(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 085 251 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.10.2016 Bulletin 2016/43

(51) Int Cl.:
A24C 5/34 *(2006.01)* ***A24F 47/00*** *(2006.01)*

(21) Application number: **16155806.9**

(22) Date of filing: **23.04.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
15001217.7 / 3 085 250

(71) Applicant: **Fontem Holdings 1 B.V.**
1083 HN Amsterdam (NL)

(72) Inventors:
- **Borkovec, Vaclav**
  22761 Hamburg (DE)
- **Gonzales, Diego**
  10243 Berlin (DE)
- **Channon, Joanne Louise**
  Cambridge, CB4 0DW (GB)
- **Smith, Simon James**
  Cambridge, CB4 0DW (GB)

(74) Representative: **Gulde & Partner**
Patent- und Rechtsanwaltskanzlei mbB
Wallstraße 58/59
10179 Berlin (DE)

Remarks:
This application was filed on 16-02-2016 as a divisional application to the application mentioned under INID code 62.

(54) PROCESS OF TESTING AN ELECTRONIC SMOKING DEVICE

(57) In a process of testing an electronic smoking device, in particular an electronic cigarette, process of testing an electronic smoking device, an electronic smoking device (2) to be tested is mounted at an inlet port (12) of a testing apparatus (20; 10). Puffs are exerted at the electronic smoking device (2), using the testing apparatus, each puff being defined by a puff sequence comprising an inhalation period and an exhalation period. At least one optical property of aerosol (22) deriving from the electronic smoking device (2) is measured in an optical measurement device (20), which is part of the testing apparatus. The optical measurement device (20) comprises a light source (24), preferably a laser or an LED source, and at least one detector (28) arranged for measuring the scattering of light emitted from the light source (24) and passing through the aerosol (22). Said detector (28) is arranged at a scattering angle with respect to a straight light path from the light source (24). The scattering angle is preferably in the range of from 60° to 120°, and, as an optical property, a signal at said detector (28) is determined.

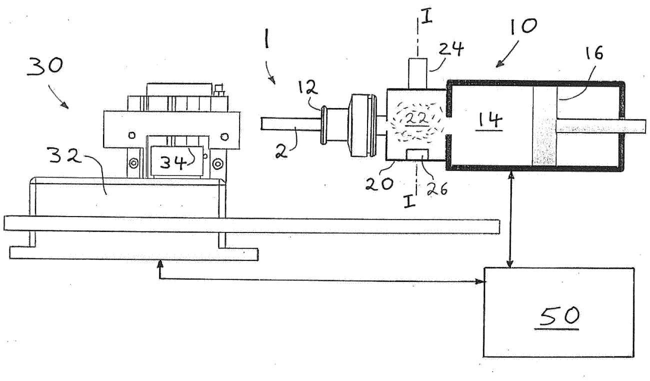

Fig. 1

EP 3 085 251 A1

Description

[0001] The invention relates to a process of testing electronic smoking devices, in particular electronic cigarettes.

[0002] An electronic smoking device, such as an electronic cigarette, usually has a housing accommodating an electric power source (e.g., a battery or a rechargeable battery), an electrically powered atomizer adapted to atomize a liquid supplied from a reservoir in order to provide an aerosol exiting from the atomizer, and control electronics which controls the activation of the atomizer. The requirement to generate an aerosol is indicated or signalled to the control electronics by an aerosol initiation unit, which is typically designed as a puff detector which detects a user puffing on the device (e.g., by sensing an under-pressure or an air flow pattern through the device) or as a simple push button pressed by the user. When the requirement to generate a puff is signalled to the control electronics by the aerosol initiation unit, the atomizer is powered, which causes the creation of aerosol. This action of the atomizer is referred to "atomization" or "atomizing" and the related product is called "aerosol", irrespective of its composition, which might include gaseous and smoke constituents. Related disclosures can be found, for example, in document US 2014/0300480 A or EP 1 403 432 A.

[0003] In such devices liquid to be atomized may be contained in a reservoir, which may be designed as a capsule containing the liquid. In some devices, the reservoir is included in a cartridge which also contains the atomizer. Such combination is sometimes called a "cartomizer".

[0004] The development of an electronic smoking device requires much testing. Conventional tobacco cigarettes can be tested by a smoking machine, which mimics users inhaling puffs and sucks up the aerosol emerging from the cigarettes mounted at an entrance port of the machine. In principle, a smoking machine for testing conventional tobacco cigarettes could also be used in testing electronic smoking devices.

[0005] Weight loss testing is the current standard for a quick evaluation of the performance of an electronic cigarette regarding the quantity of aerosol produced or dosed to the consumer. Weight loss is not synonymous with aerosol density (vapour density) due to the possible distributions of particle sizes in the aerosol in the visible and non-visible range, but the weight loss occurring during the course of aerosol production can be used to distinguish between good and bad performance within the tolerances of a single product.

[0006] Currently, the weight loss due to the aerosol emerging from an electronic smoking device is measured largely manually, which is very time-consuming and labour-intensive. An operator is required to supervise a smoking machine smoking an electronic cigarette while recording the weight (mass) of the electronic cigarette, in the ideal case, after every puff. However, because of the high labour and rapid response required to deal with the settling time of a precise scale, it is virtually impossible to determine the weight after every puff and within a puff duration of 30 s, as stipulated by CORESTA guidelines. Instead of that, the electronic cigarette is usually weighed after a certain number of puffs, and the resulting weight loss is then divided by this number. Typically, blocks of 10, 25 or 50 puffs are used, depending on the capacity of the set-up and on what resolution the results are required to show.

[0007] By weighing in blocks, any puff-by-puff variation is not visible in the results, which means that uniformity of dose (aerosol-per-puff delivery) cannot be measured precisely. There is also a lot of variation with human-operated procedures in general, which might impede the reproducibility of the results.

[0008] The object of the invention is an improvement in the process of testing electronic smoking devices, in particular electronic cigarettes.

[0009] This object is achieved by the process of testing an electronic smoking device according to claim 1. Advantageous versions of the invention follow from the dependent claims.

[0010] The disclosure further relates to an improvement in the process of testing electronic smoking devices, so that the weight loss of an electronic smoking device in the course of smoking can be monitored in an easy and precise way and can be evaluated with respect to other properties of the electronic smoking device.

[0011] In the process of testing an electronic smoking device (in particular an electronic cigarette), an electronic smoking device to be tested is mounted at an inlet port of a smoking apparatus. The smoking apparatus repeatedly exerts puffs at the electronic smoking device, wherein each puff is defined by a puff sequence comprising an inhalation period and an exhalation period. In an optical measurement device, optical properties (i.e., at least one optical property) of aerosol deriving from the electronic smoking device are measured. The actual mass of the electronic smoking device may be repeatedly determined by means of an automatic transport and weighing system, wherein the electronic smoking device is removed from the inlet port after the inhalation period of a puff has ended, is transported to a precision balance, is weighed by means of the precision balance, is transported back to the inlet port, and is mounted back at the inlet port before the inhalation period of the next puff starts.

[0012] The automatic transport and weighing system allows the quasi continuous monitoring of the mass of the electronic smoking device during the course of smoking. In particular, it is possible that the actual mass of the electronic smoking device is determined for each puff. The puff sequence, which usually consists of the inhalation period, a hold period, the exhalation period, and a pause, may have a total duration, for one puff, in the range of from 15 s to 60 s, preferably in the range of from 20 s to 40 s or of from 25 s to 35 s. This includes a duration of 30 s, as stipulated in CORESTA guidelines.

[0013] Within the period starting at the end of the inhalation period and ending at the end of the pause (or with the beginning of the inhalation period of the next puff), the automatic transport and weighing system is able to remove the electronic smoking device from the inlet port, transport it to the precision balance, weigh it, and bring it back and mount it at the inlet port. The weighing time also involves some time (typically about 5 s) in order to wait until the precision balance has settled after the electronic smoking device has been placed on the balance and a precise reading is possible. It may totally take about 15 s in order to transport the electronic smoking device back and forth. Thus, the total time required for the inhalation period and for transporting and weighing the electronic smoking article may be less than, e.g., 30 s, which permits the determination of mass for each puff and, consequently, a precise testing.

[0014] A suitable precision balance is commercially available. It may indicate the weighing results, e.g., with four significant figures or with an accuracy of 1 mg or even better. The weighing results may be transmitted, in digital form, to a data processing system.

[0015] The optical measurement device may be arranged between the inlet port and an intake chamber of the smoking apparatus so that the optical measurement device is passed by the aerosol. Apart from the optical measurement device, the smoking apparatus can be a conventional smoking apparatus, a modified conventional smoking apparatus, or a custom-made smoking apparatus. The volume of the intake chamber may be changed (e.g., by means of a reciprocating piston) in synchronisation with the puff sequence.

[0016] In the process of testing an electronic smoking device, measured optical properties of aerosol can be correlated to the loss of mass of the electronic smoking device occurring between subsequent determinations of the actual mass of the electronic smoking device. For example, it may be desirable to produce as much visible aerosol as possible from a given amount (mass) of liquid to be atomized, i.e. the ratio of visible aerosol to mass loss is to be optimised. This ratio depends on the size, concentration and distribution of the aerosol particles, which is complex and expensive to measure using conventional methods. To find an appropriate liquid or appropriate operating conditions for the atomizer of the electronic cigarette, the electronic cigarette has to be extensively tested while parameters as, e.g., the composition of the liquid or the temperature of the atomizer are varied. Applying the process according to the invention, such measurements can be automatically and easily performed, wherein the visibility of the aerosol created in a puff can be estimated via optical properties of the aerosol, and the loss of mass due to liquid consumption and aerosol creation can be determined by weighing, e.g. for each individual puff.

[0017] The optical measurement device comprises a light source, e.g. a laser or an LED source, and at least one detector arranged for measuring the attenuation and/or scattering of light emitted from the light source and passing through the aerosol (or part of the aerosol). For example, a first detector may be arranged opposite to the light source and a second detector may be arranged at an angle to the line connecting the light source and the first detector, e.g. at an angle representing a scattering angle of 90° or another scattering angle. In this case, the first detector can be used to measure the attenuation (absorption) caused by the aerosol, and in the absence of aerosol it provides a measure for the intensity of the light source. Measuring the intensity of the light source by means of the first detector is generally more precise than assuming a certain intensity based on power input values. The second detector is not hit by directly emitted light but by light scattered by the aerosol particles. The signal of the second detector provides a measure for the visibility of the aerosol. The optical measurement device may be designed as a modular device.

[0018] More generally, as an optical property, a signal at the second detector may be determined. In this context, the term "signal" is to be understood in a broad sense. It also relates to, e.g., a noise-corrected signal (e.g. obtained by subtracting, from the signal measured at the second detector with aerosol present in the optical measurement device, a background signal measured at the second detector without aerosol) and/or to a signal normalised to a signal representing the intensity of the light source (the latter obtained, e.g., by means of the first detector when no or only very little aerosol is present in the optical measurement device). Or an actual detector output can be integrated over a given time interval. Other options include the selection of certain frequency ranges, e.g. by optical filters in front of the detectors or in front of the light source. The light source preferably emits light at visible frequencies and/or in the infrared range. A person skilled in the art knows how to obtain meaningful data signals.

[0019] It is useful to have a calibration step between each puff, which re-defines the maximum signal at the first detector (light source on, no aerosol). Similarly, a minimum signal at the first detector can be measured (light source off, no aerosol) to determine when the optical measurement device needs to be cleaned from condensation that can occur on the light source or on the detectors. This allows the calculation of a "calibration coefficient" as the difference between the maximum signal and the minimum signal. When the calibration coefficient falls below a certain value, the optical measurement device must be cleaned. The calibration coefficient can also serve as a measure of reproducibility.

[0020] The optical measurement device may be prone to becoming coated in condensate during intensive use. This can be counteracted by a quick-cleaning step using a vacuum pump to clear away lingering aerosol in the optical measurement device, for example during the hold period of the puff sequence if there are no optical measurements performed.

[0021] Thus, the results of the optical measurements can provide a measure for the actual aerosol density, which then can be correlated with the actual weight loss (i.e. the mass of the aerosol of the actual puff) determined by means of the precision balance to give information about what influences the particle size distribution depending on the design of the electronic smoking device. This knowledge can be used to modify the visible characteristics of the aerosol, as well as the nicotine uptake efficiency.

[0022] Optical measurements can be performed, using the optical measurement device, on aerosol exiting from the electronic smoking device during the inhalation period of a puff. Moreover, optical measurements can be performed, using the optical measurement device, on aerosol exiting from the intake chamber during the exhalation period of a puff. The presence of the aerosol in the intake chamber roughly mimics the presence of aerosol in, e.g., a human mouth. To this end, it will be advantageous if the temperature in the intake chamber is controlled, e.g. to be maintained at about 37°C. In the intake chamber, part of the aerosol decays through coagulation and condensation so that the ratio of an "inhale signal" (e.g., a signal at the second detector, see above, measured during the inhalation period) to an "exhale signal" (e.g., a signal at the second detector, see above, measured during the exhalation period) provides a meaningful information, designated as vapour decay coefficient.

[0023] The smoking apparatus can also comprise further measurement equipment like sensors, detectors or other devices. If a conventional smoking apparatus is used, such equipment can be mounted in the apparatus or as attachments.

[0024] The transporting means of the automatic transport and weighing system can be designed in various different ways. For example, a robotic arm having various degrees of freedom and comprising a grasper may be used, controlled by a computer system and optionally involving sensor signals.

[0025] In other embodiments, the automatic transport and weighing system comprises at least two slides moving along axes arranged transversely to each other, preferably perpendicularly to each other. One of the slides may comprise a support for an electronic smoking device, which moves downwardly for placing the electronic smoking device onto the precision balance before weighing and moves upwardly for taking up the electronic smoking device from the precision balance after weighing. A holding device may hold the electronic smoking device when the electronic smoking device is removed from and mounted back at the inlet port and may release the electronic smoking device when the electronic smoking device is placed on the precision balance.

[0026] The set-up for running the process according to the invention may also comprise a manual-button activation device such that manually operated electronic cigarettes requiring a push-button to activate the atomizer can be tested automatically by the set-up. This activation device may include a magnetically driven rod which pushes against the push-button while a robotic gripper immobilises the electronic cigarette at the inlet port. To improve stability, a sleeve may be used which encases the electronic cigarette and distributes the force of the rod against the push-button. This would also allow to work with push-buttons coated in a soft rubber-like material.

[0027] The process according to the invention can be controlled by a computer system having a user interface. Generally, this easily permits modifications in the process. Preferably, the data or part of the data acquired in the process is stored, e.g. in the computer system used for controlling the process or elsewhere.

[0028] The optical measurement device can also be used in a testing apparatus which does not comprise an automatic transport and weighing system, because scattering measurements on aerosol produced by an electronic smoking device provide valuable information, even without a correlation to the weight loss of the electronic smoking device.

[0029] To this end, in a process of testing an electronic smoking device, an electronic smoking device to be tested is mounted at an inlet port of a testing apparatus. Puffs are exerted at the electronic smoking device, using the testing apparatus, wherein each puff is defined by a puff sequence comprising an inhalation period and an exhalation period. At least one optical property of aerosol deriving from the electronic smoking device is measured in an optical measurement device, which is part of the testing apparatus. The optical measurement device comprises a light source, preferably a laser or an LED source, and at least one detector arranged for measuring the scattering of light emitted from the light source and passing through the aerosol. This detector is arranged at a scattering angle with respect to a straight light path from the light source, e.g., a scattering angle in the range of from 60° to 120°, but other scattering angles are possible as well. As an optical property, a signal at this detector is determined.

[0030] In this context, the testing apparatus may comprise a smoking apparatus and may also comprise an automatic transport and weighing system. On the other hand, the testing apparatus may essentially consist of the optical measurement device and related components (like external electronics and/or pumping devices) only. In the latter case, a testing person can exert puffs so that aerosol enters the optical measurement device, where it is analysed by scattering of light. Preferably, the optical measurement device is modular and designed in such a way that it can be easily removed from the rest of any apparatus so that it can also be used as a stand-alone device.

[0031] The detector arranged at a scattering angle corresponds to the second detector described further above. It is possible that several detectors are used for measuring scattered light, e.g. detectors mounted at different scattering angles and/or detectors which are sensitive at different wavelength ranges.

[0032] The optical measurement device may further comprise a detector arranged opposite to the light source, in the straight light path, which is arranged for measuring the attenuation of light emitted from the light source and passing through the aerosol. This detector corresponds to the first detector described above.

[0033] As explained before, optical measurements can be performed, using the optical measurement device, on aerosol exiting from the electronic smoking device during the inhalation period of a puff and/or on aerosol entering the optical measurement device during the exhalation period of a puff.

[0034] Generally, the light source of the optical measurement device can be arranged so that it is removable, preferably easily removable. This enables an easy replacement or exchange of the light source. In particular, the light source can be selected depending on the desired wavelengths of the light emitted. When investigating an aerosol, light of wavelengths similar to the size of the droplets present in the aerosol is particularly useful because it is relatively strongly scattered. For example, assuming an average droplet size in the order of 500 nm, wavelengths ranging from about 400 nm to 900 nm would be appropriate. In this case, an easily available LED light source of 850 nm may be used. In an aerosol having different droplet sizes, a different light source might be more appropriate.

[0035] In the following, the invention is further explained by means of an embodiment. The drawings show in

Figure 1 a schematic diagram illustrating an embodiment of a set-up used for running the process according to the invention,

Figure 2 a schematic cross section through an optical device included in the set-up of Figure 1, in a plane indicated by axis I-I in Figure 1, and

Figure 3 a schematic three-dimensional visualisation of an automatic transport and weighing system used in the set-up of Figure 1.

[0036] In Figure 1, an embodiment of a set-up 1 used for running the process of testing an electronic cigarette 2 is illustrated in a schematic diagram.

[0037] The set-up 1 comprises a smoking apparatus 10 including an inlet port 12. At the inlet port 12, the electronic cigarette 2 can be mounted in the area of its mouth-sided end so that it is safely supported. A gasket (or an array of gaskets) at the inlet port 12 prevents aerosol exiting from the electronic cigarette 2 from escaping to the environment. The smoking apparatus 10 includes an intake chamber 14, the volume of which can be changed (increased and decreased) by means of a piston 16.

[0038] An optical measurement device 20 is arranged between the inlet port 12 and the intake chamber 14. By definition, the optical measurement device 20 is regarded as a part of the smoking apparatus 10. Alternatively, it could be considered as a separate component operated in conjunction with a smoking apparatus, e.g. a conventional smoking apparatus.

[0039] Figure 2 shows the optical measurement device 20 in a schematic cross-sectional view, in a plane indicated in Figure 1 by the axis I-I and perpendicular to the plane of the paper in Figure 1. Aerosol 22 emerging from the mouth-sided end of the electronic cigarette 2 and passing through the inlet port 12 (or returning from the intake chamber 14 into the optical measurement device 20, see below) spreads inside the casing of the optical measurement device 20. Light emitted by a light source 24 (preferably a laser or an LED, e.g. working in the visible or infrared wavelength range) is partially absorbed by the aerosol, which can be sensed by a first detector 26 mounted opposite to the light source 24. The first detector 26 can also be used for measuring the intensity of the light source 24, in particular when no or only very little aerosol 22 is present in the optical measurement device 20. Moreover, the aerosol scatters light out of this direct light path so that the scattered light can be detected under an angle relative to the straight light path by a second detector 28. In the embodiment, the second detector 28 is mounted at a scattering angle of 90°, but it may also be adapted to be fixed in different positions in order to measure scattered light at different scattering angles.

[0040] In the embodiment, the inlet port 12 is connected to the optical measurement device 20 via a short piece of silicone tubing, which runs through the actuator area of a first pinch valve (not shown in the figures). During the control of the process, the first pinch valve is operated to open and close the inlet of the optical measurement device 20. A second pinch valve acting onto another silicon tube is mounted at the casing of the optical measurement device 20 to permit a controlled exhaust of the aerosol. A vacuum pump can be used to remove the rests of the aerosol and to keep the set-up 1 clean from aerosol or its remnants.

[0041] Moreover, the set-up 1 comprises an automatic transport and weighing system 30, see Figure 1 and in particular Figure 3. This system 30 is able to transfer the electronic cigarette 2 from the inlet port 12 to a precision balance 32, where the actual mass of the electronic cigarette 2 is determined, and to bring the electronic cigarette 2 back to the smoking apparatus 10 and re-mount the electronic cigarette 2 to the inlet port 12. To facilitate the handling of the electronic cigarette 2 in the process, it can be partially surrounded by a sleeve device adapted in shape to the particular design of the electronic cigarette 2. This sleeve device is not displayed in the figures.

[0042] In the state shown in Figure 3, a weighing tray 34 of the precision balance 32 is surrounded by a support 36 which safely holds the electronic cigarette 2 by means of two notches (not shown in the figure). An adjustable backstop 38 can be moved in x direction, back and forth. It serves to ensure a correct position of the electronic cigarette 2 in x direction.

[0043] The support 36, which is designed as a slide, is mounted at a slide 40 so that it can be moved up and down, in z direction. In the embodiment, the support 36 is not moved in y direction because the center of the weighing tray 34 is aligned with the inlet port 12 along the x axis. In other designs, an additional degree of freedom for movement in y direction may be useful, however. When the support 36 is moved upwardly, it finally arrests the electronic cigarette 2 by means of two prongs 42 which, e.g., may enter into indents of the sleeve device mentioned above. In this state, the center axis of the electronic cigarette 2 aims at the center of the inlet port 12. The slide 40 can be moved in parallel to the x axis. To this end, it is arranged at a guide 44.

[0044] The set-up 1 is controlled by a computer system 50 having a user interface, which also includes a data storage, see Figure 1.

[0045] To run a process of testing an electronic cigarette, the electronic cigarette 2 can be initially mounted at the inlet port 12 by inserting the mouth-sided end of the electronic cigarette 2 into the gasket provided at the inlet port 12. This step can be performed by placing the electronic cigarette 2 on the support 36 and operating components of the automatic transport and weighing system 30, see above. Before initially mounting the electronic cigarette 2 at the inlet port 12, it is also possible to determine its mass by means of the precision balance 32, in an analogous way as described below in detail.

[0046] With the first pinch valve open and the second pinch valve closed, the piston 16 is moved to increase the volume of the intake chamber 14, and a puff detector included in the electronic cigarette 2 senses the resulting vacuum and initiates the creation of aerosol by operating an atomizer inside the electronic cigarette 2. The liquid used for generating the aerosol is supplied from a cartridge arranged in the electronic cigarette 2. If the electronic cigarette 2 comprises a manually actuatable switch for initiating the creation of aerosol instead of a puff detector, this switch can be operated by, e.g., a magnetically driven actuator mounted at the set-up 1.

[0047] The aerosol passes through the optical measurement device 20, where it can be investigated by means of the first detector 26 and the second detector 28, as outlined before and further described below.

[0048] After the aerosol has entered the intake chamber 14, the piston 16 stops so that the inhalation period of the puff ends. Now the first pinch valve is closed and the aerosol stays for some time (hold period) inside the intake chamber 14 so that aerosol particles can settle and the density of the aerosol may change. In the embodiment, the temperature of the intake chamber 14 is maintained at about 37°C.

[0049] At the end of the hold period, the second pinch valve opens and the piston 16 starts to decrease the volume of the intake chamber 14 so that the residual aerosol is expelled from the intake chamber 14 and re-enters the optical measurement device 20, where its properties can be measured by means of the first detector 26 and the second detector 28. After removing the rests of the aerosol by means of a vacuum pump (not shown in the figures), the second pinch valve is closed. Prior to the inhalation period of the next puff, a pause can be provided.

[0050] It may be advantageous if a vacuum pump is used during the hold period in order to remove lingering aerosol from the optical measuring device 20 to prevent condensate from building up in the optical measurement device 20. In this case, the intake chamber 14 has to be separated from the optical measurement device 20, during the hold period, by an additional valve or shutter.

[0051] So far, the operation of the smoking apparatus 10 including the optical measurement device 20 has been considered. When the inhalation period ends, however, it is not required that the electronic cigarette 2 remains in a state mounted at the inlet port 12. During the rest of the puff sequence, i.e. during the hold period, the exhalation period and the pause, it can be remote from the inlet port 12 and can be weighed to determine its actual mass. This is performed by the automatic transport and weighing system 30.

[0052] To this end, the electronic cigarette 2 being held between the support 36 and the prongs 42 is pulled out of the gasket of the inlet port 12. The support 36 is moved in x direction towards the precision balance 32 where it is lowered until the electronic cigarette 2 rests on the weighing tray 34. Now the electronic cigarette is supported by the weighing tray 34 only so that its mass can be determined by the precision balance 32. In the embodiment, this takes about five seconds, including the settling time of the precision balance 32. The measured mass is transmitted to the computer system 50.

[0053] Thereafter, the height in z direction of the support 36 is increased again until the electronic cigarette 2 (or its sleeve device) rests against the prongs 42, and the electronic cigarette 2 is transferred back to the inlet port 12 by moving the support 36 and the slide 40.

[0054] In practice, the accuracy of the precision balance 32 is high enough to reliably determine the mass of the aerosol consumed during the puff considered by taking the difference of the masses of the electronic cigarette 2 before and after the puff in question. It is assumed that a user typically puffs every 30 seconds. The time required for moving the electronic cigarette 2 and the settling of the precision balance 32 is about 20 seconds. That means, after the inhalation period, there is sufficient time for transporting and weighing the electronic cigarette 2 during the hold period, the exhalation period, and a pause. Thus, the set-up 1 is able to determine the actual mass of the electronic smoking device for each puff so that the cycle described so far can be repeated many times. The mass data can be correlated with the data achieved by the optical measurements and optionally with other data.

[0055] Of course, the computer system 50 may also control the set-up 1 so that the electronic cigarette 2 is weighed for every second puff only, or an in different manner. Generally, the process is very versatile.

[0056] A meaningful optical property representing the visibility of the aerosol is the signal received at the second detector 28, which may be corrected and normalised for achieving a higher precision. In the embodiment, the output signal of the second detector 28, a voltage, is digitalised by means of an analogue-to-digital converter and integrated over a pre-selected period of time. When aerosol is present in the optical measurement device 20, the result represents the scattering, but it may also include some noise. A noise correction can be obtained by subtracting, from the above result, a background signal measured at the second detector 28 after the aerosol has been removed from the optical measurement device 20 (again digitalised and integrated over the same period of time). The noise-corrected result can be normalised to a signal (digitalised and integrated over some period of time) measured by the first detector 26 after the aerosol has been removed, in order to cancel out any long-term drift in the intensity of the light source 24.

[0057] The frequency range of the light source may be selected in relation to the expected range of sizes of the aerosol particles in order to optimise the scattering signal. The light source 24 may emit light at visible frequencies and/or in the infrared range.

[0058] It is useful to have a calibration step between subsequent puffs, which re-defines the "maximum signal" at the first detector 26 (light source on, no aerosol). Similarly, a "minimum signal" at the first detector 26 can be measured (light source off, no aerosol) to determine when the optical measurement device 20 needs to be cleaned from condensation that can occur on the light source 24 or on the detectors 26, 28. This allows the calculation of a calibration coefficient as the difference between the maximum signal and the minimum signal. When the calibration coefficient falls below a certain value, the optical measurement device 20 must be cleaned. The calibration coefficient can also serve as a measure of reproducibility.

[0059] Thus, the results of the optical measurements can provide a measure for the actual aerosol visibility, which then can be correlated with the actual weight loss (i.e. the mass of the aerosol of the actual puff) determined by means of the precision balance 30.

[0060] Moreover, as seen above, optical measurements can be performed both during the inhalation period and during the exhalation period of a puff. In the intake chamber 14, part of the aerosol decays so that the ratio of the respective inhale signal to the respective exhale signal ("vapour decay coefficient") provides compact information on the decay process.

[0061] From this description, it is evident how the optical measurement device 20 can be used in general, also independent of the set-up 1, e.g. as a stand-alone device for performing measurements on light scattered from aerosol present in the optical measurement device 20, as outlined further above.

Claims

1. A process of testing an electronic smoking device, comprising:

- mounting an electronic smoking device (2) to be tested at an inlet port (12) of a testing apparatus (20; 10),
- exerting puffs at the electronic smoking device (2), using the testing apparatus, each puff being defined by a puff sequence comprising an inhalation period and an exhalation period,
- measuring at least one optical property of aerosol (22) deriving from the electronic smoking device (2) in an optical measurement device (20), which is part of the testing apparatus,
- wherein the optical measurement device (20) comprises a light source (24), preferably a laser or an LED source, and at least one detector (28) arranged for measuring the scattering of light emitted from the light source (24) and passing through the aerosol (22), said detector (28) being arranged at a scattering angle with respect to a straight light path from the light source (24), the scattering angle preferably being in the range of from 60° to 120°, and
- wherein, as an optical property, a signal at said detector (28) is determined.

2. The process of claim 1, wherein the optical measurement device (20) further comprises a detector (26) arranged opposite to the light source (24), in the straight light path, which is arranged for measuring the attenuation of light emitted from the light source (24) and passing through the aerosol (22).

3. The process of claim 1 or 2, wherein optical measurements are performed, using the optical measurement device (20), on aerosol (22) exiting from the electronic smoking device (2) during the inhalation period of a puff.

4. The process of any one of claims 1 to 3, wherein optical measurements are performed, using the optical measurement device (20), on aerosol (22) entering the optical measurement device (20) during the exhalation period of a puff.

5. The process of any one of claims 1 to 4, wherein the light source (24) is removable and is selected depending on the wavelengths of the light emitted.

6. The process of any one of claims 1 to 5, wherein the optical measurement device (20) is modular and removable from the rest of the apparatus (10).

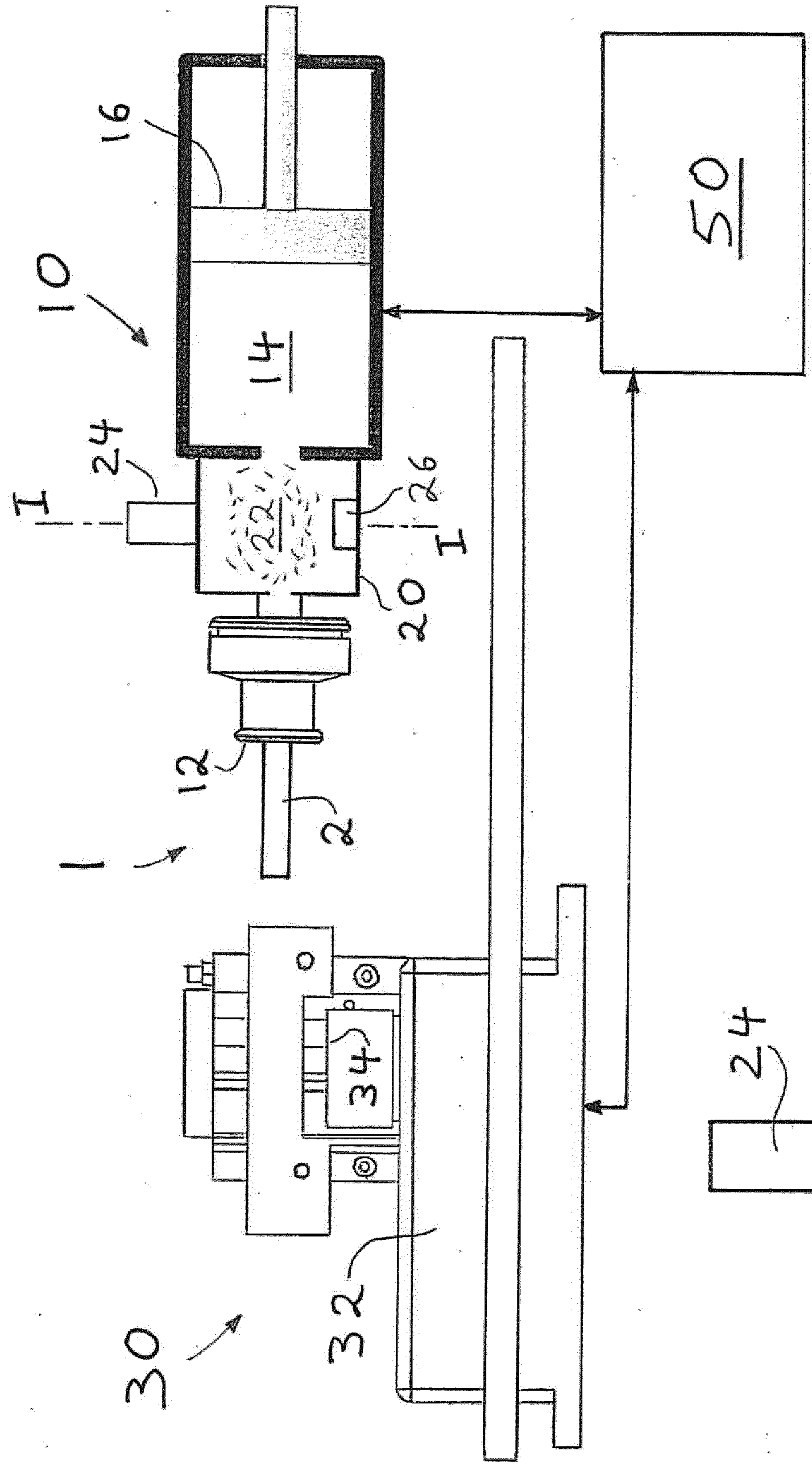

Fig. 1

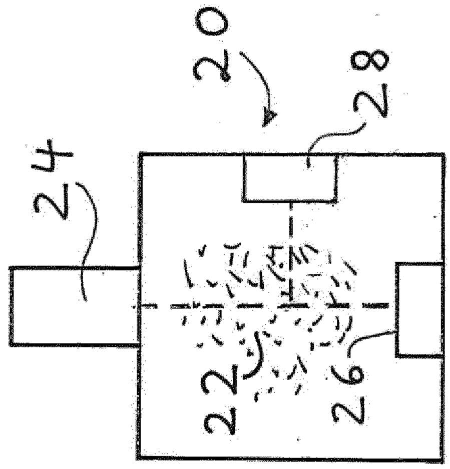

Fig. 2

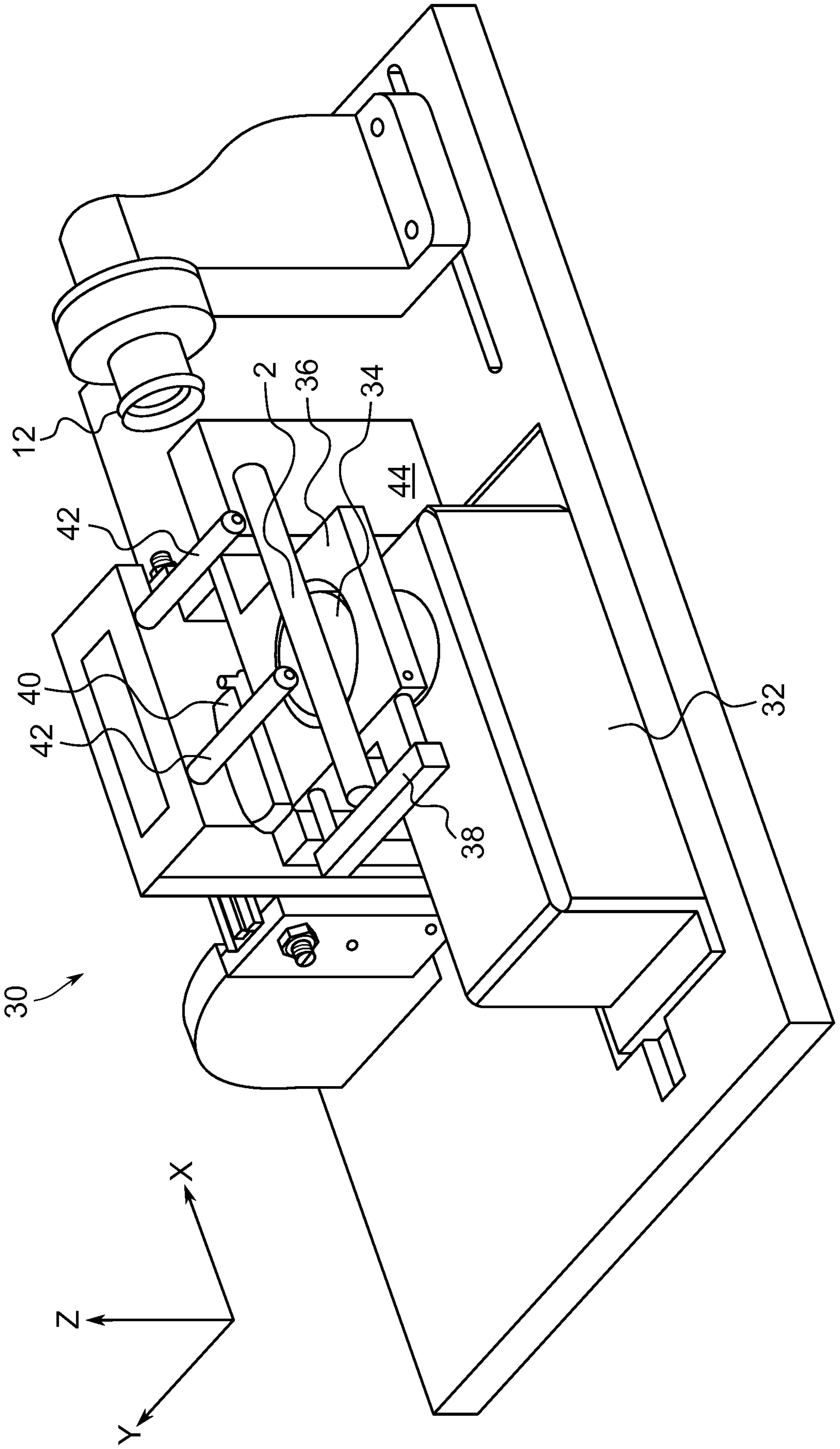

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 15 5806

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 403 432 A1 (JAPAN TOBACCO INC [JP]; MISHIMA PAPER CO LTD [JP]) 31 March 2004 (2004-03-31) * the whole document * -----	1-6	INV. A24C5/34 A24F47/00
			TECHNICAL FIELDS SEARCHED (IPC)
			A24C A24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	8 June 2016	Cardan, Cosmin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 16 15 5806

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-06-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1403432 A1	31-03-2004	AT 537299 T	15-12-2011
		CA 2447597 A1	21-11-2002
		CN 1509363 A	30-06-2004
		DK 1403432 T3	27-02-2012
		EP 1403432 A1	31-03-2004
		ES 2377395 T3	27-03-2012
		JP 3897700 B2	28-03-2007
		KR 20030093351 A	06-12-2003
		PT 1403432 E	09-02-2012
		TW I308186 B	01-04-2009
		US 2004094174 A1	20-05-2004
		WO 02092913 A1	21-11-2002

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 20140300480 A **[0002]**
- EP 1403432 A **[0002]**