Oct. 8, 1935. B. WALKER 2,016,619

FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Fig. 1.

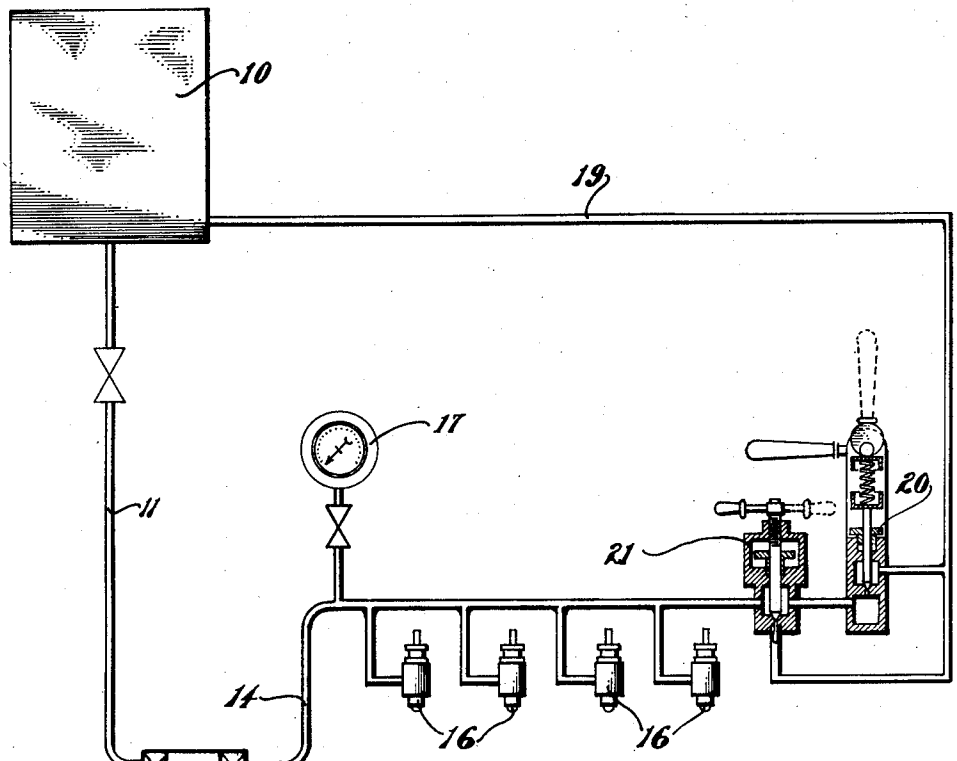
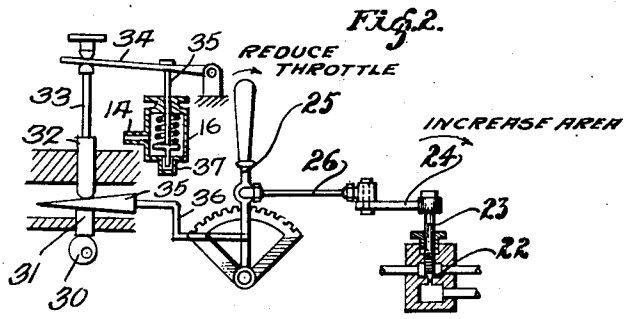


Fig. 2.



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FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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3 Claims. (Cl. 123—32)

This invention relates to internal combustion engines and particularly pertains to a line pressure fuel injection system for engines operating on the Diesel or temperature ignition principle.

By line pressure fuel injection system I mean that system in which a pump supplies a line common to all of the injection valves with fuel under a positive head which is constant during any given operating conditions, but which head may vary as the speed changes, but in which there is no appreciable change in head per cycle.

It is the principal object of the present invention to provide a line pressure fuel system for internal combustion engines by means of which a metering of the fuel will be maintained throughout a predetermined range of engine speeds.

In carrying out this object into practice, I provide in conjunction with a line pressure system, an apparatus capable of varying the fuel line pressure in such a manner as to maintain the velocity of injection substantially proportional to engine speed.

To accomplish this result the differential pressure between the fuel pressure and the pressure of the compressed charge within the cylinder must vary approximately as the square of the engine speed. This construction is such as to accomplish the desired result without the necessity of governors, electric devices, or other speed sensitive units effecting the control.

The regulation of the pressure control causes the velocity of discharge at the nozzle to vary approximately in direct proportion to the engine speed, which results in the injection of a substantially constant charge of fuel per cycle throughout a predetermined range of engine speed, and consequently will cause the engine to deliver a substantially constant maximum torque under varying speed changes without the injection of an excess of fuel at reduced speeds. This characteristic is desirable in engines operating under widely varying load conditions, such as is required in the propelling of vehicles, in which the engine, for example, may be carrying full torque at high speed when the vehicle encounters an increase in grade, which will cause the motor speed to be decreased. During this change of speed it is desirable to maintain the maximum torque without the usual delivery of an excess of fuel as the speed is reduced, due to the longer absolute time that the injection valve remains open at these reduced speeds.

In order to maintain this torque constant in an engine operating on the temperature ignition principle, in which the air charge per cycle is a relative constant, regardless of speed or throttle position, the fuel charge must also be maintained a constant per cycle.

This invention is based largely on the assumption that the displacement of the fuel pump is constant per revolution, and that it is driven by engine means. The invention resides in the combination of a fuel line system and a by-pass of the fixed area type irrespective of pressure changes, which combination makes the discharge of the injection valves into the cylinders plus the discharge of this valve equal to the displacement of the fuel pump, at full speed and at full load, and will consequently maintain the injection quantity per injection a constant at reduced speeds.

The invention is exemplified in the following description and illustrated by way of example in the accompanying drawing, in which:

Fig. 1 is a schematic view disclosing the line pressure being controlled by a rigid type by-pass.

Fig. 2 is a schematic view of an alternative type of by-pass control.

Referring to the accompanying drawing, and particularly to Fig. 1, our apparatus discloses the usual reservoir 10, which is connected by a supply line 11, to the intake port of a fuel pump 12. The discharge point of the pump 12, is connected by a delivery pipe line 14, to the fuel injection nozzles 16. These injection nozzles 16, being controlled by any well known method of constant angle of injection duration at full throttle, and throttling by reduced angle of duration, as shown in Fig. 2. The fuel line 14 is shown provided with a pressure gage 17, illustrated in the drawing.

The delivery line 14, is connected to the supply reservoir 10 by a by-pass line 19. A spring loaded by-pass valve assembly 20 is interposed between the delivery line and the by-pass line. The by-pass valve 21, is also interposed between the delivery line 14 and the discharge 19. This valve 21, is of the rigid type needle valve construction providing a fixed area orifice, regardless of pressure at a given setting.

The by-pass 20 is of the spring loaded type, manually adjustable to limit the maximum pressure obtainable in the line and the maximum engine speed. During the operation of the engine, the pump 12, which is driven at some multiple of the engine speed, delivers approximately a fixed quantity of oil per revolution against a pressure of 5,000 pounds per square inch, for example, at full speed and full throttle. The spring loaded valve, 20 may be set for 5,500 pounds as a safety

device, and the needle valve adjusted to discharge a sufficient quantity to lower the pressure to the desired 5,000 pounds.

The discharge of the pump is balanced by the discharge of the injection valves at full throttle (which are open for a given crank angle, and are therefore, open for a given percentage of the time, regardless of the engine speed, at full throttle) plus the discharge of the by-pass valve 21. The injection valves being of the usual type with injection orifices below the valve seat constituting a fixed area orifice, which orifice as stated, is open for a given percentage of the time at full throttle at all speeds. The injection valve operating for a fixed percentage of the time as described, and the fixed area by-pass cooperate to discharge the pump displacement, which varies as to the engine speed.

As disclosed herein the by-pass discharge plus the injection discharge into the cylinders has been made equal to the pump displacement so that in the event that the motor speed is reduced by half, due to exterior torque requirements the pump will discharge half as much fuel in the same time period and there will be half as much fuel discharged through the nozzles into the cylinders in the same time, but since there are half as many injections of twice the duration each, each injection will discharge the same quantity as at the high speed. With this valve fixed, the discharge characteristic will only be as described when the throttle is wide open. When the crank angle of injection duration is reduced to effect throttling, the displacement of the pump will become greater than the displacement of the injection valves 16, plus the needle valves 21, at the pressure persisting at full throttle operation and the resulting pressure may rise to the value where the spring loaded valve 20 will control it.

This metering characteristic may not be satisfactory for all cases where equal metering per injection is desired at reduced throttle operation throughout the speed range. For this purpose I have provided in Fig. 2 an alternative construction for the valve 21. In Fig. 2 the valve 22 is provided with a valve stem 23, on which is mounted a control arm 24, connected to the throttle control 25 by means of a suitable linkage 26. The valve stem 23 is provided with threads or other suitable means adapted to engage threads in the housing so that a partial rotation of the stem will vary the area of the orifice. The connection between the throttle control 25 and the valve control 24 is such as to provide an increase in the rigid discharge area irrespective of fluid pressure changes as the crank angle of injection duration decreases, and vice versa, to approximately re-establish equal metering at reduced throttle operation for a given speed range.

In the construction shown in Figure 2 the area of the by-pass valve is increased to prevent an increase of fuel pressure where the angle of injection duration is reduced for throttling only, this results in a single reduction of injecting volume only. The reduction of angle of injection duration, and not pressure necessarily, results in a reduced discharge volume per injection, thus giving a reliable throttle.

As a method of illustration, I have shown the well known wedge method of varying the crank angle of injection duration, in which the cam 30 operates a tappet 31, a movable wedge 35, a tappet 32, a push rod 33, a rocker arm 34, and the valve stem 35 of the injection valve, 16. A link 36 connects the wedge 35 with the throttle lever 25. The linkages 24 and 26 are such that as the wedge is retracted to decrease the angle of injection duration, the bypass will be opened, and vice versa. It is to be understood that any other method of varying the angle of injection duration may be employed within the scope of this invention.

While I have disclosed specific types of apparatus for practicing the invention, it is to be understood that my invention can be practiced by various types of apparatus within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a circuit for a fuel injection system of the rail pressure type, the combination of a fuel injection valve, mechanism for operating said valve, a throttle control for regulating the crank angle of discharge of said valve, said mechanism adapted to open said valve for a constant crank angle of duration at a given throttle setting, a fuel pump for supplying fuel under pressure to the pressure rail, a bypass valve continuously connected to said pressure rail, exterior means for adjusting the area of said bypass, the area remaining fixed for any given adjustment regardless of engine speed, an interconnection between said exterior means and said throttle control so as to vary the bypass adjustment and the crank angle of discharge simultaneously.

2. In a circuit for a fuel injection system of the rail pressure type, the combination of a fuel injection valve, mechanism for operating said valve, a throttle control for regulating the crank angle of discharge of said valve, said mechanism adapted to open said valve for a constant crank angle of duration at a given throttle setting, a fuel pump for supplying fuel under pressure to the pressure rail, a bypass valve continuously connected to said pressure rail, exterior means for adjusting the area of said bypass, the area remaining fixed for any given adjustment regardless of engine speed, an interconnection between said exterior means and said throttle control so as to increase the bypass area as the crank angle of injection duration is reduced at a given engine speed.

3. In a circuit for a fuel injection system of the rail pressure type, the combination of a fuel injection valve, mechanism for operating said valve, a throttle control for regulating the crank angle of discharge of said valve, said mechanism adapted to open said valve for a constant crank angle of duration at a given throttle setting, a fuel pump for supplying fuel under pressure to the pressure rail, a bypass valve continuously connected to said pressure rail, exterior means for adjusting the area of said bypass, the area remaining fixed for any given adjustment regardless of engine speed, an interconnection between said exterior means and said throttle control so as to increase the bypass area as the crank angle of injection duration is reduced at a given engine speed to maintain substantially the same fuel pressure during changed throttle settings at one engine speed and inherently produce substantially constant individual fuel discharges over a wide range of engine speeds at one throttle setting.

BROOKS WALKER.

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The above entitled patent was extended July 24, 1951, under the provisions of the act of June 30, 1950, for 6 years and 214 days from the expiration of the original term thereof.

Commissioner of Patents.