Feb. 20, 1934. J. M. R. RETEL 1,948,047

FUEL PUMP

Filed July 18, 1930

Fig. 1.

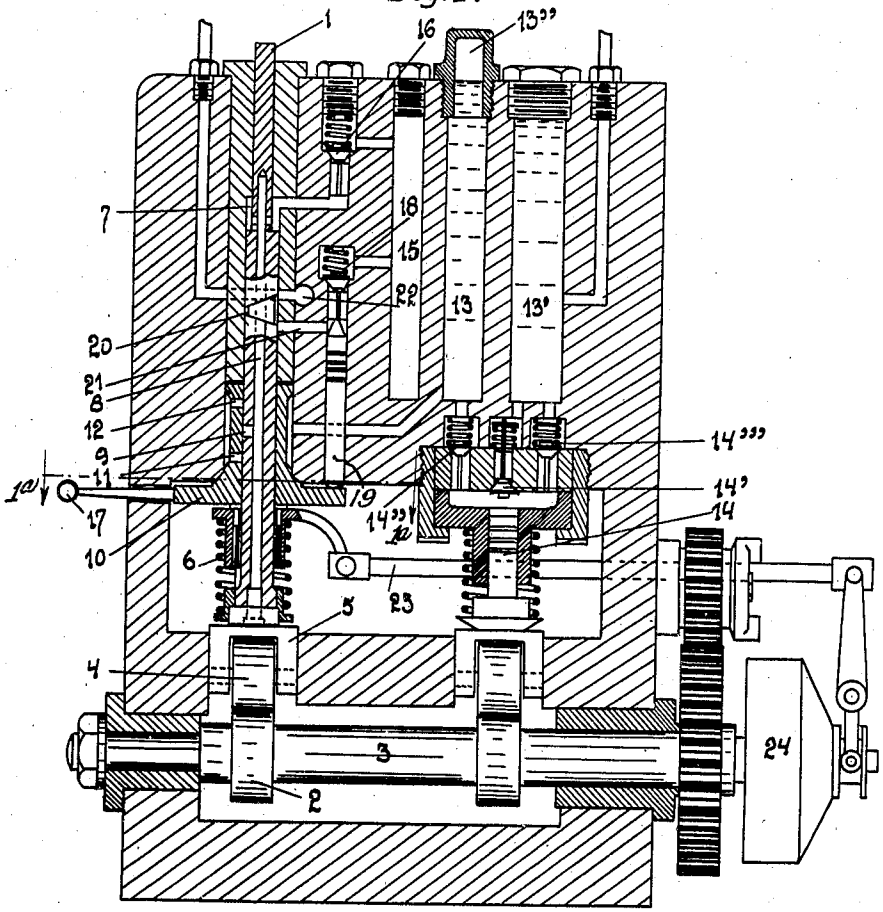

Fig. 2.

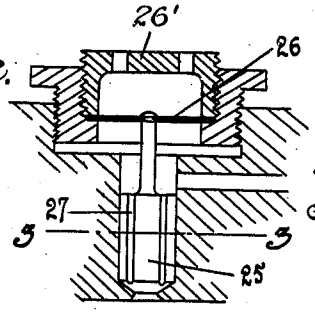

Fig. 1a

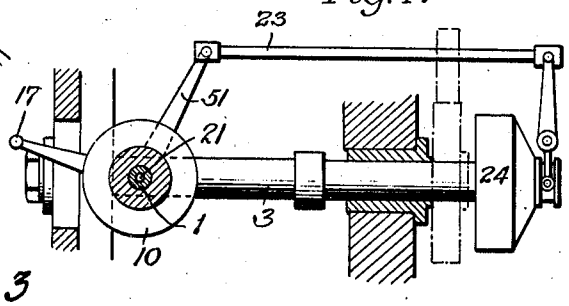

Fig. 4.

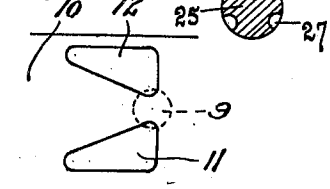

Fig. 3

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FUEL PUMP

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10 Claims. (Cl. 103—37)

Feeding high speed internal combustion engines having a mechanical injection system and adapted to run at variable speed requires special precautions as well in order to secure a suitable injection of fuel as for obtaining complete combustion of the fuel during the very short time which may be available for this purpose.

In order to obtain a good injection of fuel, it is necessary to use a pump the working speed of which should not be too high so as to have a regular working and to avoid premature wear of the different pieces.

On the other hand, injection must be effected very quickly, the beginning and the end of injection being sharply marked.

It is also absolutely necessary that the device to be employed should make it possible to separately modify, according to the needs, the quantity of liquid fuel that is injected, and the time during which injection takes place.

The injection pressure must also vary with the nature of the oil that is employed, the quantity that is used, and the speed of revolution of the engine.

To high speeds of revolution must correspond high pressures insuring a very fine spraying of the fuel so that ignition may take place very rapidly and that combustion may be completed during the power stroke. This last condition further requires a very vigorous stirring and a good dispersion of the liquid particles amidst the gaseous mass, said dispersion being made difficult by the feeble penetration of the very fine liquid particles.

My invention has for its object a feed device adapted to satisfy these requirements. This device forms a whole, complete by itself, which can be used for fitting out and operating engines of various kinds.

This device comprises:

(1) A variable flow pump discharging liquid fuel into an elastic receiver having an expansion inertia as low as possible,

(2) A slide-valve working at high speed for opening and closing during an adjustable time the fuel inlet of the injector.

My invention will be described with reference to the appended drawing in which:

Fig. 1 is a vertical axial section of the pump.

Fig. 1*a* is a part section on the line 1*a*—1*a* of Fig. 1.

Fig. 2 is a detail view showing a section taken through the axis of the fuel inlet valve of the power cylinder.

Fig. 3 is a section, transversal with respect to the preceding one on the line 3—3 of Fig. 2.

Fig. 4 is a diagrammatical view showing a detail of the quantity controlling valve.

The fuel is first compressed by means of the auxiliary pump 14, the cylinder head of which is provided with the inlet valve 14', the delivery valve 14'' and the discharge-valve 14''' which, in the case of an excess of pressure, lets oil return into the feed reservoir 13'. Oil is delivered by pump 14 into a closed reservoir 13. A compressed gas chamber is formed at the upper part of said reservoir by screwing a hollow plug 13'' into the upper opening thereof. From reservoir 13, oil is sent into the injection pump.

Said pump comprises a differential piston 1 which is given a reciprocating motion through a cam 2 mounted on a shaft revolving once for two revolutions of the engine crank-shaft if the engine is of the two-stroke type, and once for four revolutions of the crank-shaft if the engine is of the four-stroke type. Cam 2 drives piston 1 through a roller 4 and a push-rod 5. A spring 6 serves to continuously apply the roller against the cam by acting on the piston rod and the push-rod.

The pump cylinder 7 is connected, through an axial conduit 8 provided in the piston, with an orifice 9 which moves opposite a fixed valve 10 provided with two openings 11 and 12, which are symmetrical with respect to the mean point of the displacement of this orifice 9.

At the end of the downward stroke, the orifice 9 is opposite opening 11. Oil under pressure comes from reservoir 13 into the pump cylinder 7. When piston 1 moves upward, orifice 11 is shut and the pump discharges oil into the receiver 15. This receiver may be provided with an elastic organ (membrane or spring loaded piston) or comprise a space constituting a compressed gas reservoir. But it is preferable to so calculate its volume as to place oil under pressure by using the compressibility of said oil or of some suitable liquid, which reduces the inertia of elastic organs to a minimum.

At the end of the upward stroke, the orifice 9 arrives opposite opening 12 which serves for returning excess fuel to reservoir 13. The pressure falls and valve 16 closes.

When the piston has moved down to the lower dead point, the same operation again takes place during the following stroke.

The fact that the pump revolves once for two or four revolutions of the engine crank-shaft makes it possible to run the pump at a reduced

speed which is favorable for the good working thereof.

The regulation of the quantity of fuel delivered into receiver 15, where it is stored, is obtained by varying the distance between the openings 12 and 11 of valve 10. For this purpose said openings are given a triangular shape as shown in Fig. 4, and the valve 10 can be rotated about the axis of piston 1 so that the vertical distance between the points where opening 9 meets with openings 11 and 12 depends on the angular position of valve 10 with respect to piston 1.

The quantity of fuel that is delivered into receiver 15 varies with this vertical distance.

In the position for which the delivery is zero, (i. e. corresponding to the stopping of the engine) the fuel feed must be cut off. For this purpose a valve 18 is disposed in the conduit through which oil is sent from receiver 15 into slide-valve 20. This valve 18 is operated through a rod 19 the lower end of which bears upon lever 17. When this lever is set to the position that corresponds to the stopping of the engine, the lower end of rod 19 goes down into a sloping groove provided in lever 17 and the valve 18 is applied upon its seat, thus ensuring tight stopping of receiver 15. Any leakage in the pipes is thus prevented.

The diameter of conduit 8 is so chosen that, during the delivery of fuel, the increase in diameter of the piston rod produced by the pressure of liquid inside the conduit may reduce the leakage and help in ensuring the fluid-tightness of the pump-cylinder.

The slide-valve consists of a groove 20 provided in the surfaces of the piston, the sides of this groove being symmetrically inclined with respect to the generatrices of the piston rod.

Two openings 21 and 22 communicating, one with the reservoir of oil under pressure 15, the other with the feed conduit of the injector, are located at a suitable distance from each other and are symmetrically disposed with respect to a horizontal plane passing through the mean point of the oscillatory path of the middle point of groove 20.

When the piston is moving, there comes a time when the groove uncovers simultaneously openings 21 and 22. Oil passes from the reservoir into the injector conduit. Then, as the piston keeps on moving, there is no longer communication between the two openings. The same operation takes place when the piston returns, moving in the opposite direction. Therefore, injection takes place twice for every revolution of the cam-shaft, that is to say once for every revolution of the engine crank-shaft if the engine is of the two-stroke type, and once for two revolutions of the crankshaft if the engine is of the four-stroke type. A suitable shape of the cam will produce the return of the same operations at equal intervals of time for a constant speed of revolution of the shaft.

It will be noticed that, although they take place at one time during the outstroke of the pump piston, at another during the instroke, the injections are comparable between themselves, owing to the symmetrical disposition of openings 11 and 12 with respect to the mean point of the path of orifice 9.

It should also be noticed that the opening and closing of the orifices take place during the part of the piston stroke in which said piston is moving at the highest instantaneous speed. Therefore these operations of opening and closing are effected as quickly as possible in the best conditions.

The regulation of the time during which injection takes place is effected by rotating piston 1 about its axis through a suitable angle, by means of lever 23. On account of the obliquity of the edges of the slide-valve, openings 21 and 22 are uncovered during a more or less important part of the total stroke. It is thus possible to obtain periods of injection as short as it is wanted, while retaining reasonable sizes for the orifices.

The regulation of the time during which injection takes place being effected by means of the above-described arrangement, is therefore independent of the regulation of the quantity of liquid delivered by the pump into receiver 15. For when piston 1 is rotated about its axis, thus modifying the width of the part of groove 20 that reciprocates past openings 21 and 22, it obviously modifies the relative angular position of aperture 9 with respect to apertures 11 and 12. But valve 10 can easily be rotated through lever 17 in such a manner that the original angular position of aperture 9 with respect to apertures 10 and 11 is restored. It follows that the time during which injection takes place and the quantity of oil that is injected into the chamber 15 are two independent variables (in opposition with results given by other known devices). The regulation of the time during which injection takes place presents an obvious interest for engines adapted to run at variable speeds, for it makes it possible to increase the ratio of the time of injection to the total period of a stroke when the engine is running at high speed and thus to avoid an excess of pressure of injection which would result from too short periods of injection, a disadvantage that is to be found in the direct pumping devices. Inversely, at low speeds, the relative reduction of the period of injection makes it possible to maintain sufficiently high pressures of injection.

The relative increase of the period of injection when the number of revolutions per minute of the engine increases also makes it possible to effect preinjection at high speeds, a condition that is essential to a good efficiency of the engine.

Lastly it will be seen that by suitably disposing the edges of the slide-valve, it is possible that the rotation of the piston rod may modify, together with the point of injection and the period of injection, the quantity of fuel delivered by the pump, and, in particular that it may reduce and even cut off the supply of fuel if the engine tends to exceed its normal working speed and to race.

In practice lever 23 is connected to a centrifugal governor 24 which automatically controls its motion.

As shown in Fig. 1*a*, lever 23 is articulated, through a ball and socket joint, to a pivoting fork engaging a collar provided on centrifugal governor 24. The other extremity of lever 23 is also connected, through a ball and socket joint, to a lever 51 integral with piston 1. The direction in which said lever 51 is caused to rotate depends obviously upon the shape and relative position of the different apertures 11, 12 and 20. But anyway it is such that, when the speed of revolution of the engine tends to increase, lever 23 is actuated by the centrifugal governor in such a manner as to cause piston 1 to rotate in the direction that causes the period of injection to be increased, and that period to begin sooner but

simultaneously causes the quantity of fuel injected at each stroke to decrease. Under these conditions, the speed of revolution of the engine tends to decrease. That mechanism is therefore a real speed auto-regulating device.

It should be noticed that these different regulations are effected in the same manner whatever be the direction in which the engine is revolving. The same is true for the operations of the pump and of the slide-valve. Accordingly when it is desired to reverse the engine, it will suffice to turn the cam through a suitable angle above its shaft.

This result can easily be obtained by using helical pinions for driving the pump shaft and by sliding one of these pinions along its axis. The same result will be obtained by actuating the piston rod through a rocker arm the axis of which will be displaced by a given quantity. These devices could also be used for effecting a supplementary regulation of the point of injection.

As shown in Fig. 2, the injector consists of a valve 25, normally applied upon its seat by an elastic organ 26 with a pressure that may be adjusted through screw-threaded plug 26'. Said elastic organ is so disposed that its deformation under the action of the pressure of the fluid to be injected lifts valve 25 just enough for producing a suitable wiredrawing of the fuel through the opening. The spraying is obtained through the impacts of the thin streams of liquid against one another. In order to obtain a thorough spraying it is preferable to form a certain number of streams distinct from one another and meeting at determined angles of incidence. This result can be arrived at by giving to the valve a suitable tapering shape and by feeding the liquid fuel at given points between the valve and its seat. For this purpose it will suffice to provide the end of the valve stem with a plurality of grooves 27 (Figs. 2 and 3) which may be inclined or not with respect to the axis thereof and act as fuel inlet conduits.

According to the number of revolutions per minute of the engine and to the quantity of liquid injected, the pressure in reservoir 15 increases or decreases until the lift of valve 25 is sufficient for permitting, during the operation thereof, the normal flow of the quantity of oil delivered by the pump.

Thus a well determined pressure of injection is established for each working speed.

What I claim is:

1. A device of the type described comprising in combination, a pump including a cylinder and a piston, a source of fluid, means for feeding fluid from said source to said pump cylinder, a fluid accumulator, discharge means for conveying fluid from said pump to said accumulator, discharge means for conveying fluid from said accumulator to the point of use for the fluid, a slide valve rigidly connected to said piston adapted to cooperate with the last mentioned discharge means for controlling the flow of the fluid therethrough, said slide valve being adjustable by rotating the piston about its axis, and adjustable means for controlling the amount of fluid delivered by the piston to the accumulator on the pump discharge stroke.

2. A device of the type described comprising in combination, a pump including a cylinder, a piston and a piston chamber, a source of fluid, means for feeding fluid from said source to said pump cylinder, a fluid accumulator, a discharge line from said pump to said accumulator, a discharge line from said accumulator to the point of use for the fluid, the latter line including a portion of the piston chamber, a valve member on the piston adapted to control this last line, said valve member being adjustable by rotating the piston about its axis, and adjustable means for controlling the amount of fluid delivered by the piston to the accumulator on the pump discharge stroke.

3. A device of the type described comprising in combination, a pump including a cylinder and a piston, a source of fluid, a feed line from said source to said pump cylinder, a fluid accumulator, discharge means for conveying fluid from said pump to said accumulator, discharge means for conveying fluid from said accumulator to the point of use for the fluid, a slide valve rigidly connected to said piston adapted to cooperate with the last mentioned discharge means for controlling the flow of the fluid therethrough, said slide valve being adjustable by rotating the piston about its axis, and means for controlling the amount of fluid delivered by the piston to the accumulator on the pump discharge stroke, the last mentioned means being adjustable by rotating the piston about its axis.

4. A device of the type described comprising in combination, a pump including a cylinder, a piston, and a piston chamber, a source of fluid, a feed line from said source to said pump cylinder, a fluid accumulator, a discharge line from said pump to said accumulator, a discharge line from said accumulator to the point of use for the fluid, the latter line including a portion of the piston chamber, a valve member on the piston adapted to control this last line, said valve member being adjustable by rotating the piston about its axis, and adjustable means for controlling the amount of fluid delivered by the piston to the accumulator on the pump discharge stroke, the last mentioned means being adjustable by rotating the piston about its axis.

5. A device of the type described comprising in combination, a pump including a cylinder, a piston and a piston chamber, a source of fluid, a feed line from said source of fluid to said pump, a fluid accumulator, a discharge line from said pump to said accumulator, a discharge line including a portion that leads from said accumulator to a point of the wall of said piston chamber and another portion that leads from another point of the wall of said piston chamber to the point of use for said fluid, said piston being provided with an annular groove adapted to connect together said two portions of the last mentioned discharge line for a part of the reciprocating displacement of said piston, said groove having its sides inclined with respect to the axis of said piston so that the length of time for which said two portions of the discharge line are connected together through said groove can be varied by turning said piston about its axis, and adjustable means for controling the amount of fluid delivered by the piston to the accumulator on the dump discharge stroke.

6. A device of the type described comprising in combination, a pump including a cylinder, a piston and a piston chamber, a source of fluid, a feed line from said source of fluid to said pump, a fluid accumulator, a discharge line from said pump to said accumulator, a discharge line including a portion that leads from said accumulator to a point of the wall of said piston chamber and another portion that leads from another point of the wall of said piston chamber to the point of use for said fluid, said piston being provided with an annular groove adapted to connect

together said two portions of the last mentioned discharge line for a part of the reciprocating displacement of said piston, said groove having its sides inclined with respect to the axis of said piston so that the length of time for which said two portions of the discharge line are connected together through said groove can be varied by turning said piston about its axis, and means, adjustable by turning the piston about its axis, for controlling the amount of fluid delivered by the piston to the accumulator on the pump discharge stroke.

7. A device of the type described comprising in combination, a pump including a cylinder and a piston having an inner longitudinal conduit opening at one end into said cylinder, a fluid accumulator, discharge means for conveying the fluid from said pump to said accumulator, discharge means for conveying fluid from said accumulator to the point of use for the fluid, a slide valve rigidly connected to said piston adapted to cooperate with the last mentioned discharge means for controlling the flow of fluid therethrough, said slide valve being adjustable by rotating the piston about its axis, an annular chamber surrounding said piston, a source of fluid, a feed line from said source of fluid to said annular chamber, a sleeve provided with two symmetrical ports having inclined edges disposed in said annular chamber and fitting about said piston, said piston being further provided with a conduit opening at one end into its outer surface opposite said ports and at the other end into said longitudinal conduit, and means for orienting said sleeve about said piston.

8. A device of the type described comprising in combination, a pump including a cylinder, a piston, and a piston chamber, a fluid accumulator, a discharge line from said pump to said accumulator, a discharge line from said accumulator to the point of use for the fluid, the latter line including a portion of the piston chamber, a valve member on the piston adapted to control this last line, said valve member being adjustable by rotating the piston about its axis, an annular chamber surrounding said piston, a source of fluid, a feed line from said source of fluid to said annular chamber, a sleeve provided with two symmetrical ports having inclined edges, disposed in said annular chamber and fitting about said piston, said piston being further provided with a conduit opening at one end into its outer surface opposite said ports and at the other end into said cylinder, and means for orienting said sleeve about said piston.

9. A device according to claim 8, further comprising means operatively connected with said sleeve for cutting off the second mentioned discharge line when said sleeve is so oriented that one of its ports is always in communication with the first mentioned opening of said conduit in the piston.

10. A device according to claim 8, further comprising a driving shaft for said pump and means responsive to the speed of revolution of said shaft for controlling the orientation of said piston with respect to said sleeve.

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