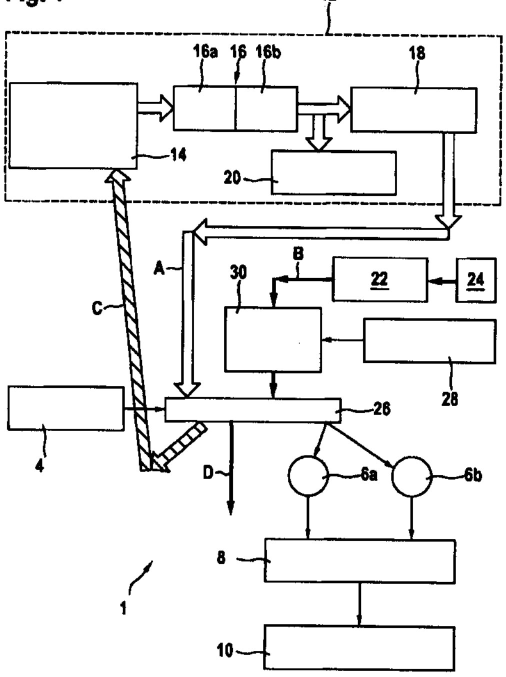
## ABSTRACT

# DEVICE FOR MEASURING A PARTICLE CONCENTRATION IN MOTOR VEHICLE EXHAUST GASES

0 6 JUN 2012

A device (1, 2, 3) for measuring a particle concentration in motor vehicle exhaust gases comprises a measurement chamber (26), which can be filled with a gas-particle mixture to be measured, at least one light source (4) and at least one light sensor (6a, 6b), wherein the light sensor (6a, 6b) is designed to detect light which is scattered by particles present in the gas-particle mixture, an exhaust gas feeding unit(22) designed to feed exhaust gases to be measured to the measurement chamber (26), a zero gas source (12) to provide a low-particle zero gas, and a switching element (30), which is disposed between the exhaust gas feeding unit(22) and the measurement chamber (26) and is suited for selectively allowing or preventing the feeding of the exhaust gases into the measurement chamber (26).


Fig. 1



I/We claim:

1. A device (1, 2, 3) for measuring a particle concentration in motor vehicle exhaust gases comprises:

a measurement chamber (26) filled with a gas-particle mixture to be measured;

at least one light source (4) and at least one light sensor (6a, 6b), wherein the light sensor (6a, 6b) is adapted to detect light which is scattered by particles present in the gas-particle mixture;

an exhaust gas feeding unit (22) adapted to feed exhaust gases to be measured to the measurement chamber (26);

a zero gas source (12) to provide a low-particle zero gas; and

a switching element (30) disposed between the exhaust gas feeding unit (22) and the measurement chamber (26), wherein the switching element (30) is suited for selectively allowing or preventing the feeding of the exhaust gases into the measurement chamber (26).

2. The device (2, 3) as claimed in claim 1, wherein a switching element (32, 34), which is disposed between the zero gas source (12) and the measurement chamber (26) is suited for selectively allowing or preventing the feeding of the zero gas into the measurement chamber (26).

3. The device (2, 3) as claimed in claim 2, wherein the switching element (32, 34) is a switchover element, which is designed such that it prevents the feeding of the exhaust gases into the measurement chamber (26), if it allows the feeding of the zero gas and permits the feeding of the zero gas into the measurement chamber (26), if it prevents the flow of the exhaust gases.

4. The device (1, 2, 3) as claimed in one of the preceding claims, wherein the zero gas source (12) has at least one filter (16).

5. The device (1, 2, 3) as claimed in one of the preceding claims, wherein the zero gas source (12) has at least one pressure sensor (20).

6. The device (1, 2, 3) as claimed in one of the preceding claims, wherein the device (1, 2, 3) has at least one pump (18).

7. The device (1, 2, 3) as claimed in claim 6, wherein a pump (18) is disposed upstream to the measurement chamber (26).

8. The device (1, 2, 3) as claimed in one of the claim 6 or 7, wherein a pump (18) is disposed downstream to the measurement chamber (26).

9. The device (1, 2, 3) as claimed in one of the preceding claims, wherein the zero gas source (12) is connected to the measurement chamber (26) such that zero gas flowing from the measurement chamber (26) is supplied to the zero gas source (12).

10. The device (1, 2, 3) as claimed in one of the preceding claims, which is configured to automatically perform a zero adjustment.

**Dated this 05th day of June 2012**

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**To**
**The Controller of Patents**
**The Patent Office at New Delhi**

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06 JUN 2012

**Fig. 1**

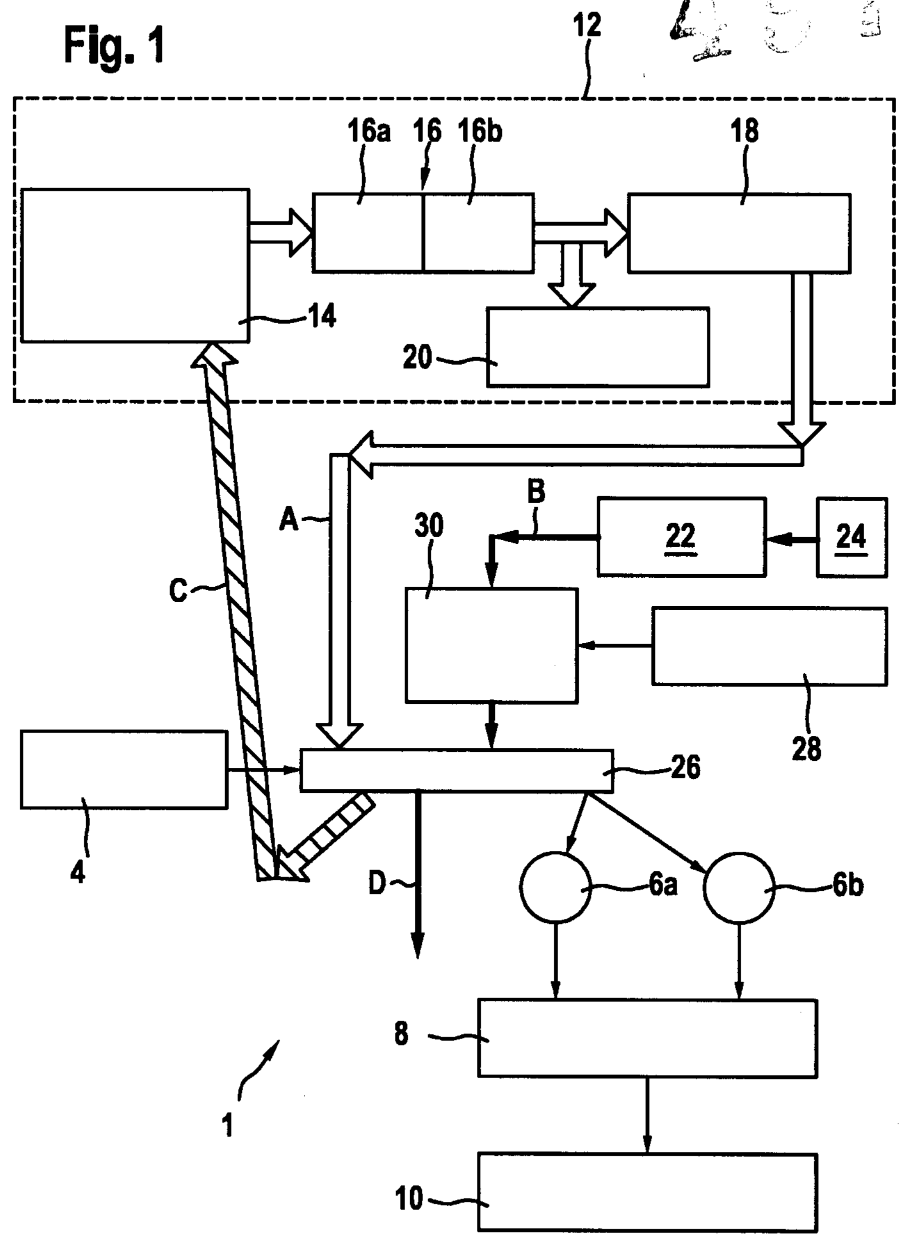


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**Fig. 2**

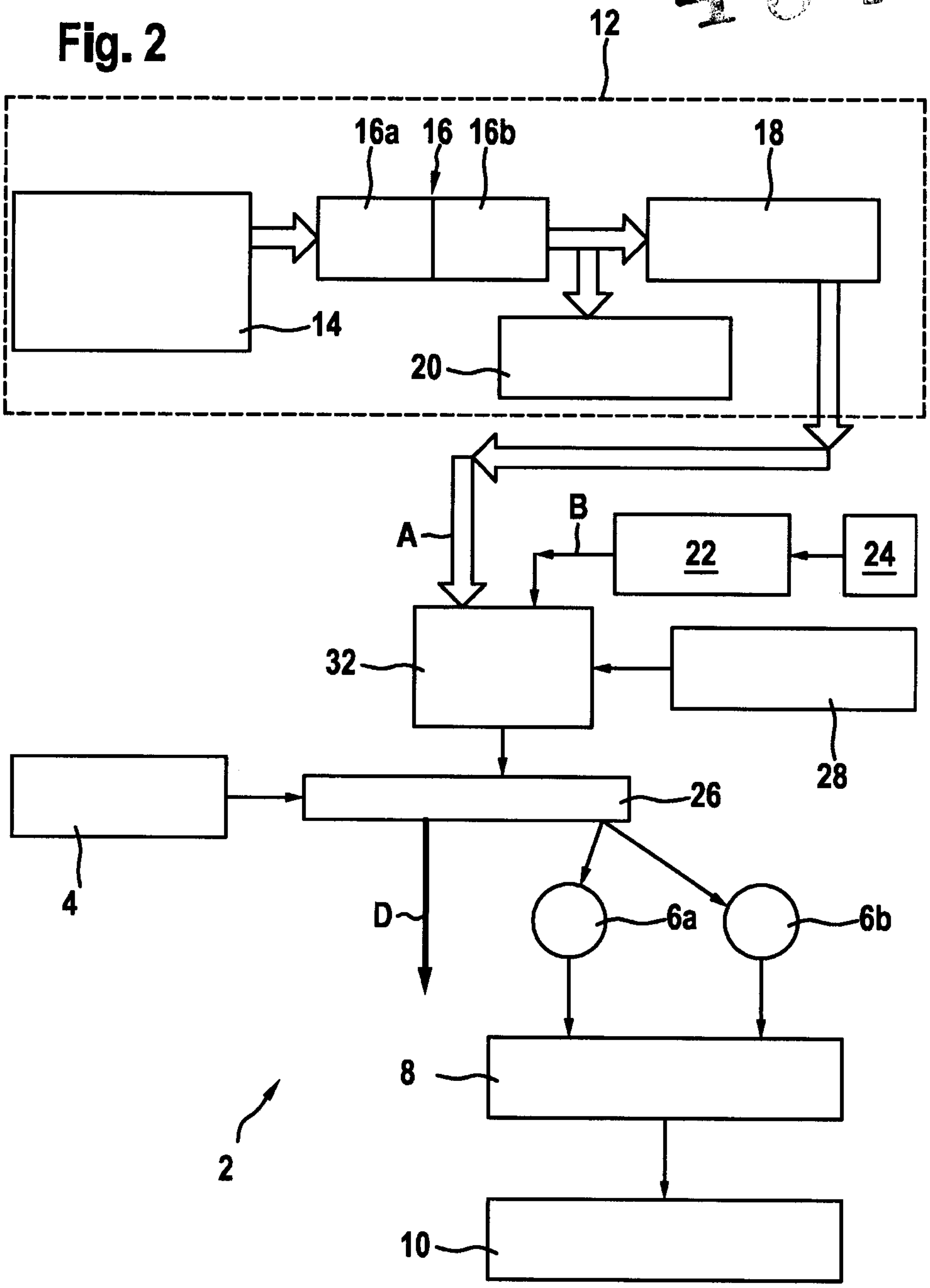


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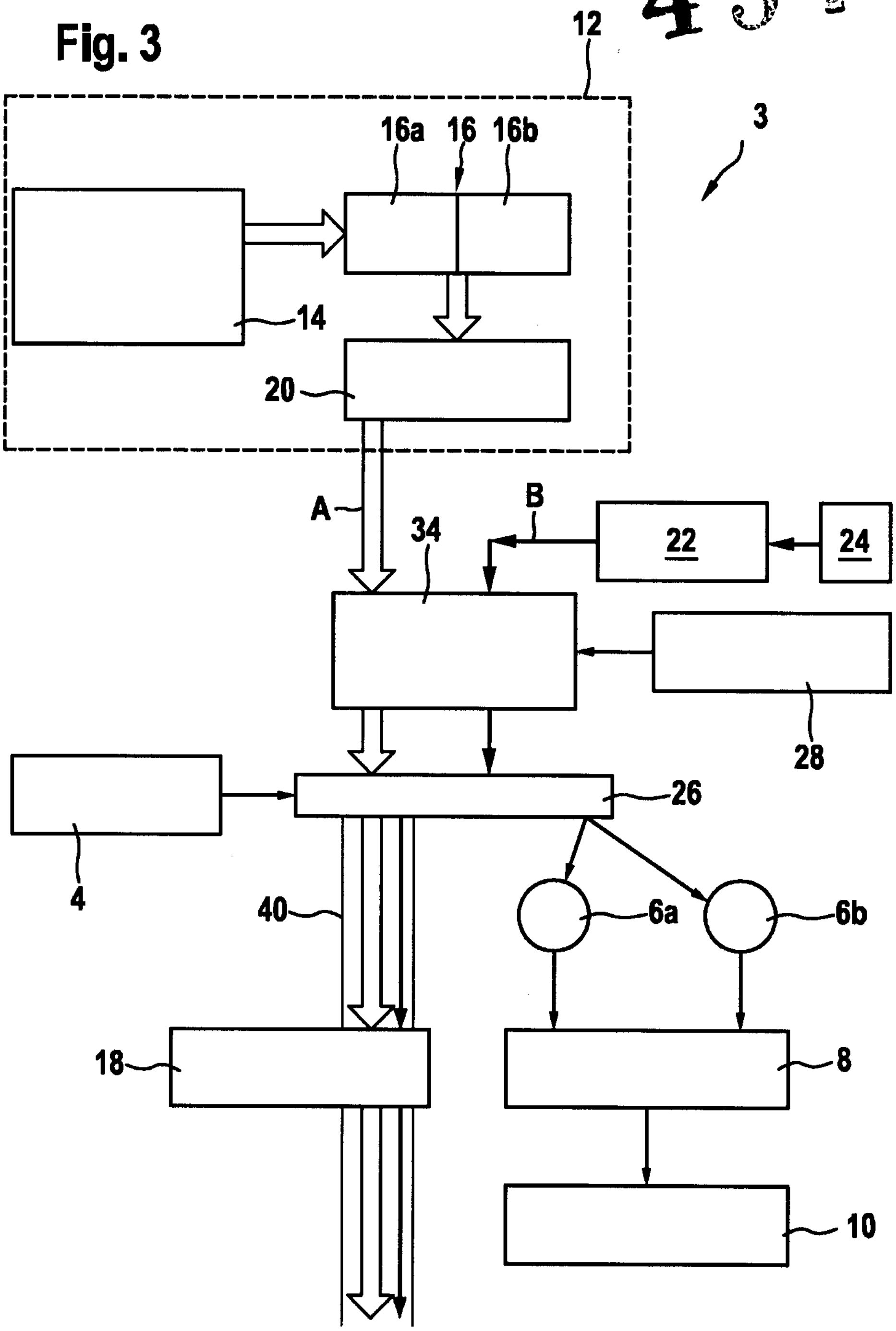
Fig. 3

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## TECHNICAL FIELD

The present subject matter relates to a device for measuring a particle concentration in motor vehicle exhaust gases.

## BACKGROUND

A scattered light method is often used for particulate measurement in exhaust gases and other colloids, wherein the colloid to be measured is passed through a measurement chamber. Here, for example, a laser is used as a light source such that the light emitted from the light source is scattered by particles that exist in the colloid. In addition, there exists at least one, and even better multiple light sensors, which detect light scattered by the particles (scattered light). The light sensors can be arranged at different angles with respect to an irradiation direction of light.

Fundamentally, the components involved, such as light source, light sensors and the electronic evaluation circuit of the sensor signals, have diverse offset and drift mechanisms, which take place invariant in time temporarily, are however usually very slow. These mechanisms include, for example, a temperature drift of the emitted light power from the light source, a drift of the sensors, a drift of the evaluation circuit, offset sizes of these components and aging effects. Apart from these measurement errors caused by these electronic components still other possible sources of errors are added with light scattering methods. Examples of these are reflections from the measurement chamber geometry, when the light source is switched on, even when there are no particles in the measurement chamber, and other signal components from particles, because the measurement chamber is filled with a medium, for example, a gas or ambient air, which contains a certain, though compared to exhaust gases, a smaller amount of particles.

In the case of test equipment used in workshops, the ambient air is often heavily polluted with particles and therefore affects the measurement accuracy significantly.

Particularly, if the emissions of modern motor vehicles with particulate filters are judged by the measuring equipment, which have a very low emission levels, the mechanisms described above have a major impact on the accuracy of measurement and diagnosis.

It is therefore require eliminating the aforementioned sources of error in order to measure the particle concentration in motor vehicle exhaust gases with high accuracy.

## SUMMARY

This summary is provided to introduce concepts related to a device for measuring a particle concentration in motor vehicle exhaust gases, and the concepts are further described below in the detailed description. This summary is neither intended to identify essential features of the claimed subject matter nor is it intended for use in determining or limiting the scope of the claimed subject matter.

In one embodiment, the subject matter disclosed herein describes a device for measuring a particle concentration in motor vehicle exhaust gases. The device includes a measurement chamber filled with a gas-particle mixture to be measured and include at least one light source and at least one light sensor, where the light sensor is adapted to detect light scattered by particles present in the gas-particle mixture. The device further includes an exhaust gas feeding unit adapted to feed exhaust gases to be measured to the measurement chamber, a zero gas source to provide a low-particle zero gas, and a switching element disposed between the exhaust gas feeding unit and the measurement chamber. The switching element is suited for selectively allowing or preventing the feeding of the exhaust gases into the measurement chamber.

## BRIEF DESCRIPTION OF DRAWINGS

Further advantages, features and details will emerge from the description below, in which with reference to the figures, various embodiments of the present subject matter are shown. Thereby, the characteristics mentioned in the claims and in the description can be essential for the present subject matter individually or in any combination, wherein:

Fig. 1 schematically shows a first embodiment of a measuring device, in accordance with the present subject matter.

Fig. 2 schematically shows an alternative embodiment of the measuring device.

Fig. 3 schematically shows a third embodiment of the measuring device.

## DETAILED DESCRIPTION

It is an object of the present subject matter to provide an emission measuring device for measuring at least a particle concentration present in vehicle exhaust gases, with which the particle concentration can be determined with high accuracy.

This object is achieved according to the present subject matter by a device for measuring a particle concentration in motor vehicle exhaust gas according to the independent patent claim 1.

The device for measuring a particle concentration in vehicle exhaust gases as described herein has a measurement chamber, which is filled with a gas particulate mixture (colloid) to be measured and has at least one light source and at least one light sensor, wherein the light sensor is formed in order to detect strewn light (scattered light) emitted from the light source and from the particles existing in the gas-particle mixture.

The device, in an embodiment, also includes an exhaust gas circulation unit and a zero gas source. The exhaust gas circulation unit is designed to direct the exhaust gas to be measured into the measurement chamber. A zero gas source is formed to supply a low-particle zero gas to the measurement chamber. A switching element, which is disposed between the exhaust gas circulation unit and the measurement chamber, is suited for selectively allowing or preventing the feeding of exhaust gas into the measurement chamber.

Through the present device with a switching element, which is suitable to prevent the feeding of exhaust gas into the measurement chamber, a zero adjustment can be easily accomplished without, for example, the need to remove and/or relocate the hoses. By the regular execution of the zero adjustment, the accuracy of the measurement results determined by the measuring device is improved.

Such a device also provides the ability to automatically perform the zero adjustment of the measurement system and thus automatically ensure sufficient accuracy of the measurement results.

In one embodiment, a switching element is provided, which is arranged between the zero gas source and the measurement chamber and is adapted to selectively permit or stop the feeding of zero gas into the measurement chamber. Because the feeding of zero gas into the measurement chamber during the measurement process can be shut off, the measurement can be performed more effectively and accurately, since the measurement results can not be corrupted by blended zero gas.

In one embodiment, the switching element is a switchover element, which is designed such that it prevents the flow of the exhaust gas into the measurement chamber, if the supply of the zero gas is permitted, and permits the feeding of the zero gas, if the feeding of the exhaust gas is prevented. In that optionally only the zero gas or exclusively the exhaust gas can be introduced into the measurement chamber, so that both the zero adjustment (only the zero gas in the measurement chamber) and the actual measurement (only the exhaust gas in the measurement chamber) are particularly effective and performed with high accuracy.

In one embodiment, the zero gas sources have at least one filter. Appropriate zero gas, particularly in a more economical way, can be provided through ambient air filtered with a filter.

In one embodiment, the zero gas source has a two-part filter. A two-part filter includes a coarse filter and a fine filter disposed downstream to the coarse filter, effectively filters the ambient air. The maintenance costs are reduced because the coarse and fine filter if required can be independently cleaned or replaced.

In one embodiment, the zero gas sources has at least one pressure sensor. By a pressure sensor, the pressure of the supplied zero gas can be monitored and is suitably set by a suitable control device. Moreover, the degree of contamination of the filter is determined by the determination of the pressure drop of the zero gas occurring at the filter.

In one embodiment, the zero gas source includes at least one pump. Using a pump, the zero gas can be supplied effectively into the measurement chamber.

In one embodiment, the pump is arranged in a flow direction behind the measurement chamber. If the pump is located downstream to the measurement chamber, after filling the measurement chamber with zero gas, by shutting off the zero gas feeding and continuing the operation of the pump, a negative pressure in the measurement chamber can be produced. Since the concentration of particles in a gas is proportional to its pressure, by lowering the pressure, the particle concentration in the zero gas can be lowered below the particle concentration in the measurement chamber. Thus the zero level is lowered and the sensitivity of the measuring device is improved.

In one embodiment, the zero gas source is connected to the measurement chamber in such a manner that the zero gas flowing from the measurement chamber is supplied to the air supply of the zero gas source. Thus, a closed circuit is made for the zero gas and the zero gas is used in a particularly effective manner. The zero gas is passed in the circuit repeatedly through the filter or filters, where the particle concentration in the zero gas can be lowered.

In one embodiment, the emission measuring device is arranged such that the zero adjustment is performed automatically. The automatic execution of zero adjustment ensures that the meter, independent of the habits of the user, who might miss out manual zeroing out of convenience, always provide sufficiently accurate results.

An automatic zero adjustment can be triggered after a predetermined number of measurements and/or at predetermined time intervals. The method may also be furnished such that a zero calibration is performed automatically when either a predetermined number of measurements have been reached or the time interval between two successive measurements exceeds a predetermined time interval, whichever criterion is met first.

The accuracy of the zero point adjustment needs to be secured over the intermediate period between two successive zero adjustments. Measurement error due to drift phenomena can be reliably prevented or minimized. In an extreme case, a zero adjustment can be performed automatically and necessarily before each measurement in order to obtain results with very high accuracy.

Embodiments of the present subject matter are described below with reference to the accompanying drawings.

The measuring device 1 shown in Fig. 1, according to a first embodiment of the present subject matter, includes a measurement chamber 26 with a light source 4, which is formed, for example, as laser and radiates light in the measurement chamber 26 during operation. The measurement chamber 26 is provided with two light sensors 6a, 6b.

In the schematic representation of Fig. 1, the light sensors 6a, 6b for reasons of clarity are shown outside of the measurement chamber 26, although in reality, are disposed at least partially within or at the measurement chamber 26. The light sensors 6a, 6b detect light emitted from light source 4, which is scattered by particles existing in the measurement chamber 26 (scattered light). The light sensors 6a and 6b are arranged such that they each detect light, which has been scattered in different angles.

The two light sensors 6a, 6b are connected to an evaluation unit 8, which evaluates the signals given by the light sensors 6a, 6b, and determines more particularly the particle concentration in the measurement chamber 26. The results of the evaluation are output via an output device 10. The output device 10 may include a display device (display), a printer, and/or a data interface, which is formed to transmit the results to the data processing or data storage device, for example a floppy disk or a USB stick.

The exhaust gases of a schematically illustrated motor vehicle 24, which are to be measured, is received by an exhaust gas probe 22, which is mounted in or on the exhaust of the motor vehicle 24, and is fed through an exhaust hose and a switching element 30 of the measurement chamber 26 (exhaust gas stream B). Before (upstream) or after (downstream) the measurement chamber 26, a pump (not shown in Fig. 1) may be provided to support the exhaust stream in addition to produce exhaust gas pressure from the engine of the motor vehicle 24.

The switching element 30 is connected to a control unit 28 and is switchable between an open state in which it allows flow of the exhaust gases from the motor vehicle 24 into the measurement chamber 26, and a closed state in which the flow of the exhaust gases from the motor vehicle 24 into the measurement chamber 26 is turned off. The control unit 28 is, for example, electrically, mechanically or hydraulically connected with the switching element 30, which is formed as a switching valve.

From the measurement chamber 26, the exhaust gases flow via a not shown exhaust gas recirculation device from outward (exhaust gas stream D), without contaminating or poisoning the immediate environment of the measurement chamber 26, for example, as a garage or a test site.

In an embodiment, the measuring device 1 additionally includes a zero gas source 12, which provides the so-called zero gas, i.e., gas with a particularly low particle concentration. The zero gas source 12 has an air supply 14, which receives air from the environment. The measuring device 1 is operated in a very polluted and/or dusty environment, such as a workshop, so the air supply 14 may be formed with a pipe or chimney in order to introduce the ambient air from a greater distance, such as outside the building. Alternatively, clean air can be taken from the delivered gas cylinders.

The air supply 14 supplies the ambient air received from a filter unit 16, which is adapted to reduce the particle concentration in the received air. For this purpose, the filter unit 16 comprises at least one fine filter 16b (for example a so-called HEPA filter), which is able to filter the supplied air so clean that the concentration of the particles that still remains in the zero gas after filtering is lower than the particle concentration in exhaust gases, which are supplied from a vehicle with a well-functioning gas-particle filter.

The fine filter 16b is connected upstream of a coarse filter 16a, which filters the very coarse particles from the air supplied before they get into the fine filter 16b, thus preventing a rapid contamination and/or clogging of the fine filter 16b. This allows that the maintenance intervals for replacement or cleaning of the filters 16a and 16b may be extended. Also, the coarse filter 16a and the fine filter 16b can be changed or cleaned separately in accordance with the actual requirements. Through these measures, the maintenance costs are reduced.

A pump 18 is provided downstream to the filter unit 16, which draws in ambient air through the air supply 14 and the filter unit 16 and outputs to the measurement chamber 26 (zero gas stream A).

A pressure sensor 20 is provided within the course of the air flow between the air supply 14 and the pump 18, which measures the pressure of the supplied air in the zero gas source 12 and passes the result to the control unit (not shown in the Fig. 1). The measured pressure can be used to control the pump 18 to ensure a sufficient zero gas stream A from the zero gas source 12 into the measurement chamber 26.

With a known power of the pump 18, the degree of contamination of the filter unit 16 may be concluded, from the pressure of air supplied to and/or from, the pressure drop occurring at the filter unit 16, since a large pressure drop occurs because of a dirty filter unit 16 as compared to a clean filter unit 16. If the pressure drop across the filter unit 16 exceeds a predetermined limit, a warning signal is outputted, which indicates the user that at least one filter of the filter unit 16 needs to be replaced. Also, the pump 18 is switched off on exceeding the predetermined limit value, which may be equal to or greater than the limit value at which a warning is issued, if the contamination of the filter unit 16 is so strong that a reliable functioning of the zero gas source 12 will no longer be ensured.

In addition, a second pressure sensor 20 may be located upstream between the air supply 14 and the filter unit 16.

In the embodiment shown in the Fig. 1, the zero gas flowing from the measurement chamber 26 is again supplied to the air supply 14 (zero gas backflow C). This results in a zero gas circuit in which the zero gas is passed repeatedly through the filter unit 16. Thus, the particle concentration in the zero gas can be reduced even further. In addition, the need for externally supplied gas is reduced, which is particularly advantageous when clean gas from gas cylinders is used the zero gas.

Before the actual measurement process, the control unit 28 controls the switching element 30 in such a way that no exhaust gas flows from the motor vehicle 24 into the measurement chamber 26.

The pump 18 is switched on, so that zero gas from the zero gas source 12 filtered through the filter unit 16 flows into the measurement chamber 26.

A zero adjustment of the measurement chamber 26 carried out by switching on the light source 4 and evaluating the signals output by the light sensors 6a, 6b, which scatters the light based on the particles in the measurement chamber 26 and collected by the light sensors 6a, 6b.

After the zero adjustment has been performed, the control unit 28 controls the switching element 30 in such a way that the supply of the exhaust gases from the motor vehicle 24 into the measurement chamber 26 is opened and the exhaust gases from the combustion vehicle 24 can flow through the measurement chamber (exhaust gas stream B, C), so that the particle concentration can be measured in the exhaust gases. Alternatively, the switching of the switching element 30 may take place mechanically by an operator. In this case, a motor for switchover of the switching element 30 can be omitted.

In the embodiment shown in the Fig. 1, the zero gas stream A during the measurement of particle concentration in the exhaust gases will not be switched off. The zero gas from the zero gas source 12 flows simultaneously with the exhaust gases to be measured through the measurement chamber 26. Here, the zero gas is guided as a purge gas directly in front of the sensors 6a, 6b and/or along the light exit opening of the light source 4 in order to prevent the contamination of the sensors 6a, 6b and the light exit opening by the deposition of particles from the exhaust gas stream B.

Fig. 2 schematically shows an alternative embodiment of the measuring device 2.

The structure of this measuring device 2 according to the second embodiment substantially corresponds to the embodiment shown in the Fig. 1. The same elements are given the same reference numerals and are not described again as far as they correspond in structure and function with the first embodiment.

The measuring device 2, according to the second embodiment, differs from the measuring device 1 of the first embodiment, where a switching element 32 is formed as a switchover element, so that the gas supply into the measurement chamber 26 can be switched between the combustion gases from the motor vehicle 24 and the zero gas from the zero gas source 12. This means that during the measuring process, when the exhaust gases are guided from the motor vehicle 24 into the measurement chamber 26, in order to determine the particle concentration in the exhaust gases, the zero-gas from the zero gas source 12 does not flow into the measurement chamber 26. Similarly, during the zero adjustment, when the zero gas is guided from the zero gas source 12 to the measurement chamber 26, no exhaust gas flows through the measurement chamber 26.

During the measuring process, no zero gas flows into the measurement chamber 26, by which a dilution of the exhaust gases of the motor vehicle 24 is avoided in the measurement chamber 26 and also a low particle concentration in the exhaust gases can be determined with high accuracy.

Fig. 3 shows a third embodiment of an inventive measuring device 3.

Here too, the elements having the same structure and the same function as in the previously shown embodiments not described again.

The measuring device 3, according to the third embodiment, differs from the previously shown measuring devices 1, 2, where the pump 18, which is provided for delivery of the zero gas, is not within the zero gas source 12 upstream to the measurement chamber 26 but is disposed downstream to the measurement chamber 26 in an exhaust pipe 40, which is provided to remove the exhaust gases from the measurement chamber 26.

In this embodiment, the pump 18 supplies the zero gas from the zero gas source 12 by suction of the zero gas through the measurement chamber 26. At the same time, the pump 18 supports the exhaust gas stream B from the motor vehicle 24 through the measurement chamber 26 when it is operated during the measurement process.

In the third embodiment shown in the Fig. 3, a switching element 34 is designed such that it, unlike in the previous second embodiment shown, can switch not only between the zero gas stream A and the exhaust gas stream B, but also provide adjustment, in which both the supply the exhaust gas stream B and the supply of the zero gas stream A are switched off.

By simultaneously shutting the supply of the zero gas and the exhaust gases with simultaneous operation of the pump 18, a negative pressure can be produced in the measurement chamber 26. Since the particle concentration in a gas volume is proportional to its pressure, the particle concentration in the measurement chamber 26 can be reduced even further by lowering the pressure or generating a negative pressure in the measurement chamber 26. Thus, a lower zero level of the measuring device 3 is reached and a recognition threshold for particles in the exhaust gas stream B can be lowered even further. As a result, the accuracy achievable with the measuring device 3 can be further increased.

Each of the measuring devices 1, 2, 3 shown in the three embodiments can be advantageously formed such that a measurement can be performed only if a zero adjustment has been performed previously. Particularly, the measuring devices 1, 2, 3 may be formed such that a zero adjustment is automatically performed before each measurement. Thus, it is prevented that a necessary zero adjustment is not implemented due to forgetfulness or convenience of the operator and a measurement is performed, which provides wrong results of measurement due to the lack of zero adjustment.

A measuring device that performs the automatic zero adjustment provides highly reliable measurement results with the best possible accuracy.