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(11)

EP 1 132 610 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.09.2001 Bulletin 2001/37

(51) Int Cl.7: **F02M 27/08**

(21) Application number: **00200817.5**

(22) Date of filing: **08.03.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

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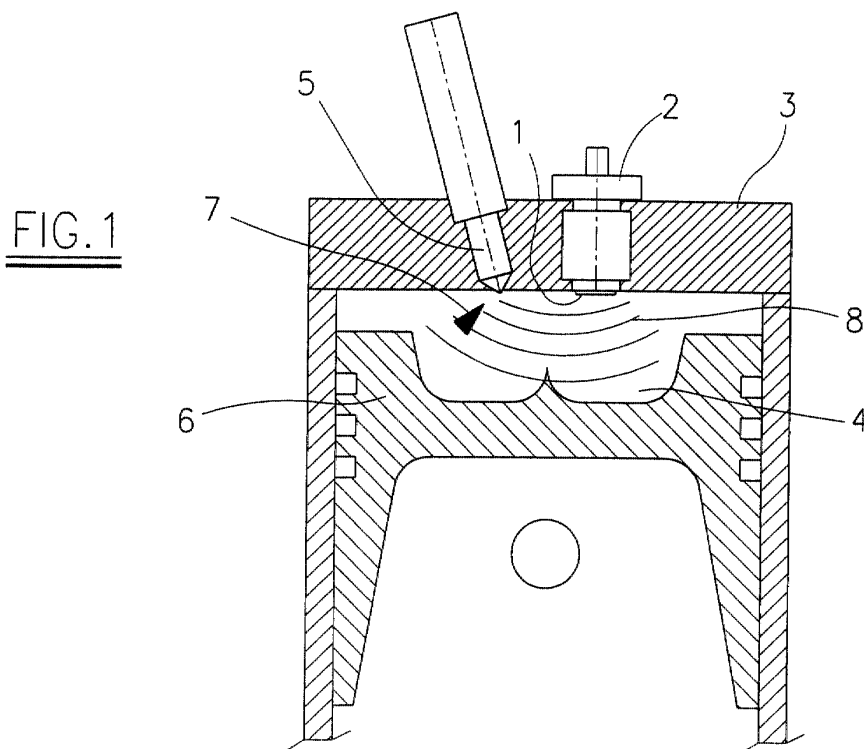
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(54) **Device for regulating the degree of atomization of the fuel droplets in internal combustion engines**

(57) A device for regulating the degree of atomization of the injected fuel based on the effect of one or more piezoelectric crystals (1) powered by a high frequency voltage generator. It enables a low injection pressure to be used. The electrical pulse applied to the

crystal causes the surface of the exposed crystal to vibrate. The high frequency vibration is transmitted into the medium in the form of the air-fuel mixture. This destabilizes the fuel droplets located within the field of action of the vibration.



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Description

[0001] This invention aims to improve the degree of atomization in an internal combustion engine, with particular reference to diesel engines.

[0002] The system for fuel atomization in a diesel engine, whether in the case of direct injection (DI) or in the case of indirect injection (IDI), currently requires a particularly high injection pressure (of the order of some hundreds of bars).

[0003] It is difficult to adjust the jet atomization over a wide operating range because the injection pressure varies with the engine r.p.m.

[0004] In this respect, the injection pressure and consequently the jet atomization tend to drastically decrease to an insufficient level as the engine r.p.m. decreases.

[0005] This aspect is particularly critical in the case of direct injection, when the air turbulence at low engine r.p.m. becomes insufficient. Likewise, at the highest engine r.p.m., correct air-fuel mixing would require low atomization as the turbulence generated by the piston movement is particularly high.

[0006] Recently, injection systems have been introduced which operate with a particularly high injection pressure (> 1000 bar) throughout the entire operating range.

[0007] These systems, known as common rail systems, require sophisticated injection control, together with very complicated engineering because of the particularly critical pressure required by the injection system. Moreover, this system is unsuitable for less than three cylinders.

[0008] This invention provides a device for regulating the degree of atomization of the injected fuel based on the effect of one or more piezoelectric crystals powered by a high frequency voltage generator. The invention enables a low injection pressure to be used because the atomization is no longer provided by the injection process alone.

[0009] The electrical pulse applied to the crystal causes that surface of the crystal exposed to the combustion chamber to vibrate at a frequency which depends on the electrical characteristics of the pulse.

[0010] The high frequency vibration is transmitted into the medium in the form of the fuel-air mixture as pressure wave trains which propagate at the speed of sound.

[0011] These destabilize those fuel droplets lying within the field of action of the vibration wavelength.

[0012] The wavelength (λ) is related to the frequency (f) by the relationship, $\lambda = a/f$, where a is the speed of sound within the medium.

[0013] Although the destabilizing action can also be effective with different orders of magnitude, the greatest effectiveness is obtained when the wavelength resonates the droplet to be disintegrated in one of its vibration modes.

[0014] The degree of atomization can be regulated by

varying the frequency and amplitude of the emission.

[0015] From the aforesaid, the invention enables:

- air-fuel mixing to be optimized for different r.p.m. and loads
- injection systems to be constructed for lower pressure, with size and cost advantages.

[0016] The device can also be applied in controlled ignition engines to achieve a more homogeneous air-fuel mixture. In these engines it can also be mounted on the manifold. It can be particularly convenient in single-point injection systems.

Figures 1 and 2 show by way of non-limiting example two possible locations for the piezoelectric crystal;

Figure 3 shows the physical principle of disintegration by pressure wave;

Figures 4 and 5 show two logic diagrams of the power and control system.

[0017] Figure 1 shows a direct-injection diesel engine in which the piezoelectric crystal 1 is housed in a cartridge 2.

[0018] The cartridge 2 is housed in the cylinder head 3 with the piezoelectric crystal 1 facing the combustion chamber 4. For ease of understanding, certain components which are important but not significant for the description of the invention (valves, piping, connecting rod etc.) have been omitted from the figure for ease of understanding.

[0019] That stage in the fuel injection by the injector 5 with the piston 6 in proximity to the top dead centre (TDC) is shown.

[0020] In the combustion chamber 4 the jets 7 leaving the discharge orifices of the atomizer are struck by the wave train 8 produced by the crystal. The action of the ultrasonic waves is effective from the start of injection and until the combustion process is complete.

[0021] Figure 2 shows an indirect injection engine, in which the cartridge 2 with the piezoelectric crystal 1 is housed in the prechamber 40 into which the fuel is injected. Again in this figure certain components which are important but not significant for the description of the invention (including the preheating plug) have been omitted from the figure for ease of understanding.

[0022] Figure 3 schematically illustrates the disintegration of the droplet by the effect of passage of the pressure wave W through a generic fuel droplet 9.

[0023] If the droplet size is comparable with the wavelength, the ultrasonic wave, by yielding energy, destabilizes it and causes it to split into two or more parts. The stages in this destabilization are indicated in the same figure by I, II, III.

[0024] The diagram of Figure 4 shows the basic electrical components, namely the piezoelectric crystal 1 and the high frequency voltage generator 10.

[0025] Figure 5 is a diagram showing how regulation is achieved by a control unit 11 which acts on the main circuit by ON-OFF control and acts on the amplitude and frequency adjustment circuit of the generator 10.

[0026] The control unit 11 receives input signals from appropriate transducers 12 which measure engine operating parameters such as r.p.m., load, engine coolant temperature and booster pressure, and from others transducers 13 which communicate process control signals (such as camshaft angular position and/or injection line pressure and/or injector needle rise).

Claims

1. A device for regulating the degree of atomization of the fuel droplets in internal combustion engines, having at least one chamber in which the fuel droplets are injected by at least one injector (5), the device comprises:

- at least one piezoelectric crystal (1) facing said chamber,
- at least one high frequency voltage generator (10),
- means to connect said piezoelectric crystal (1) with said at least one high frequency voltage generator (10),

said at least one high frequency voltage generator (10) feeds electrical pulses to said at least one piezoelectric crystal (1) so that said at least one piezoelectric crystal (1) emits pressure waves (W) able to disintegrate fuel droplets which have been injected in the chamber.

2. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 1, characterised by the fact that said chamber is a combustion chamber (4).
3. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 2, characterised by the fact that said at least one piezoelectric crystal (1) is positioned in the combustion chamber (4).
4. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 1, characterised by the fact that said chamber is a combustion prechamber (40).
5. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 4, characterised by the fact that said at least one pie-

zoelectric crystal (1) is positioned in the combustion prechamber (40).

6. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 1, characterised by the fact that said chamber is an air-fuel mixture induction manifold communicating with a combustion chamber.
7. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 6, characterised by the fact that said at least one piezoelectric crystal (1) is positioned in said air-fuel mixture induction manifold.
8. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 1, characterised by the fact that said at least one piezoelectric crystal (1) are two piezoelectric crystals.
9. A device for regulating the degree of atomization in internal combustion engines, as claimed in claim 7, characterised by the fact that each of said two piezoelectric crystals can have different response characteristics.
10. A device for regulating the degree of atomization in internal combustion engines, as claimed in the preceding claims, characterised by the fact that each of the piezoelectric crystals can be excited at different frequencies.
11. A device for regulating the degree of atomization in internal combustion engines, as claimed in the preceding claims, characterised by the facility for regulating the oscillation intensity and frequency on the basis of the r.p.m. and load.
12. A device for regulating the degree of atomization in internal combustion engines, as claimed in the preceding claims, characterised by the facility for also regulating the oscillation intensity and frequency in a single wave train.
13. A device for regulating the degree of atomization in internal combustion engines, as claimed in the preceding claims, characterised by the facility for regulating the intervention time in relation to the fuel injection process.

FIG.1

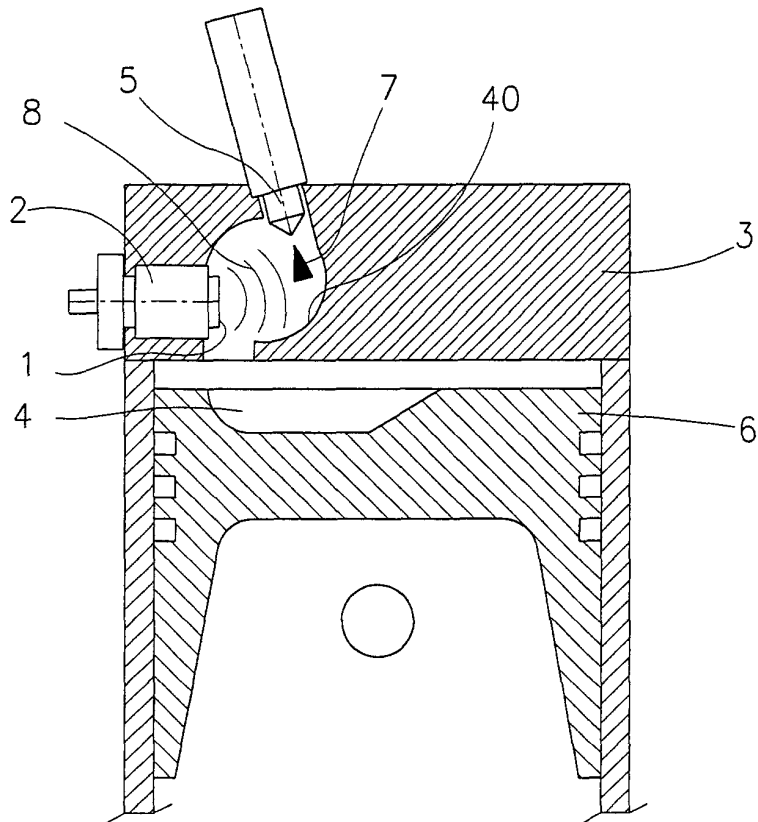
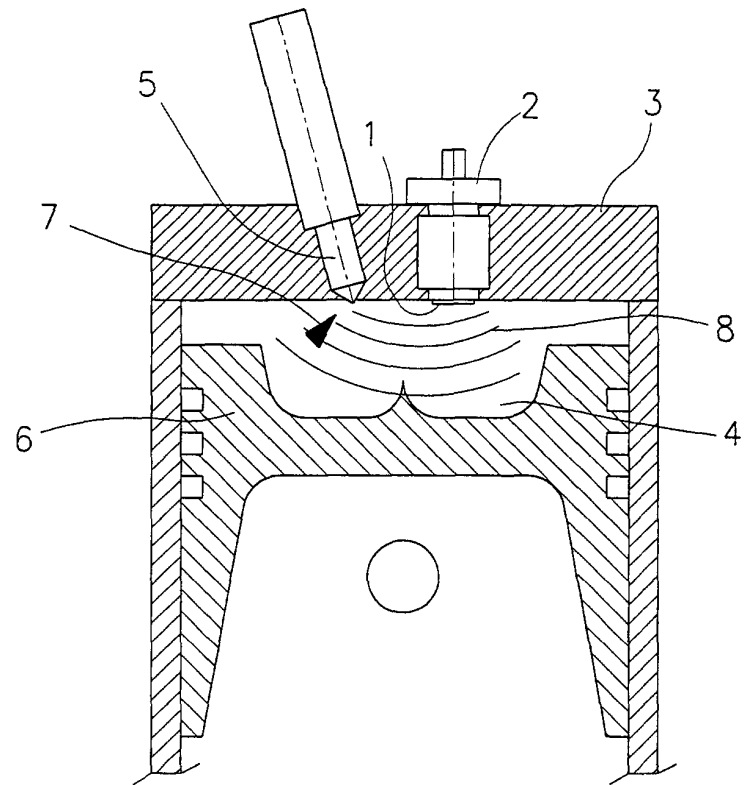
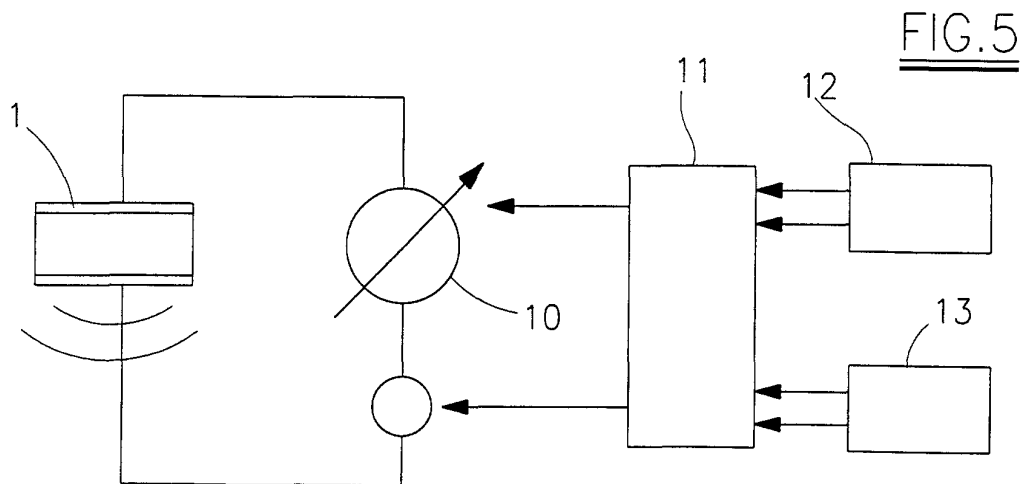
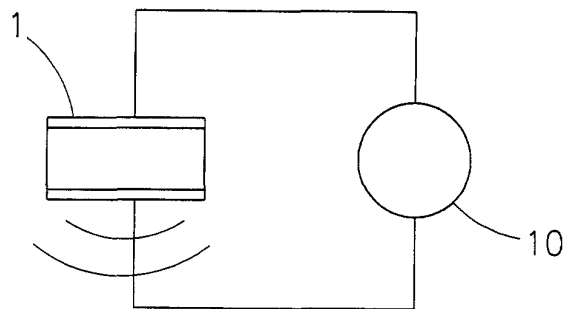
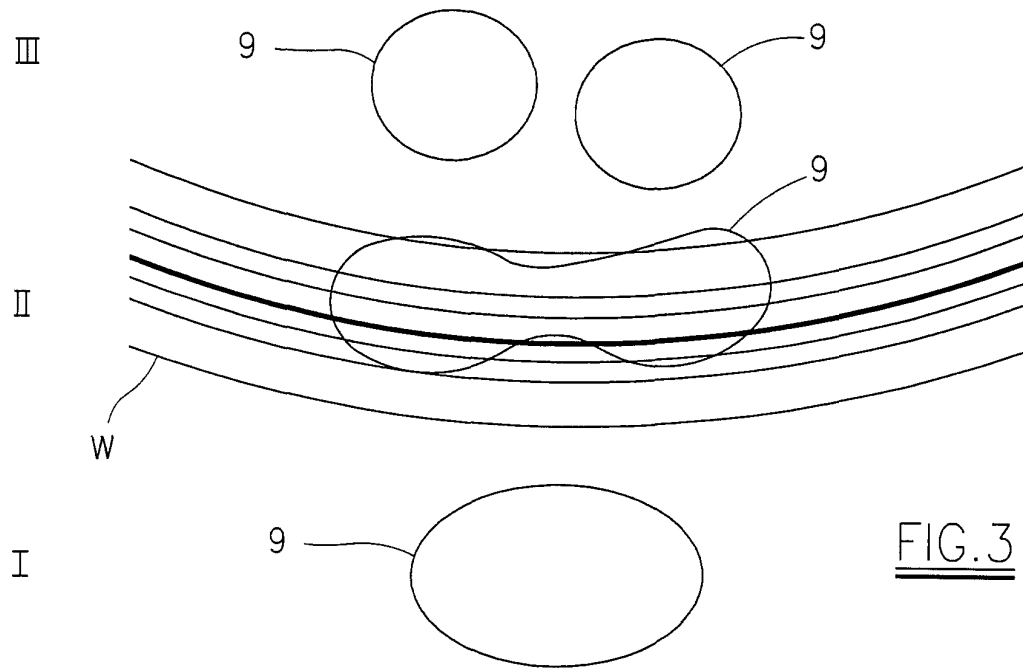


FIG.2





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EPO FORM 1503 03/82 (P04C01)



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