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(71) Applicant: **AEA S.r.l.**
**60030 ANGELI DI ROSORA AN (IT)**

(72) Inventor: **Romiti, Gino**
**60024 Filottrano (Ancona) (IT)**

(74) Representative: **Faggioni, Carlo Maria et al**
**Fumero**
**Studio Consulenza Brevetti Snc**
**Pettenkoferstrasse 20-22**
**80336 Munich (DE)**

(54) **Device for the detection of fuel leaks in internal combustion engines**

(57) A device (2) for blow-by detection in injectors (1) of internal combustion engines is disclosed, which comprises a probe (3) employing optical fibres (6, 7) which radiates the end portion of the injector (1). Preferably, radiance occurs at UV wavelength and said probe (3) is connected to a spectrometer (5) by cables (4).

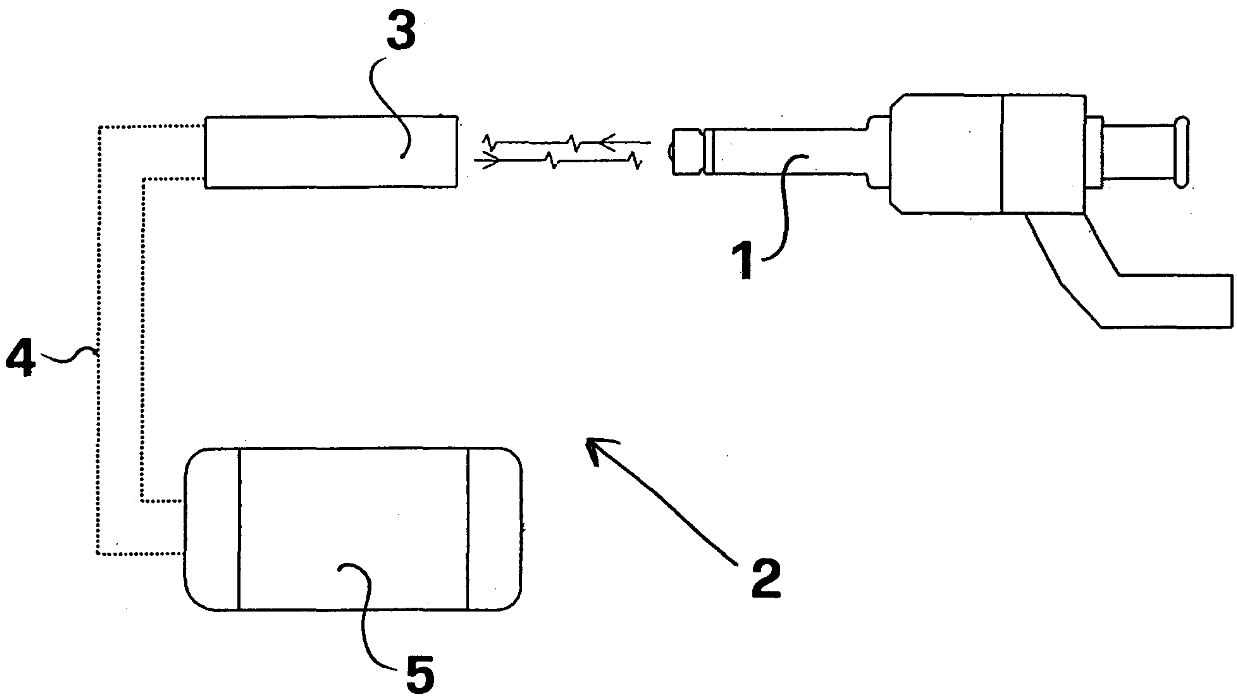


FIG. 1

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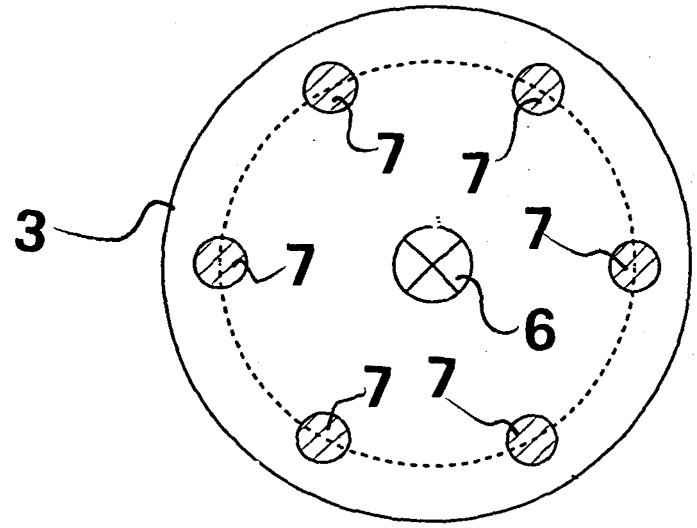



FIG. 2

## Description

**[0001]** The present invention relates to a device for the detection of fuel leaks in internal combustion engines, such as controlled ignition engines or diesel engines.

**[0002]** In modern injectors for automotive use, and in particular in those employing direct petrol injection, known as GDI, it is particularly important to guarantee that fuel leaks in a closed valve condition are really minimal, since - due to the nature of the Otto cycle - should blow-by occur with the engine turned off, upon the subsequent starting of the engine, self-ignition may occur in the cylinder where the malfunctioning injector operates. These self-ignitions may cause potentially serious damage, such as crankshaft or compression ring breakage.

**[0003]** GDI injectors are particularly prone to this problem, since they work at fuel pressures in the order of 200 bar. Thereby, the fuel remains stored in significant amounts in the manifold which feeds the injectors with these pressures, even in the presence of a turned-off engine. An optimal blow-by value is believed to be one below 0,1 $mm^3$/min of petrol.

**[0004]** These very low values, as can be understood, cannot be obtained by the conventional technique, consisting in testing air blow-by and in experimentally correlating it to that of fuel. Even more advanced techniques, such as vacuum tests, using helium as a marker, have proven to be insufficiently reliable, since also small residual traces of liquids can affect results.

**[0005]** A technique was hence devised, to check fuel at set point pressure, measuring blow-by by the pressure increase being generated in a small sealed chamber coupled with the injector nose. This method is described in detail in DE-C2-19 809 926. Also this system has, however, some major drawbacks. Its reliability is seriously impaired by the delicacy and complexity of some of its mechanical components, for example gaskets, which also call for frequent maintenance. The method implies remarkably-long checking times, whereas checks in automatic high-baud-rate manufacturing systems require an ever shorter time. Moreover, said method has extremely high overall costs and is close to the limits of technically achievable sensitivity, leaving no room for further lowering of the blow-by acceptance threshold.

**[0006]** Such drawbacks are brilliantly solved by the present invention, which refers to a device for blow-by detection, characterised in that it comprises an optical-fibre probe which irradiates the end portion of the injector. Preferably, radiance occurs at ultraviolet (UV) wavelength.

**[0007]** This invention will now be described in greater detail, with reference to the accompanying drawings, wherein

**[0008]** fig. 1 is an operation diagram of the device according to this invention;

**[0009]** fig. 2 is a cross-section view of the optical-fibre probe of this invention; and

**[0010]** fig. 3 is a diagram, showing the spectrum or the radiation reflected by the fuel found on the injector head.

**[0011]** Fig. 1 shows injector 1 which is to be checked. The check is run by means of detection device 2 according to the present invention. Device 2 comprises an optical-fibre probe 3, connected by cables 4 to a spectrometer 5, which can advantageously be a spectrophotometer.

**[0012]** As can be seen in fig. 2, probe 3 comprises optical fibres 6 for transmitting a radiation from probe 3 to injector 1 and optical fibres 7 for collecting the reflected radiation.

**[0013]** During operation, injector 1 is brought opposite device 2, aligning it with probe 3. Through optical fibres 6, probe 3 radiates the surface of injector 1. The presence of liquid, possibly blown-by from injector 1, affects radiation reflection, by varying the intensity of the reflected radiation, the wavelength being equal. For the sake of analysis simplicity, ultraviolet radiation is preferred.

**[0014]** Optical fibres 7 collect the reflected radiation and, through cables 4, transmit it to spectrophotometer 5.

**[0015]** As can be seen in fig. 3, depending on the wavelength radiated on the surface of injector 1, an intensity reaction curve is obtained. Each curve is characteristic of the amount of fuel blown by from injector 1. In order to then return to the actually blown-by amount of fuel, a calibration model is resorted to, obtained by calibration with a known amount of fuel. Various algorithms exist which may be used for calibration; PLS (partial least squares) chemometric methods have proven to be particularly suitable.

**[0016]** The present invention allows to achieve the following advantages. A remarkable mechanical simplicity, since it is possible to operate at set point pressure, or at an only slightly higher pressure, to heighten leaks, not requiring any mechanical device downstream of the injector. Remarkable reliability is achieved, since this is an indirect measurement with no risk of breakage or failure, apart from the regular replacement of the (long-lasting) UV lamp. Moreover, the technique provided by the present invention is extremely quick, reducing by up to two or three times the time currently required. Finally, the device according to the present invention is highly sensitive, being able to detect leaks in the order of 0,1 $mm^3$/min. Further improvements may be obtained by using a larger number of optical fibres or more sensitive spectrophotometers.

## Claims

1. Device (2) for the detection of blow-by in injectors (1) of internal combustion engines, **characterised in that** it comprises a probe (3) employing optical fibres (6, 7) which irradiates the end portion of the injector (1).

2. Device (2) as claimed in claim 1), **characterised in that** radiance occurs at UV wavelength.

**3.** Device (2) as claimed in claim 1) or 2), **characterised in that** said probe (3) is connected through cables (4) to a spectrometer (5).

**4.** Device (2) as claimed in claim 3), **characterised in that** said spectrometer is a spectrophotometer (5).

**5.** Device (2) as claimed in any one of the previous claims, **characterised in that** the probe (3) comprises optical fibres (6) to transmit a radiation from the probe (3) to the injector (1) and optical fibres (7) for collecting the reflected radiation.

**6.** Device as claimed in any previous claim, **characterised in that**, in order to trace the actually blown-by amount of fuel, a calibration model is resorted to for correlating the spectrum of the reflected radiation to the actually blown-by amount of fuel.

**7.** Device as claimed in claim 6), **characterised in that** the calibration model is obtained through a PLS (partial least squares) algorithm.

**8.** Method for the detection of blow-by in injectors (1) of internal combustion engines, **characterised in that** it provides the following steps:

a) irradiating the surface of the injector (1) with a radiation having known wavelength and intensity;
b) collecting the reflected radiation;
c) assessing the intensity of the reflected radiation at one or more pre-defined wavelengths; and
d) calculating blow-by extent by means of a calibration mode

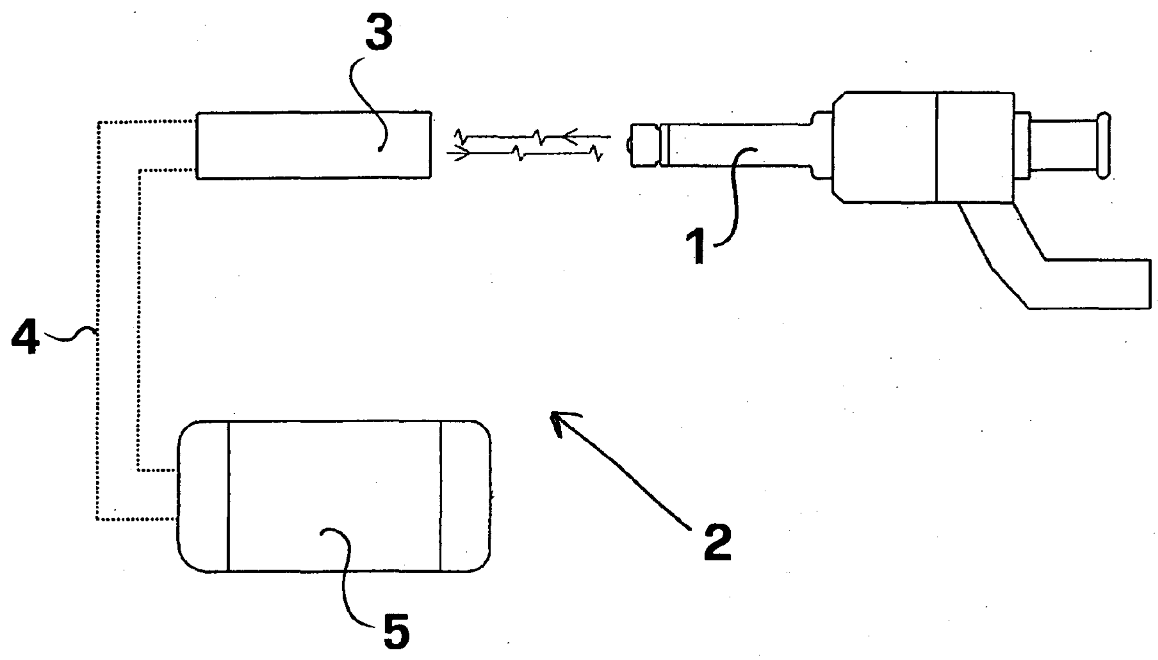
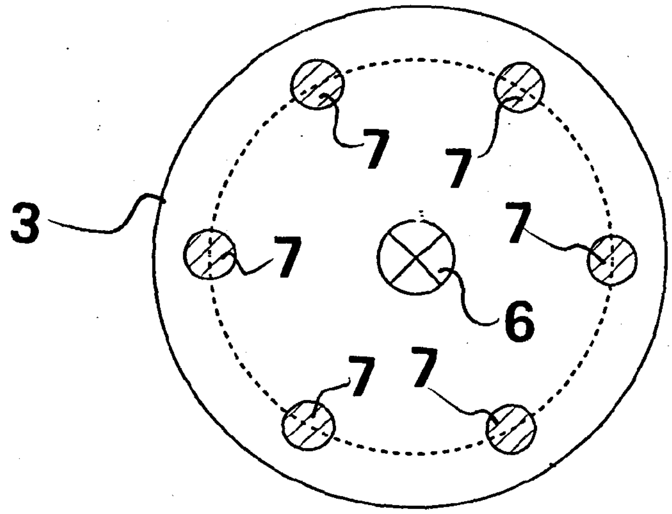



FIG. 1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7
7
7
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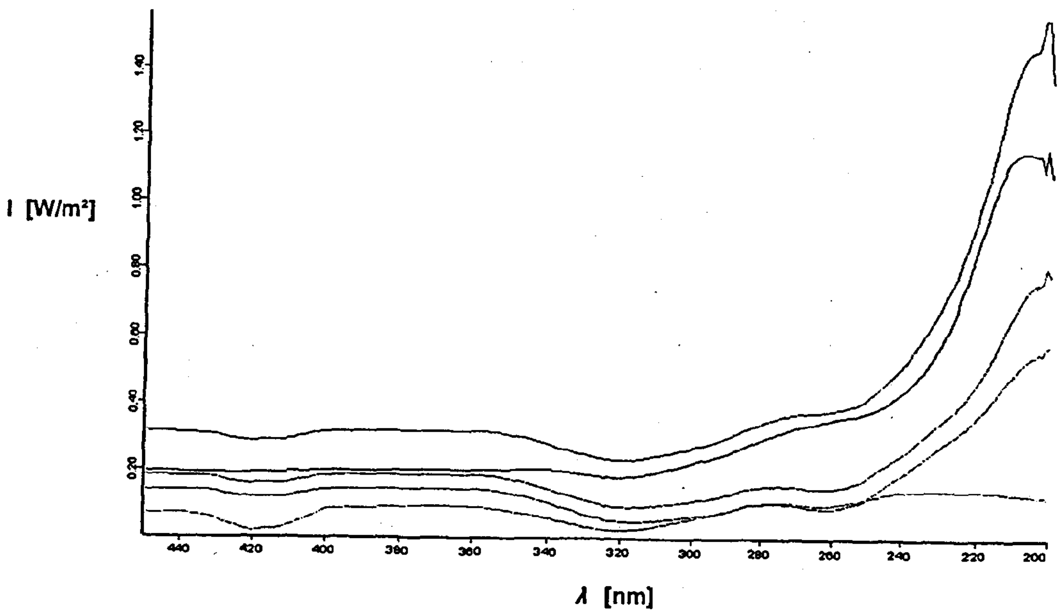
7
6

FIG. 2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0.80
1.00
1.20
1.40
440
420
400
380
360
340
320
300
280
260
240
220
200
λ [nm]

FIG. 3

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- DE 19809926 C2 **[0005]**