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(54) Title: METHOD AND APPARATUS FOR SENSING THE NATURE OF A GASEOUS COMPOSITION, PARTICULARLY VEHICULAR EMISSIONS

(57) Abstract: A method and apparatus are described for sensing the nature of a gaseous composition, particularly vehicular emissions over a roadway surface, by: disposing substantially parallel to the surface an optical transmission channel including an optical radiation source at one end and a retro-reflector at the opposite end, which retro-reflector is movable axially of the optical transmission channel substantially parallel to the surface towards and away from the optical radiation source; at a first location of the optical transmission channel, diverting a part of the optical radiation therein towards the surface, and detecting by a Light Detection and Ranging (LIDAR) system the particulate matter in the gaseous composition at the first location; at a second location of the optical transmission channel, diverting another part of the optical radiation in the optical transmission channel towards a retro-reflector fixed with respect to the surface, and detecting by a Fourier Transform Infrared Spectroscopy (FTIS) detector system the gaseous composition at the second location, while moving the movable retro-reflector with respect to the optical radiation source; and processing the outputs of the two detector systems to determine whether either output unduly exceeds a predetermined baseline value.



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METHOD AND APPARATUS FOR SENSING THE NATURE OF A GASEOUS COMPOSITION, PARTICULARLY VEHICULAR EMISSIONS

RELATED APPLICATION

5 The present application is related to Provisional Patent Application Serial No. 61/093,530, filed September 2, 2008, the contents of which are incorporated herein by reference, and claims the priority date of said prior application.

FIELD AND BACKGROUND OF THE INVENTION

10 The present invention relates to a method and apparatus for sensing the nature of a gaseous composition, including one containing particulate matter. The invention is particularly useful for sensing vehicular emissions over a roadway, and is therefore described below with respect to such an application.

Vehicular emissions, particularly those resulting from inefficient combustion, have been identified as a major contributor to the air pollution in urban and rural areas. The rapidly increasing vehicle fleets, particularly diesel powered vehicles, and 15 the high rate of urbanization, are major contributing factors to the increase in pollution levels.

Vehicular emissions include carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons (HCs), and particulate matter (PM). Such emissions contribute to the formation of photochemical smog, acid deposition, and elevated CO levels, while 20 reactions of NO_x and HCs also contribute to ozone (O₃) formations. These pollutants cause serious respiratory problems and increases toxicity and mortality. The effects are more severe in urban areas where traffic is dense, than in rural areas.

Current European inspection and maintenance programs are based on periodical (usually annual) and random (roadside) tests of CO concentration for spark 25 ignition (SI) engines, and particulate or smoke levels (for diesel engines) in the vehicle exhaust. These measurements are usually carried out by conventional Non-Dispersive Infrared (NDIR) gas analyzers and smoke meters. A disadvantage of such conventional tests are that they are time and labor consuming and require driver cooperation.

30 Recently, in an effort to detect and reduce these emissions, the remote sensing technology was introduced. Remote sensing (RS) of vehicle exhaust does not require

physical sampling of exhaust gases from stationary vehicles, but instead, use a non-intrusive measurement method while the vehicles are moving. The testing capacity of RS systems is far greater than the conventional system; that is, an RS device can perform inspection of thousands of vehicles per day. Taking into account the high correlation between pollutants emitted by vehicles, and the mechanical condition of the vehicle, remote sensing could also be an important tool in identifying faulty vehicles.

The existing commercial RS systems have several inherent drawbacks. These include the facts that they are expensive, the measurements sometimes are unreliable, the system set-up is complicated, and the systems usually require complex calibration schemes.

A broad object of the present invention is to provide a method and apparatus for sensing the nature of a gaseous composition having advantages in one or more of the above respects. A more particular object of the invention is to provide a method and apparatus for sensing vehicular emissions caused by vehicles, having advantages in one or more of the above respects.

BRIEF SUMMARY OF THE PRESENT INVENTION

According to one aspect of the present invention, there is provided a method for sensing the nature of a gaseous composition adjacent a surface, comprising: disposing substantially parallel to the surface an optical transmission channel including an optical radiation source at one end thereof and a retro-reflector at the opposite end thereof, which retro-reflector is movable axially of the optical transmission channel substantially parallel to the surface towards and away from the optical radiation source; at a first location of the optical transmission channel, diverting a part of the optical radiation therein towards the surface, and detecting by a Light Detection and Ranging (LIDAR) detector system the particulate matter in the gaseous composition at the first location, to produce an output corresponding thereto; at a second location of the optical transmission channel, diverting another part of the optical radiation in the optical transmission channel towards a retro-reflector fixed with respect to the surface, and detecting by a Fourier Transform Infrared Spectroscopy (FTIS) detector system the gaseous composition at the second location, while moving the movable retro-reflector with respect to the optical radiation source, to produce an output corresponding thereto; and processing the outputs of the two

detector systems to determine whether either output exceeds a predetermined baseline value.

According to another aspect of the present invention, there is provided apparatus for sensing the nature of a gaseous composition adjacent a surface, comprising: a housing to be disposed substantially parallel to the surface and housing an optical transmission channel including an optical radiation source at one end thereof, and a retro-reflector at the opposite end thereof, which retro-reflector is movable axially of the optical transmission channel substantially parallel to the surface towards and away from the optical radiation source; a first beam splitter within the housing at a first location of the optical transmission channel, and effective to divert a part of the optical radiation therein out of the housing towards the surface; a Light Detection and Ranging (LIDAR) detector system for detecting the particulate matter in the gaseous composition at the first location, and producing an output corresponding thereto; a second beam splitter within the housing at a second location of the optical transmission channel effective to divert another part of the optical radiation therein out of the housing towards the surface; a Fourier Transform Infrared Spectroscopy (FTIS) detector system for detecting the gaseous composition at the second location, and for producing an output corresponding thereto; and a processor for processing the outputs of the two detector systems to determine whether either output unduly exceeds a predetermined baseline value.

Light Detection and Ranging, (hereinafter referred to as LIDAR), detector systems are well-known optical remote sensing systems that measure properties of scattered light to find range and/or other information of a distant target. Like radar, which uses radio waves, namely light that is not in the visible spectrum, they determine range to an object by measuring the time delay between transmissions of a pulse and detection of the reflected signal. The primary difference between LIDAR and RADAR is that with LIDAR, much shorter wavelength of the electromagnetic spectrum are used, typically in the ultraviolet, visible or near infrared range. In general, it is possible to image a feature or object only about the same size as a wavelength, or larger. Thus, LIDAR is highly sensitive to aerosols and cloud particles. In the present invention, such a system is used for detecting the particulate matter in the gaseous composition being sensed and to produce to an output corresponding thereto.

Fourier Transform Infrared Spectroscopy (hereinafter FTIS) detector systems are known system which include two mirrors, or retro-reflector reflectors, located at a right angle to each other and oriented perpendicularly, with a beam splitter placed at the vertex of the right angle and oriented at a 45° angle relative to the two mirrors.

5 The beam splitter receives radiation from one port, divides the radiation into two parts, each of which propagates down one of two arms, and is reflected off one of the mirrors in the form of two beams. The two beams are then recombined and transmitted out of another port. When the position of one mirror (the translating mirror) is continually varied along the axis of the corresponding arm, an interference
10 pattern is produced as two phase shifted beams interfere with each other. Such a detector system is used in the present invention to detect, and to produce a measurement of, the gaseous composition by measuring the absorption spectrum of the gaseous ingredients. The output is processed, together with the output of the LIDAR detector system, to determine the nature of the gaseous composition.

15 The foregoing method is particularly useful for detecting vehicle emissions over a roadway and for determining whether such emissions exceed a predetermined baseline value. The preferred embodiment of the invention described below is therefore used for this purpose.

According to a further aspect of the embodiment of the invention, there is
20 provided a method of detecting excessive emissions from vehicles travelling over a roadway, comprising: disposing an emission detector system over the roadway to overlie a section thereof through which the vehicles travel; detecting a vehicle approaching or travelling in the roadway section; and upon detecting a vehicle in or approaching the roadway section, actuating the emission detector system to measure
25 the emission from the vehicle.

In other preferred features of embodiments of the invention, the optical transmission channel is located to overlie the roadway, and the fixed retro-reflector is fixed to the roadway to underlie the optical transmission channel.

In the described preferred embodiment, the optical transmission channel is
30 located to extend transversely across the roadway, and the movable retro-reflector is movable transversely of the roadway towards and away from the optical radiation source.

According to another feature in the described preferred embodiment, the roadway includes a plurality of lanes; one of the above-described optical transmission

channels is located to extend transversely across each of the lanes and cooperates with a retro-reflector fixed to the roadway to underlie each of the optical transmission channels.

Such a method and apparatus for sensing and measuring vehicles emissions thus enable simultaneous inspection of both the gases and the particulate material of vehicle emissions by a combination of LIDAR and FTIS detector systems using a common lighting module serving as the optical radiation source. For example, the lighting module is a halogen lamp emitting radiation having a high UV and infrared content. Such a system enables the use of known lighting modules and off-the-shelf optical-electrical-mechanical components, thereby enabling significant cost reduction in the initial installation as well as in the maintenance of the installation. Such a system may also be made more reliable and accurate, in comparison with the current data processing, by the use of continuous baseline calibration integrated in the measurement scheme. Further, the overhead installation layout in the described preferred embodiment enables high capacity measurements on various road configurations (multi-lane roads, cross-junctions, two-way traffic loads, etc.). The fixed retro-reflectors are preferably coated retro-reflectors, integrated into the road surface. Multiple gaseous pollutants can be monitored simultaneously, as well as different particulate matter size distributions.

It will thus be seen that, in general, the described method and apparatus provide high reliability both with respect to spark-ignition and diesel vehicles. They permit unmanned operation, which allows performing all measurement operations in an automatic manner. In case a malfunctioning vehicle is detected, such information could be sent to a remote operator automatically for alerting the driver or an inspector.

Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 pictorially illustrates one form of two-lane roadway in which each lane is provided with an overhead apparatus constructed in accordance with the present invention for detecting and measuring vehicular emissions by vehicles travelling in the respective lane;

FIG. 2 more particularly illustrates the construction of one unit utilized in the apparatus of FIG. 1 for detecting and measuring vehicular emissions in the respective lane of the roadway; and

FIG. 3 is a flowchart illustrating one manner of using the systems of FIGs. 1 and 2 for detecting undue vehicular emissions in each of the two lanes of the roadway of FIG. 1.

It is to be understood that the foregoing drawings, and the description below, are provided primarily for purposes of facilitating understanding the conceptual aspects of the invention and possible embodiments thereof, including what is presently considered to be a preferred embodiment. In the interest of clarity and brevity, no attempt is made to provide more details than necessary to enable one skilled in the art, using routine skill and design, to understand and practice the described invention. It is to be further understood that the embodiments described are for purposes of example only, and that the invention is capable of being embodied in other forms and applications than described herein.

DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention, in some embodiments thereof, relates to a method and apparatus for sensing gaseous emissions, and more particularly, but not exclusively, to sensing of vehicular emissions from vehicles travelling over a roadway in order to detect an undue level of emissions caused by such vehicles. Fig. 1 pictorially illustrates an embodiment of the invention embodied in such a system, including a roadway 2 divided into two lanes 2a, 2b for detecting emissions, shown as plumes 3, 4, of two vehicles 5, 6 as each travels over one of the lanes 2a, 2b. For this purpose, the apparatus includes an overhead horizontal structure 7 extending transversely across both lanes 2a, 2b, and supported at its opposite ends by a pair of vertical structures 8 and 9 straddling the opposite sides of the roadway 2. The overhead horizontal structure 7 mounts two detector units, generally designated 10, one over each of the two lanes 2a, 2b to detect the gaseous emissions 3, 4 of the vehicles 5, 6 travelling the two lanes.

Fig. 2 more particularly illustrates the construction of each of the emission detector units 10 of Fig. 1; and Fig. 3 illustrates the operation of each of the emission detector units 10.

As shown in Fig. 2, each of the emission detector units 10 includes a housing 11 extending transversely across, and substantially parallel to, each lane 2a, 2b. Housing 11 includes an optical transmission channel having an optical radiation source 12 at one end and a retro-reflector 13 at the opposite end. Optical radiation source 12 includes a Tg-Halogen lamp 12a emitting radiation having a high UV and infrared content, and a parabolic reflector 12b oriented to direct such radiation to the retro-reflector 13 at the opposite end of the optical transmission channel. As shown by arrow 14, retro-reflector 13 is to be moved axially of the optical transmission channel and substantially parallel to the surface of the respective lane 2a monitored by the respective unit 10.

A collimating optics system generally designated 15, including a pair of lens 16, 17 and an iris 18 between the lenses, is provided immediately downstream of the optical radiation source 12 to section 19 of the optical transmission channel. The light between lens 17 and the movable retro-reflector 13 at the opposite end of the channel, is thus collimated.

The end of collimating section 19 of the optical transmission channel proximate to the optical radiation source 12 is provided with a first beam splitter 20, and the opposite end of collimating section 19, proximate to the movable retro-reflector 13, is provided with a second beam splitter 30.

Beam splitter 20 diverts a part of the radiation within section 19 of the optical transmission channel towards a Light Detection and Ranging (LIDAR) detector system, generally designated by box LIDAR; whereas beam splitter 30 diverts another part of the radiation within section 19 of the optical transmission channel to a Fourier Transform Infrared Spectroscopy (FTIS) detector system, generally designated by box FTIS.

The LIDAR detector system includes a diverging lens 21 for transmitting the part of the radiation diverted by beam splitter 20 towards plume 3 produced by the vehicle travelling along the respective lane 2a 2b (Fig. 1). This light, after reflection by the plume 3, is focused by a converging lens 22 onto a detector 23 which thereby produces an output corresponding to the particulate matter in plume 3 emitted from the vehicle travelling along the respective lane 2a.

The part of the radiation within section 19 of the optical transmission channel diverted by beam splitter 30 to the FTIS detector system is directed through plume 3 towards a retro-reflector 31 fixed into, or with respect to, the surface of the roadway

defined by the respective lane 2a. Fixed retro-reflector 31 is located with its axis perpendicular to the axis of movable retro-reflector 13 such that the beam reflected from the movable retro-reflector 13 introduces a time delay with respect to the beam reflected from the fixed retro-reflector 31. The two beams thus interfere, allowing the temporal coherence of the light to be measured at each different time delay setting, to effectively convert the time domain into a spatial coordinate. By making the measurements of the signal at many discrete positions of the movable retro-reflector 13, the spectrum can be reconstructed using Fourier Transform of the temporal coherence of the light. Such spectrographs are capable of very high spectral resolution observations of light sources, particularly those rich in infrared radiation for measuring the gas composition of the exhaust plume 3.

The emission sensor unit 10 illustrated in Fig. 10 further includes a processor, generally designated 40, which includes a connection 41 to the optical radiation source 12, another connection 42 to the output of the LIDAR detector system, and another connection to the FTIS detector system. Processor 40 includes one or more outputs, such as output 44 to a signaling device, output 45 to a display device, and/or output 46 to a recording or other processing device.

Fig. 3 illustrates a preferred example of the operation of each of the emission sensor units 10 as controlled by its respective processor 40 to detect undue emission from a vehicle travelling in the respective lane. When such an undue emission is detected, the processor 40 may provide a signal of its condition in its signaling device 44, may produce a display of this condition in its display device 45, and/or may record the condition in its recording or other processing device 46.

Thus, as shown in Fig. 3, when the detector operation is initiated, processor 40 controls the apparatus to sense the emissions of each vehicle travelling over the respective part of the roadways. This is done is by sensing the air composition over the selected part of the roadway when not being traversed by a vehicle and determining a baseline value, as shown by boxes 51a, 51b; then detecting a vehicle travelling over the respective part of the roadway, as indicated by boxes 52a, 52b; and then actuating the LIDAR detector system to detect the particulate matter in the gaseous emission as shown by block 54a, and the FTIS detector system to detect the level of the gaseous emission, as indicated by block 54b. That is, the operation performed by box 54a involves temporal filtering for data retrieval and Fast Fourier

Transform of the retrieved data for the spectra analysis; and the operation by block 54b involves the temporal filtering for data retrieval.

As shown by block 55a, the baseline data measured by block 51a is subtracted from that measured by block 54a; and similarly, as indicated by block 55b, the baseline data measured in block 51b is subtracted from that produced by block 54b. If either of these measurements indicates an undue level of vehicle emission from the respective vehicle, a video monitoring system is triggered, as indicated by block 57. As mentioned earlier, the video monitoring system could produce an alarm signal, could display the respective measurement, and/or could be recorded for further processing or other use.

While the invention has been described with respect to one preferred embodiment, it will be appreciated that many variations, modifications and other applications of the invention may be made. For example, other radiation sources or radiation detectors could be used. Further, their outputs could be numerical values of the measurements from which a determination could be made whether or not a predetermined baseline value or range has been exceeded. Also, the sensor apparatus could be mounted to extend along the opposite sides of the roadway rather than to overlie the roadways. In addition, the invention could be used for measuring or detecting the nature or composition of other gaseous compositions.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the

specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to
5 the present invention. To the extent that the section headings are used, they should not be construed as necessarily limiting.

Many other variations, modifications or applications of the invention will be apparent.

What is claimed is:

1. A method of sensing the nature of a gaseous composition adjacent a surface, comprising:

disposing substantially parallel to the surface an optical transmission channel including an optical radiation source at one end thereof and a retro-reflector at the opposite end thereof, which retro-reflector is movable axially of the optical transmission channel substantially parallel to the surface towards and away from the optical radiation source;

at a first location of the optical transmission channel, diverting a part of the optical radiation therein towards the surface, and detecting by a Light Detection and Ranging (LIDAR) detector system the particulate matter in the gaseous composition at the first location, to produce an output corresponding thereto;

at a second location of the optical transmission channel, diverting another part of the optical radiation in the optical transmission channel towards a retro-reflector fixed with respect to the surface, and detecting by a Fourier Transform Infrared Spectroscopy (FTIS) detector system the gaseous composition at the second location, while moving the movable retro-reflector with respect to the optical radiation source, to produce an output corresponding thereto;

and processing the outputs of said two detector systems to determine whether either output unduly exceeds a predetermined baseline value.

2. The method according to Claim 1, wherein said surface is a roadway for automotive vehicles, and the method senses the emissions of each vehicle travelling over a selected part of said roadway.

3. The method according to Claim 2, wherein the optical transmission channel is located to overlie the roadway, and the fixed retro-reflector is fixed to the roadway to underlie the optical transmission channel.

4. The method according to Claim 3, wherein the optical transmission channel is located to extend transversely across the roadway, and the movable retro-reflector is movable transversely of the roadway towards and away from the optical radiation source.

5. The method according to Claim 4, wherein the roadway includes a plurality of lanes, and a optical transmission channel is located to extend transversely across each of the lanes and cooperates with a retro-reflector fixed to the roadway to underlie each of the optical transmission channels.

6. The method according to Claim 1, wherein said surface is a roadway for automotive vehicles, and when the method senses the emissions of each vehicle travelling over a selected part of said roadway by:

sensing gases and particulate ingredients of the air composition over said selected part of the roadway when not being traversed by a vehicle, and determining a baseline value for each of the LIDAR and FTIS detector systems;

detecting a vehicle travelling over said selected part of the roadway and producing exhaust emissions;

actuating said LIDAR and FTIS detector systems to determine the level of the gaseous and particulate emissions from said vehicle;

comparing said gaseous and particulate emissions with said baseline values;

and producing an output whenever a measured gaseous emission or particulate emission unduly exceeds its respective measured baseline.

7. The method according to Claim 1, wherein the optical radiation source is a single source including a halogen lamp emitting radiation having a high UV and infrared content.

8. A method of detecting excessive emissions from vehicles travelling over a roadway, comprising:

disposing an emission detector system over said roadway to overlie a section thereof through which the vehicles travel;

detecting a vehicle approaching or travelling in said roadway section;

and upon detecting a vehicle in or approaching said roadway section, actuating said emission detector system to measure the emission from said vehicle.

9. The method according to Claim 8, wherein said emission detector system includes an optical transmission channel parallel to said roadway section and having an optical radiation source at one end, a movable retro-reflector at the opposite end movable axially towards and away from said optical radiation source, a beam splitter at a location between said optical radiation source and said movable retro-reflector for diverting a part of the optical radiation in said optical transmission channel 90° towards said roadway section, a fixed retro-reflector fixed in said roadway section for receiving said diverted part of the optical radiation and reflecting it back through said optical transmission channel, and an optical detector over said roadway section to receive said reflected-back radiation and to define a Fourier Transform Infrared Spectroscopy (FTIS) system and for using same to measure the vehicular emissions.

10. The method according to Claim 9, wherein said optical transmission channel includes a second beam splitter for diverting another part of the optical radiation therein 90° towards said roadway section, and a second optical detector for receiving the optical radiation diverted by said second beam splitter, after impinging the vehicular emissions from a vehicle travelling over said roadway section, to define a Light Detection and Ranging (LIDAR) detector system for detecting and measuring the emissions from said vehicle.

11. The method according to Claim 9, wherein the optical transmission channel is located to extend transversely across the roadway, and the movable retro-reflector is movable transversely of the roadway towards and away from the optical radiation source.

12. The method according to Claim 11, wherein the roadway includes a plurality of lanes, and an optical transmission channel is located to extend transversely across each of the lanes and cooperates with a retro-reflector fixed to the roadway to underlie each of the optical transmission channels.

13. Apparatus for sensing the nature of a gaseous composition adjacent a surface, comprising:

- a housing to be disposed substantially parallel to the surface and housing an optical transmission channel including an optical radiation source at one end thereof, and a retro-reflector at the opposite end thereof, which retro-reflector is movable axially of the optical transmission channel substantially parallel to the surface towards and away from the optical radiation source;

- a first beam splitter within the housing at a first location of the optical transmission channel, and effective to divert a part of the optical radiation therein out of the housing towards the surface;

- a Light Detection and Ranging (LIDAR) detector system for detecting the particulate matter in the gaseous composition at the first location, and producing an output corresponding thereto;

- a second beam splitter within the housing at a second location of the optical transmission channel effective to divert another part of the optical radiation therein out of the housing towards the surface;

- a Fourier Transform Infrared Spectroscopy (FTIS) detector system for detecting the gaseous composition at the second location, and for producing an output corresponding thereto;

and a processor for processing the outputs of the two detector systems to determine whether either output unduly exceeds a predetermined baseline value.

14. The apparatus according to Claim 13, wherein said housing is configured and dimensioned for mounting adjacent to a roadway for sensing the emissions of each vehicle travelling over a selected part of said roadway.

15. The apparatus according to Claim 14, wherein the housing is configured and dimensioned for mounting over the roadway, and the fixed retro-reflector is configured and dimensioned to be fixed to the roadway to underlie the housing.

16. The apparatus according to Claim 15, wherein the housing is configured and dimensioned to extend transversely across the roadway, and the fixed retro-reflector is configured and dimensioned to be fixed to the roadway to underlie the housing.

17. The apparatus according to Claim 16, wherein the apparatus includes a plurality of the housings each having a the optical transmission channel, for mounting transversely across a plurality of lanes of the roadway, with each optical transmission channel overlying one of the lanes, and cooperable with a fixed retro-reflector fixed to the respective lane.

18. The apparatus according to Claim 13, wherein said surface is a roadway for automotive vehicles, and wherein said LIDAR and FTIS detector systems detect the particulate matter and gaseous composition of emissions of each vehicle travelling over a selected part of said roadway; and further wherein said processor is programmed:

to sense gaseous and particulate ingredients of the air composition over said selected part of the roadway when not being traversed by a vehicle, and determine baseline values for the gaseous and particulate ingredients of the air composition over said selected part of the roadway;

to detect a vehicle traversing over said selected part of a roadway and producing exhaust emissions;

to actuate said LIDAR and FTIS detector systems to determine the level of the gaseous and particulate emissions from said vehicle;

to compare said gaseous and particulate emissions with said baseline values;

and to produce an output whenever a measured gaseous emission or particulate emission unduly exceeds its respective measured baseline.

19. The apparatus according to Claim 13, wherein the optical radiation source is a single source including a halogen lamp emitting radiation having a high UV and infrared content.

20. The apparatus according to Claim 13, wherein the optical transmission channel further includes collimating optics between the optical radiation source and the first location.

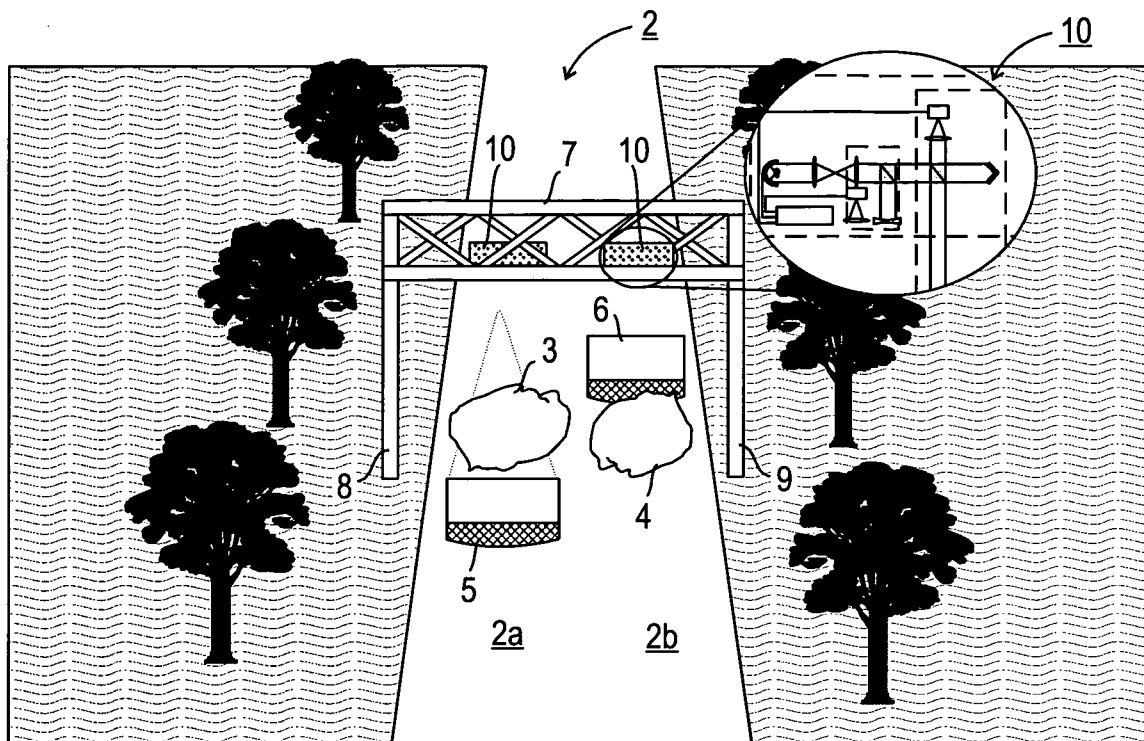


FIG. 1

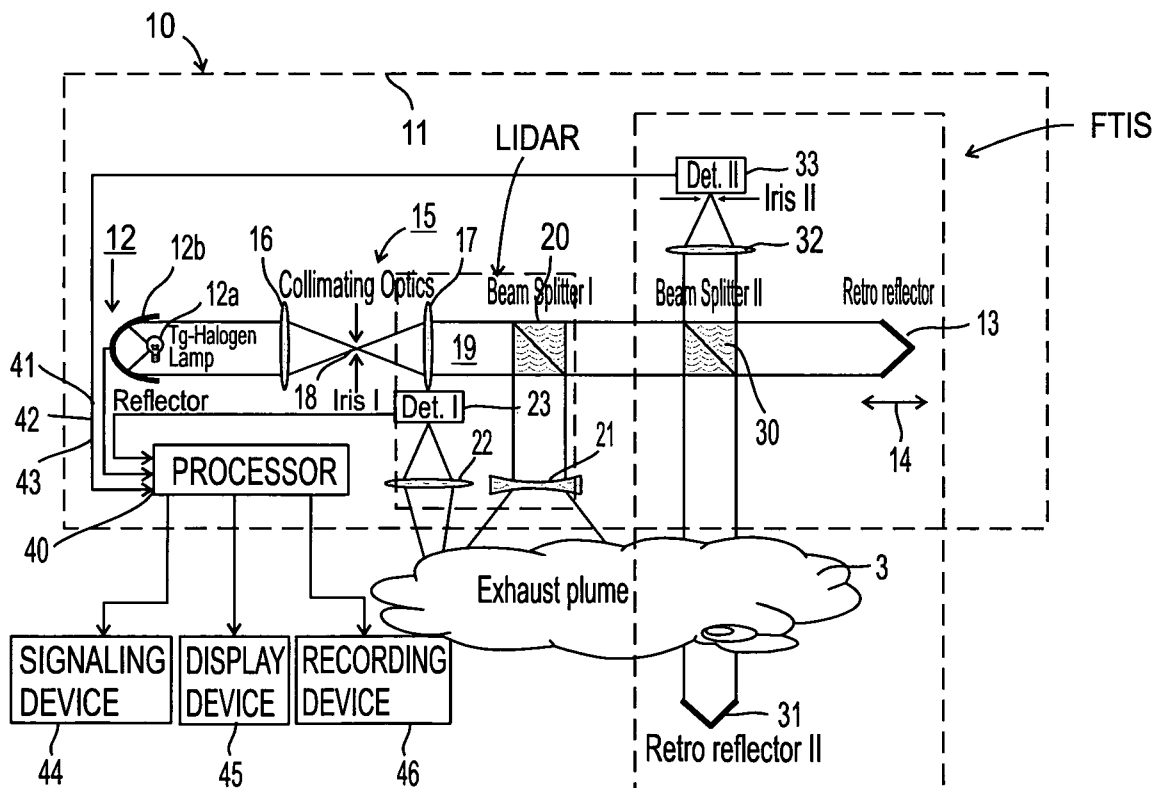


FIG. 2

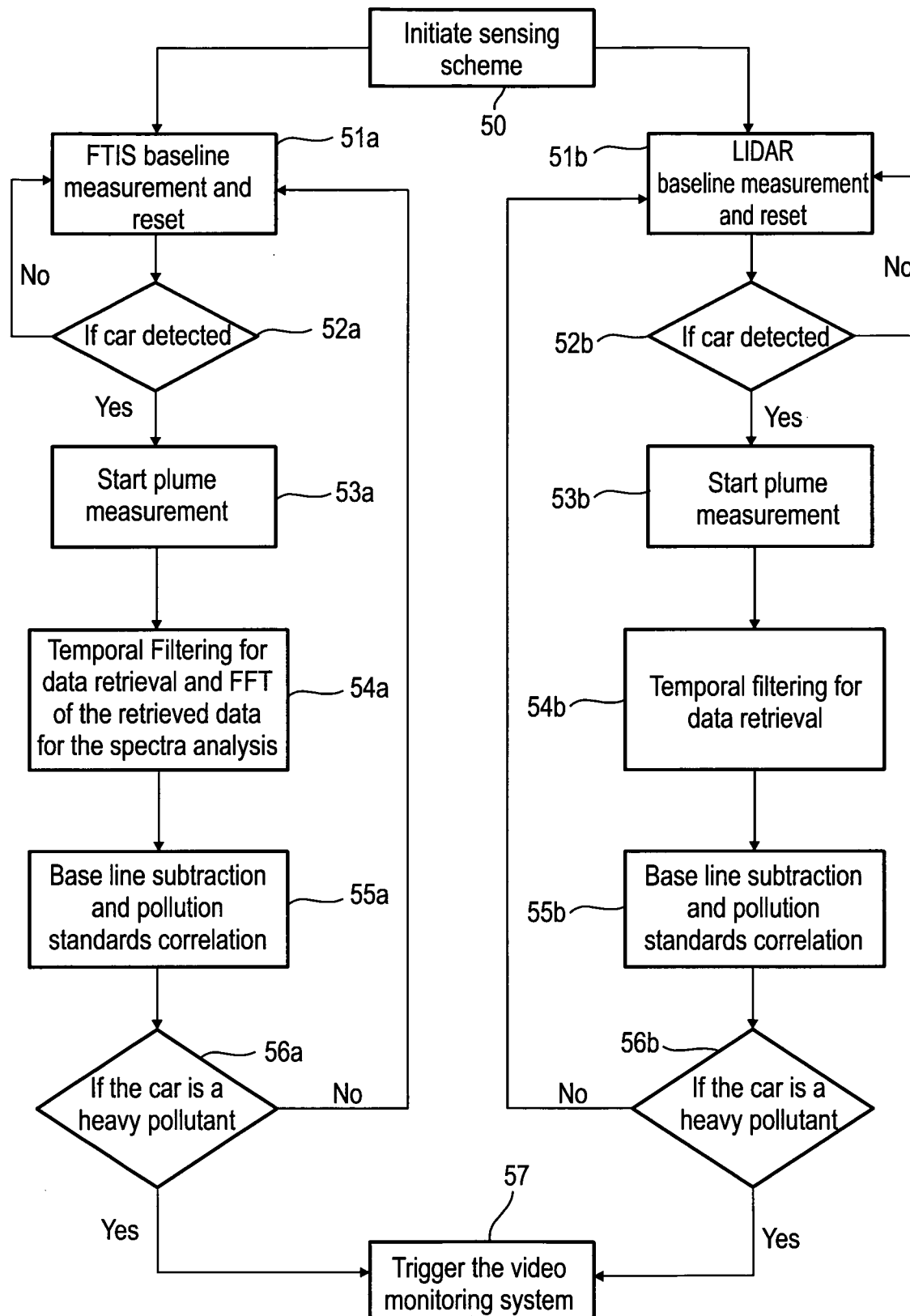


FIG. 3