the output of said pump cylinder, said conduit including a throttled portion, a discharge conduit, passage means leading from said pump cylinder output to said discharge conduit to establish a communication between said pump cylinder output and said discharge conduit, a valve member movable in said passage means between a position of rest in which it closes said communication and a position in which it opens said communication, resilient means for urging said valve member toward said position of rest, means for exerting on said valve member a force urging it away from said position of rest and proportional to the difference between the pressures in said feed conduit respectively upstream and downstream of said throttled portion thereof, said above mentioned elements being determined so that the variation of the time taken by said valve member to move from said position of rest to said second mentioned position thereof is such as to achieve self-regulation of the amount of liquid fed from said pump through said fuel conduit, a plurality of injectors, with individual conduits provided between each of said injectors and the portion of said feed conduit located downstream of said throttled portion thereof, and distributor means for successively connecting said individual conduits with said last mentioned portion of said feed conduit.

3. A device according to claim 2 in which said distributing means include a rotary member in line with the shaft of said pump and movable therewith, and a sleeve surrounding said rotary member and resiliently connected with the casing of said pump.

4. A liquid injection device which comprises, in combination, an injection pump including a cylinder and a piston reciprocable in said cylinder, at least one injector, a feed conduit connecting the output end of said pump cylinder with said injector, said conduit including a throttled portion, an auxiliary cylinder having one of its ends in communication with a point of said feed conduit located upstream of said throttled portion and the other of its ends in communication with a point of said feed conduit located downstream of said throttled portion, a liquid discharge conduit leading out from an intermediate point of said auxiliary cylinder to a low pressure area, a piston valve slidable in said auxiliary cylinder between a position of rest in which it closes said outlet conduit and a position in which it clears said outlet conduit by moving to the other side thereof from said first mentioned end of said auxiliary cylinder, resilient means for urging said piston valve toward said position of rest, and spring operated means mounted in the portion of said feed conduit located between said two points thereof for cutting off the communication between said two points when the pressure at said first mentioned point is lower than that at said second mentioned point, said spring operated means and said resilient means being adjusted so that said piston valve starts moving away from said position of rest thereof substantially as liquid starts flowing through said feed conduit and the above mentioned parts being determined so that the variation of the time taken by said piston valve to move from said position of rest to said second mentioned position thereof is such as to achieve automatic adjustment of the amount of liquid fed from said pump to said injector.

5. A device according to claim 4, in which said spring operated means consist in a check-valve located in the portion of said feed conduit located between said two points thereof, said check-valve being arranged to prevent backflow of liquid through said feed conduit portion.

6. A device according to claim 4, in which said spring operated means are constituted by said piston valve itself, said first mentioned point of said feed conduit being located in the wall of said auxiliary cylinder so that said

feed conduit is closed at said last mentioned point when said piston valve is in its position of rest.

7. A device according to claim 1 in which said distributing means include a rotary member in line with the shaft of said pump and movable therewith, and a sleeve 5 surrounding said rotary member and resiliently connected with the casing of said pump.

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