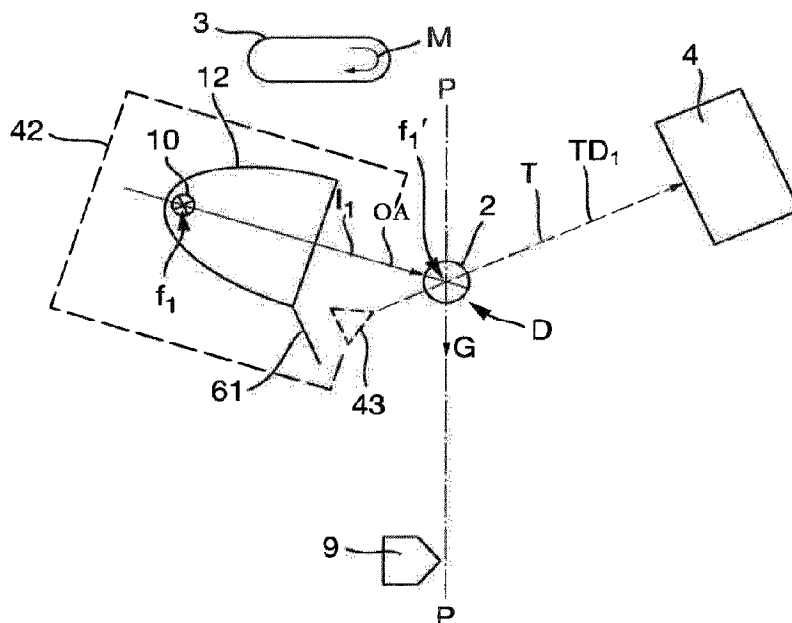




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(54) **Titre : PROCÉDE ET APPAREIL DE DETECTION DE MATIERE**
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(57) **Abrégé/Abstract:**

An apparatus for detecting matter comprises bulk feeding means (3; 3') configured for feeding a plurality of objects (2; 2') into a detecting region (D); at least one light source (8; 10, 20; 40) having a focusing element and being configured for illuminating at least one object (2; 2') moving in an object plane (P-P) in the detecting region (D); and a first light-analyzing apparatus (4) arranged to sense light that has been transmitted through the object. In the associated method, the object is caused to move in the plane and the object is illuminated with incident light. Light that has been transmitted through the object and is falling in a measuring plane (T) is detected, and an object-specific parameter based on the detected transmitted light is determined.



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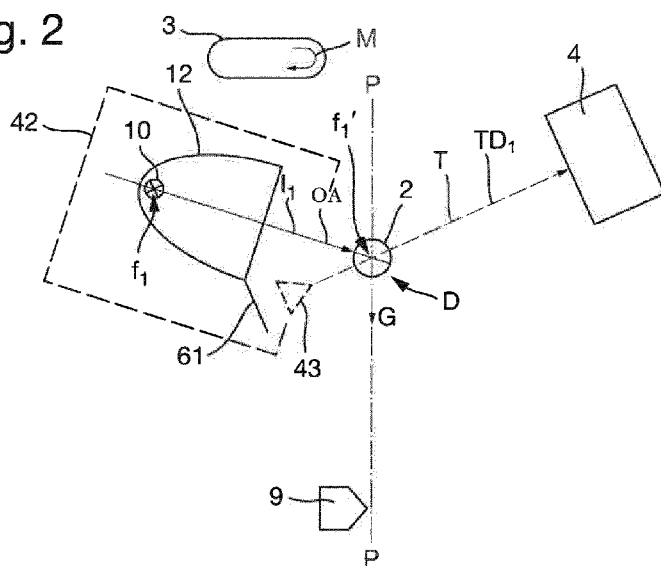
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Fig. 2



(57) Abstract: An apparatus for detecting matter comprises bulk feeding means (3; 3') configured for feeding a plurality of objects (2; 2') into a detecting region (D); at least one light source (8; 10; 20; 40) having a focusing element and being configured for illuminating at least one object (2; 2') moving in an object plane (P-P) in the detecting region (D); and a first light-analyzing apparatus (4) arranged to sense light that has been transmitted through the object. In the associated method, the object is caused to move in the plane and the object is illuminated with incident light. Light that has been transmitted through the object and is falling in a measuring plane (T) is detected, and an object-specific parameter based on the detected transmitted light is determined.

Method and apparatus for detecting matter

Field of the invention

The invention concerns systems and methods for non-destructive evaluation. More specifically, the invention concerns optical systems, devices and methods for detecting
5 matter and for determining one or more parameters of an object. The invention is particularly useful for determining properties of one or more translucent objects.

Background of the invention

Various techniques exist for determining the quality of harvested fruit and vegetables. In the agriculture industry, it is of interest to grade the produce based on internal
10 parameters such as sugar content, acidity, ripeness, rot and damage, and external features such as size, geometry and colour, and to perform certain sorting operations based on these parameters and features.

The use of near-infrared (NIR) spectroscopy and visible light (VIS) spectroscopy in determining various properties of harvested fruit and vegetables is well known. NIR
15 radiation is commonly defined as the range of the electromagnetic spectrum between 780 and 2500 nm, while the spectrum between 400nm and 780 nm is referred to as VIS radiation. In NIR or VIS spectroscopy, the object subjected to analysis is irradiated, and the reflected or transmitted radiation is measured. Changes in the reflected light are analysed to determine various characteristics of the surface of the object. Transmitted
20 light, i.e. radiation that penetrates the object, is subjected to scattering and/or absorption which affect its wavelength. These changes depend on the light-scattering properties of the object, as well as its chemical composition.

The state of the art includes JP 2010 210355 A, which describes a method and an apparatus for performing non-destructive measurement of a concentration of a target
25 component. In the method, a food item to be measured, such as a vegetable, fruit, meat, is irradiated with a light of wavelength in the range of 400 to 2500 nm. An absorbance spectrum is obtained by detecting the transmitted light and/or the reflected light, and the concentration of a target component of a measuring object is determined by using a

calibration curve from the absorbance of all measuring wavelengths or a specific wavelength.

The state of the art also includes CN 2733343 Y, which describes an internal non-destructive integral analytical equipment for agricultural products such as fruit and vegetables, comprising a light source system, a filter and an imaging system. The equipment can light different agricultural products in different angles, and light permeating specimens can enter a spectrometer (light source is chromatic) or a detector (light source is monochromatic) as much as possible via lens imaging function for utilizing visible-near infrared spectroscopy to analyze the quality of the agricultural products.

Moreover, JP 2009 226 248 , describes a method of detecting discoloured pellets by analysing light which has been reflected/backscattered from the pellets.

Further, US 6 646 218 describes an article sorting apparatus where light reflected from the articles is analysed in order to distinguish between acceptable and unacceptable articles.

Furthermore, JP 2007 033 273 describes an apparatus for detecting a foreign substance in white food using reflected and transmitted white light, where the optical axis of the light to be transmitted is aligned with the field-of-view of the camera so that a foreign substance will be clearly visible.

In the known systems and methods, the objects are irradiated and analysed one by one, which requires that each object is placed inside the detector either manually or on a conveyor belt having designated receptacles for each object. It is thus desirable to increase the throughput of objects in the above mentioned devices.

Summary of the invention

The invention is set forth and characterized in the main claims, while the dependent claims describe other characteristics of the invention.

It is therefore provided an apparatus for detecting matter, characterized by:

- bulk feeding means configured for feeding a plurality of objects into a detecting

region;

- at least one light source having a focusing element and being configured for illuminating at least one object moving in an object plane in the detecting region; and
- a first light-analyzing apparatus arranged to sense light that has been transmitted through the object.

According to one example there is provided an apparatus for detecting matter, characterized by:

- bulk feeding means configured for feeding a plurality of objects into a detecting region;
 - at least one light source each having a focusing element and being configured send light in a respective first direction for illuminating at least one object moving in an object plane in the detecting region; and
 - a first light-analyzing apparatus arranged to sense light that has been transmitted through the object, and to identify an amount of light that has been received from said at least one light source,
- wherein said first light-analyzing apparatus is arranged to sense light having a direction within the field-of-view of said first light-analyzing apparatus, and wherein said respective first direction is different from the directions within the field-of-view of said first light-analyzing apparatus.

In other words, when there is no object in the detection region, the light emitted or sent by said at least one light source will generally not be sensed by said first light-analyzing apparatus. In yet other words, when there is no object in the detection region, the light emitted or sent by said at least one light source will be sent outside the field of view of said first light-analyzing apparatus. In more detail, generally none or not more than a minor portion of the light sent from said at least one light source will be sensed by said first light-analyzing apparatus due to e.g. scattering in the ambient atmosphere or surface(s), when no object is present in the detection region. According to one example, at most 10 % or at most 5 % or at most 1 % or at most 0.5 % or at most 0.1 % or at most 0.05 % of the light sent from the at least one light source, when no object is present in the detection region, is identified by said first light-analyzing apparatus.

According to one example, when an object is present in the detection region and irradiated by said at least one light source, the light from said at least one light source is diffusely transmitted through or refracted by said object before it reaches the sensor of the light-analyzing apparatus. In more detail, more than 75 % or more than 90 % this
 5 light from said at least one light source light that reaches the sensor of said first light analyzing apparatus, has been diffusely transmitted through or refracted by said object before it reaches the sensor of the light-analyzing apparatus.

As is stated above, said first light-analyzing apparatus is arranged to identify light that has been received from said at least one light source; in other words said first light-
 10 analyzing apparatus is arranged to discriminate between ambient light and light which is received from the at least one light source. In yet other words, the amount of light that is received from said first light-analyzing apparatus is clearly higher than the noise level, which is present when the at least one light source is/are not switched off.

According to one example, the light source and focusing element has a resulting optical
 15 axis directed in a first direction. Said first direction being outside the field of view of said first light analyzing apparatus, in other words unrefracted light emitted along said first optical axis, is out-side the field of said first light-analyzing apparatus and will not be sensed by said first light-analyzing apparatus.

In one embodiment, the at least one light source is arranged to send incident light
 20 towards the plurality of objects that are moving in the object plane; and where the first light-analyzing apparatus is arranged such that a measuring plane for the transmitted light and the incident light are not in the same plane.

In one embodiment, the bulk feeding means are configured for feeding objects into the detecting region in a random fashion.

25 The at least one light source is in one embodiment arranged in the first focus of a truncated ellipsoid-shaped reflector, and the reflector is arranged such that the truncated ellipsoid-shaped reflector second focus is coinciding with the object plane.

In words, the light emitted from the at least one light source will first be converging to a focus, whereafter it will diverge. The light analyzing-apparatus is advantageously arranged such that the diverging light will not reach its sensor.

The at least one light source may comprise one or more light emitting diodes (LEDs),
 5 and may further comprise at least one lens, capable of focusing the light in the object plane.

In one embodiment, the light source and the first light-analyzing apparatus are arranged on opposite sides of the object plane. In one embodiment, a first light source is arranged symmetrically with a second light source about a central axis.

10 A second light-analyzing apparatus is in one embodiment arranged on the opposite side of the object plane with respected to the first light-analyzing apparatus and is configured to receive reflected light from the object resulting from light sent from the respective first and second light sources.

In one embodiment, at least a third light source is arranged on the same side of the
 15 object plane as the first light-analyzing apparatus and configured to irradiate the object with light that is reflected to the first light-analyzing apparatus.

The light-analyzing apparatus may comprise a spectroscopy system or a hyperspectral camera system.

The at least one light source is in one embodiment a pulsed light source, arranged to
 20 send pulsated light into the detecting region. Light control means may be arranged and configured to controllably send pulsated light into the detecting region.

The bulk feeding means may comprise a vibration feeder or a conveyor belt, optionally in combination with a chute, whereby the objects are caused to fall through the detecting region. The bulk feeding means also comprise a translucent conveyor belt that
 25 extends into the detecting region and is arranged to at least partially support the object in the detecting region.

In one embodiment, the conveyor belt comprises a wire mesh conveyor belt, or two conveyor belts being separated by an intervening gap.

It is also provided a system for sorting objects, wherein the invented apparatus is combined with an expulsion device configured to controllably and selectively expel the object from the system based on properties of the light received by the first light-analyzing apparatus.

- 5 It is also provided a method of determining a parameter of at least one object, comprising the steps of
- i) causing the object to move in a plane in a detecting region;
 - ii) illuminating the object with incident light;
 - iii) detecting light that has been transmitted through the object and is falling in a
 - 10 measuring plane; and
 - iv) determining an object-specific parameter based on the detected transmitted light falling in the measuring plane.

Moreover, it is also provided a method of determining a parameter of at least one object, comprising the steps of

- 15 i) causing the object to move in a plane (P-P) in a detecting region (D);
- ii) illuminating the object with incident light having a first direction, which light is emitted from at least one light source;
- iii) detecting and identifying light originating from said at least one light source and being transmitted through the object, said light having a second direction different from
- 20 said first direction; and
- iv) determining an object-specific parameter based on the detected transmitted light.

In one embodiment, the measuring plane for the transmitted light and the incident light are not in the same plane. The movement in step i) comprises free-falling or may be effected by a conveyor belt.

- 25 In one embodiment of the invented method, the illumination step comprises sending pulsating light towards the detecting region; and the detecting step additionally comprises detecting ambient light during time intervals where there is no light sent towards the detecting region.

The object-specific parameter may comprise one or more of the parameters on a list comprising: sugar content, acidity, ripeness, rot, mechanical damage, presence of foreign matter, presence of bone.

5 In one embodiment, the object is sorted based on the object-specific parameter determined in step iv).

The invention is not limited to near-infrared (NIR) spectroscopy or visible light (VIS) spectroscopy, but may generally be used with any spectroscopy method, also including, but not necessarily limited to, ultraviolet (UV) spectroscopy and mid-infrared (MIR) spectroscopy.

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Further, what has been stated above in relation to the apparatus, may normally also be applied to the methods.

Brief description of the drawings

15 These and other characteristics of the invention will become clear from the following description of a preferential form of embodiment, given as a non-restrictive example, with reference to the attached schematic drawings, wherein:

Figures 1a and 1b are a side view and a top view, respectively, of a first embodiment of the system according to the invention;

20 Figure 2 is a side view of a second embodiment of the system according to the invention;

Figure 3 is a side view of a third embodiment of the system according to the invention;

Figure 4 is a side view of a fourth embodiment of the system according to the invention;

Figure 5 is a side view of a fifth embodiment of the system according to the invention;

Figure 6 is a side view illustrating another variant of the invention; and

25 Figure 7 shows an arrangement where light from the lamp housing is pulsed.

Detailed description of a preferential embodiment

The following description will use terms such as “horizontal”, “vertical”, “lateral”, “back and forth”, “up and down”, “upper”, “lower”, “inner”, “outer”, “forward”, “rear”, etc. These terms generally refer to the views and orientations as shown in the drawings and that are associated with a normal use of the invention. The terms are used for the reader’s convenience only and shall not be limiting.

Figures 1a and 1b are a schematic representation of the system according to the invention. An illumination system 8 transmits light L towards a spectroscopy system 4. A conveyor 3 feeds a plurality of objects 2 (for example harvested fruit or vegetables) in the direction indicated by the arrow M such that the objects 2 subsequently fall off and (in a generally parabolic trajectory) down past an illuminated region defined between the illumination system and the spectroscopy system. Reference letter S denotes a scan line, reference letters P-P denote an object plane, and reference letters SR denote the scanning range. The objects 2 are thus illuminated from behind as they fall in the object plane in the detecting region D, and transmitted light is detected and analysed by the spectroscopy system 4.

The illumination system may comprise one or more light sources and ancillary devices (e.g. reflectors, lenses) capable of focusing the light in the object plane P-P. Thus, suitable light sources may include supercontinuum lasers, broadband light sources such as halogen bulbs, or one or more light-emitting diodes (LEDs), in combination with suitable lenses or other focusing elements. One example of such focusing element is disclosed in EP 0 772 498 B1, describing an optical inspection system having lenses for directing light from source units, such as LEDs, onto the products passing through an inspection region. A light source may be e.g. single broadband LED, or an array of multiple LEDs, each having different spectral bandwidths.

The spectroscopy system 4 comprises in the illustrated embodiment a rotating mirror 6 and a sensor 7. This set-up produces a single spectrum for each point on the scan line S. It should be understood that the sensor may comprise e.g. a spectrometer or a hyperspectral camera system. The spectroscopy system may also utilize very sensitive spectrometer systems having e.g. avalanche-photodiodes (APD) or photomultiplier tubes (PMT), which are known in the art.

Figure 2 is a schematic representation of a second embodiment of the system according to the invention. Reference number 3 indicates a bulk feeding device, such as conveyor belt or a vibration feeder and a chute; the function of which being to feed a plurality of objects such that they fall into the detecting region D. For clarity of illustration, only one object is illustrated in figure 2. However, it should be understood that several objects may fall in the detecting region D simultaneously, similar to the situation shown in figures 1a,b. Figure 2 illustrates a situation where an object 2 (e.g. a fruit or a vegetable) has fallen off the feeding device 3 and is falling in the detecting region D as indicated by the arrow G.

A light source 10 is arranged to send an incident light beam I_1 towards the object 2 which is falling in the object plane P-P. The line T indicates the transmitted light that is falling in the measuring plane (seen along the plane), i.e. the transmitted light T that is detected by the spectroscopy system 4. In other words, a portion of the incident light beam I_1 is transmitted through the object and thereafter detected/identified by the spectroscopy system 4, this portion is referred to as the transmitted and detected light. As can be seen in Figure 2, the direction of the incident light I_1 is different from the direction of the transmitted and detected light TD_1 . In more detail, the direction of the incident light may be equal to the direction of the center axis of the incident light; and the direction of the transmitted and detected light may be equal to the center axis of the transmitted and detected light.

When there is no object in the detection region, the light emitted or sent by the light source 10 will not be sensed by spectroscopy system 4, as the light emitted by the light source 10 will be sent outside the field of view of said spectroscopy system 4. In more detail, generally none or not more than a minor portion of the light sent from the light source will be sensed by spectroscopy system 4 due to e.g. scattering in the ambient atmosphere, when no object is present in the detection region. According to one example, at most 10 % or at most 5 % or at most 1 % or at most 0.5 % or at most 0.1 % or at most 0.05 % of the light sent from the light source 10, when no object is present in the detection region, is identified by spectroscopy system 4.

When an object is present in the detection region and irradiated by said light source 10, the light from the light source is diffusely transmitted through or refracted by said object before it reaches the sensor spectroscopy system 4. In more detail, more than 75 % or more than 90 % of this light from the light source that reaches the sensor of spectroscopy system 4, has been diffusely transmitted through or refracted by said
5 object before it reaches the sensor of the light-analyzing apparatus.

According to one example, the light source 10 and focusing element 12 has a resulting optical axis (OA) directed in a first direction. Said first direction being outside the field of view of said spectroscopy system 4, in other words unrefracted light emitted along
10 said first optical axis, is out-side the field of said spectroscopy system 4 and will not be sensed by the spectroscopy system 4.

In the spectroscopy system, the transmitted and detected light is being analysed in order to determine internal properties of the object. If these internal properties are outside predetermined tolerances, for example if the object has internal regions that are rotten or
15 damaged, a command signal (control lines not shown) is sent to an ejection device 9 (which is arranged downstream of the detecting region D) which removes the object from the system. The ejection device 9, which is optional, may be any known mechanical ejection or removing device, such as a flap, mechanical fingers, air nozzles, etc.

20 The light source 10 and the spectroscopy system 4 are arranged such that the incident light I_1 and the measuring plane T are not aligned. The region DB, on the other side of the object 2 with respect to the spectroscopy system 4, is either void or comprises an optional dark reference element 61. Such reference element ensures that the spectroscopy system is not blinded if and when there are no objects in the detecting
25 region.

In order to optimize the light intensity in the object plane, the light source 10 comprises in the illustrated embodiment a broadband light source, such as a halogen bulb, arranged inside a reflector 12 as shown in figure 2. Thus, with reference to figures 1a,b, the illumination system 8 comprises in the embodiment illustrated in figure 2 the light
30 source 10 and the reflector 12 in a lamp housing 42. The reflector 12 has the shape of a

truncated ellipsoid (truncated parallel with ellipsoid minor axis), and the light source 10 is arranged at the truncated ellipsoid's first focus f_1 . As every light beam emitted from the first focus f_1 of the truncated ellipsoid is reflected by the reflector to converge at the second focus f'_1 , the system is designed such that the object plane P-P intersects the second focus f'_1 . This ensures that the object 2 is irradiated with concentrated light when falling through the detecting region D. In other words, the light emitted from the light source 10 will first be converging to a focus f'_1 , whereafter it will diverge. The light analyzing-apparatus is normally arranged such that the diverging light does not reach its sensor.

10

It should be understood that although figure 2 shows the object 2 falling vertically, along the object plane P-P, this is not a requirement for the invention. It is sufficient that the object intersects the second focus f'_1 and the object plane in the detecting region D; i.e. the object may have a non-vertical trajectory.

Figure 3 is a schematic representation of a third embodiment of the system according to the invention. Only aspects that differ from those described above with reference to figure 2 will be discussed in the following. In this third embodiment, a second light source 20 and a corresponding second truncated ellipsoid-shaped reflector 22 are arranged similarly to the first light source 10 and first reflector 12 as described above, inside a lamp housing 42, with the second light source 20 at the truncated ellipsoid's first focus f_2 . The second reflector 20 and the first reflector 10 are arranged symmetrically about a common central axis C, and the second reflector 20 is (like the first reflector 10) arranged such that the object plane P-P intersects the second focus f'_2 of the second reflector. Thus, the second foci f'_1 , f'_2 coincide and lie in the object plane P-P, as illustrated in figure 3. This embodiment effectively doubles the irradiation intensity on the object 2, compared to the embodiment illustrated in figure 2.

The first and second light sources 10, 20 send their respective first and second light beams I_1 , I_2 towards the object 2 which is falling in the object plane P-P. Transmitted light falling in the measuring plane T is detected by the spectroscopy system 4 as described above. In other words, a portion of the incident light beam I_1 and a portion of

30

the incident light beam I_2 are transmitted through the object and thereafter detected by the spectroscopy system 4, these portions are referred to as the transmitted and detected light. As can be seen in Figure 3, the directions of the incident light beams I_1 , I_2 are different from the direction of the transmitted and detected light TD_{12} . In more detail,
 5 the direction of an incident light beams may be equal to the direction of the center axis of the incident light beam; and the direction of the transmitted and detected light may be equal to the center axis of the transmitted and detected light.

A dark reference element 61 is arranged between the reflectors 12, 22, ensuring that the spectroscopy system is not blinded if and when there are no objects in the detecting
 10 region D. In a practical embodiment, the reflectors and their respective light sources may be incorporated into a single lamp housing 42. Thus, with reference to figures 1a,b, the illumination system 8 comprises in the embodiment illustrated in figure 2 the light sources 10, 20, the reflectors 12, 22 and the reference element 61 in the housing 42.

Figures 2 and 3 also show an optional white reference element 43 arranged inside the
 15 lamp housing 42 but within the scan range of the spectroscopy system 4. The white reference element 43 makes it possible to calibrate the system while it is in operation, which could improve measurement accuracy. The white reference element may for example be a small barium pyramid, placed such that it is illuminated by the light source(s).

20 Figure 4 is a schematic representation of a fourth embodiment of the system according to the invention. The lamp housing has been omitted in this illustration. Only aspects that differ from those described above with reference to figure 3 will be discussed in the following.

In this fourth embodiment, the dark reference element (reference number 61 in figure 3)
 25 has been replaced by an opening (or light guide) 62 between the reflectors 12, 22, and a second spectroscopy system 5 is arranged collinearly with the first spectroscopy system 4. As the first and second incident light beams I_1 , I_2 are sent towards the object 2, a portion T is transmitted and sent to the first spectroscopy system 4. However, a portion of the incident light is also reflected (indicated by $R_{1,2}$) towards the second spectroscopy
 30 system 5. This configuration thus allows for both transmission spectroscopy (in the first

spectroscopy system 4), and reflection spectroscopy (in the second spectroscopy system 5).

The fourth embodiment also comprises a third light source 30 and an optical filter 63 arranged to send a third incident light beam I_3 towards the object 2. The optical filter 63 is configured to block light of wavelengths that would otherwise interfere with the transmitted light falling in the measuring plane T. Thus, the third incident (filtered) light beam I_3 is reflected by the object 2 and a reflected light R3 is directed to the first spectroscopy system 4. This third light source 30 enables the measurement and evaluation of the object's surface properties. It should be understood that a plurality of light sources similar to the third light source 30 may included, e.g. symmetrically on the other side of the first spectroscopy system 4.

Figure 5 is a schematic representation of a fifth embodiment of the system according to the invention. This embodiment is essentially a combination of the third and fourth embodiments. The lamp housing has been omitted in this illustration. The dark reference element 61 is arranged between the first and second reflectors 12, 22 as described above with reference to figure 3, and the third light source 30 and optical filter 63 are arranged as described above with reference to figure 4.

Figure 6 shows a variant where the invented system is arranged such that the object 2 is not falling in the object plane (as in the embodiments of the invention described above), but is carried through the detecting region D on a conveyor belt 3' moving in the direction B. The conveyor belt 3', which is aligned with the object plane P-P, is transparent and/or translucent such that the light beams $I_{1,2}$ are allowed to pass through the belt and onto the object. The conveyor belt 3' may thus for example be a wire mesh conveyor belt, a translucent conveyor belt, or two conveyor belts arranged with an intervening gap. The set-up shown in figure 6 allows the invented system to be used for analysing and sorting objects that do not lend themselves to being dropped, for example meat products. Examples of such meat products are chicken, pork belly and ground meat. The set-up is also suitable for detecting, analysing and sorting objects that have lesser defined shapes and are capable of forming a layer or lumps on the conveyor belt 3', such as ground beef, minced meat, meat farce, etc. This type of object is indicated by

reference number 2' in figure 6. It should be understood that the set-up of figure 6 could be reversed, i.e. the light sources being above the conveyor belt 3' and the spectroscopy system below.

In use, any of the embodiments of the invented system and apparatus may typically be installed in industrial environments, e.g. adjacent to produce packing equipment or in meat processing plants, where conditions for conducting optical detection processes may be less than ideal. For example, the light detected by the spectroscopy system is generally the sum of (i) light generated by the light sources that has been transmitted through the object, and (ii) ambient light. This is illustrated in figure 7, where arrows marked "A" indicate ambient light, and L' represents pulsating light coming from a pulsed light source 40 in a lamp housing 42. The ambient light may constitute a significant portion of the detected light and may affect the detection process in an adverse manner. It is therefore of interest to be able to factor ambient light out of the detection and measurement process.

The invention therefore comprises a method and associated means for switching off the light source(s) for a period of time such that the spectroscopy system may measure only ambient light. When the light source is switched off, no light is transmitted through the object. A processing device (not shown) in the spectroscopy system 4 subtracts the ambient light measurement from the measurement made by the spectroscopy system when light generated by the illumination system (the light sources) is transmitted through the object.

The objects are typically moving (e.g. falling) through the detecting region at a high speed; and the time periods in which the light source is switched off must match this speed. This may be obtained by pulsed focused LEDs, which enable a rapid on/off cycle. A pulsed LED arrangement enables the detection of received light from neighbouring pixels when the light source is off (only ambient light) and on (generated light + ambient light). If the light source is e.g. a halogen bulb (having longer response times), the pulsated light L' may be obtained by arranging a light control means 45 in front of the light source, as shown in figure 7. The light control means 45 may be e.g. a

mechanical shutter or so-called switchable glass. Switchable glasses are well known, one example being SmartGlass™, which is marketed and sold by Schott AG.

This ability to measure and subtract ambient light during the detection process improves the versatility of the system. For example, the detecting region does not need to be in an
5 enclosed cabinet, but may be in the open and exposed to ambient light. It should be understood that pulsed LEDs may be combined with the light control means 45.

Although the invention has been described with reference to detecting matter in fruits, vegetables and meat, it should be understood that the invention is equally applicable to detecting matter in translucent objects in general, including but not limited to other
10 foodstuffs.

Claims

1. An apparatus for detecting matter, comprising:
 - bulk feeding means configured for feeding a plurality of objects into a detecting region;
 - 5 - at least one light source each having a focusing element and being configured to send light in a respective first direction for illuminating at least one object moving in an object plane in the detecting region, wherein the at least one light source is a pulsed light source, arranged to send pulsated light into the detecting region;
 - a first light-analyzing apparatus arranged to sense light that has been emitted from said
 - 10 at least one light source and transmitted through the object, and to identify an amount of light that has been received from said at least one light source after transmission through the object, and further to discriminate between ambient light and said light received from said at least one light source after transmission through the object;
 - means for switching off said at least one light source for a period of time such that the
 - 15 light-analyzing apparatus measures only the ambient light,
 - a processing device arranged to subtract the measured ambient light from the identified amount of light that has been received from said at least one light source after transmission through the object;
 - means for determining a parameter of the objects based on said identified amount of
 - 20 light received from said at least one light source after transmission through the object wherein said first light-analyzing apparatus is arranged to sense light having a direction within the field-of-view of said first light-analyzing apparatus, and wherein said respective first direction is different from the directions within the field-of-view of said first light-analyzing apparatus.
- 25 2. The apparatus of claim 1, wherein the bulk feeding means are configured for feeding objects into the detecting region in a random fashion.
3. The apparatus of any one of claims 1-2, wherein the at least one light source is arranged in the first focus of a truncated ellipsoid-shaped reflector and the reflector is arranged such that the truncated ellipsoid-shaped reflector second focus is coinciding
- 30 with the object plane.

4. The apparatus of any one of claims 1-3, wherein the at least one light source comprises one or more light emitting diodes.
5. The apparatus of any one of claims 1-4, wherein the at least one light source further comprises at least one lens, configurable to focus the light in the object plane.
- 5 6. The apparatus of any one of claims 1-5, wherein the light source and the first light-analyzing apparatus are arranged on opposite sides of the object plane.
7. The apparatus of any one of claims 1-6, wherein a first light source is arranged symmetrically with a second light source about a central axis.
8. The apparatus of claim 7, wherein a second light-analyzing apparatus is arranged
10 on the opposite side of the object plane with respected to the first light-analyzing apparatus and is configured to receive reflected light from the object resulting from light sent from the respective first and second light sources.
9. The apparatus of any one of claims 1-8, further comprising at least a third light source arranged on the same side of the object plane as the first light-analyzing
15 apparatus and configured to irradiate the object with light that is reflected to the first light-analyzing apparatus.
10. The apparatus of any one of claims 1-9, wherein the light-analyzing apparatus comprises a spectroscopy system or a hyperspectral camera system.
11. The apparatus of any one of claims 1-10, further comprising light control means
20 arranged and configured to controllably send pulsated light into the detecting region.
12. The apparatus of any one of claims 1-11, wherein the bulk feeding means comprises a vibration feeder or a conveyor belt, in combination with a chute, whereby the objects are caused to fall through the detecting region.
13. The apparatus of claim 12, wherein the vibration feeder or conveyor belt is in
25 combination with a chute, whereby the objects are caused to fall through the detecting region.

14. The apparatus of any one of claims 1-13, wherein the bulk feeding means comprises a translucent conveyor belt that extends into the detecting region and is arranged to at least partially support the object in the detecting region.

15. The apparatus of claim 14, wherein the conveyor belt comprises a wire mesh conveyor belt, or two conveyor belts being separated by an intervening gap.

16. A system for sorting objects, comprising the apparatus as defined by any one of claims 1-15, and an expulsion device configured to controllably and selectively expel the object from the system based on properties of the light received by the first light-analyzing apparatus.

17. A method of determining a parameter of at least one object, comprising the steps of

- i) providing a light-analyzing apparatus having a field-of-view;
- ii) causing the object to move in a plane in a detecting region;
- iii) illuminating the object with incident light by sending pulsating light towards the detecting region, said incident light having a first direction, which light is emitted from at least one light source, wherein said first direction of the incident light is different from the directions of said field-of-view of said first light-analyzing apparatus;
- iv) detecting and identifying light originating from said at least one light source and being transmitted through the object, said light having a second direction different from said first direction, and detecting ambient light during time intervals where there is no light sent towards the detecting region;
- v) discriminating said detected and identified light from ambient light by switching off said at least one light source for a period of time such that the light-analyzing apparatus measures only the ambient light, and subtracting the measured ambient light from the identified light originating from said at least one light source and being transmitted through the object; and
- vi) determining an object-specific parameter based on the detected and identified light originating from said at least one light source and being transmitted through the object.

18. The method of claim 17, wherein the movement in step ii) comprises free-falling.
19. The method of claim 17, wherein the movement in step ii) is effected by a conveyor belt.
- 5 20. The method of any one of claims 17-19, wherein the object-specific parameter comprises one or more of the parameters on a list comprising: sugar content, acidity, ripeness, rot, mechanical damage, presence of foreign matter, presence of bone.
21. The method of any one of claims 17-20, wherein the object is sorted based on the object-specific parameter determined in step vi).

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Fig. 1a

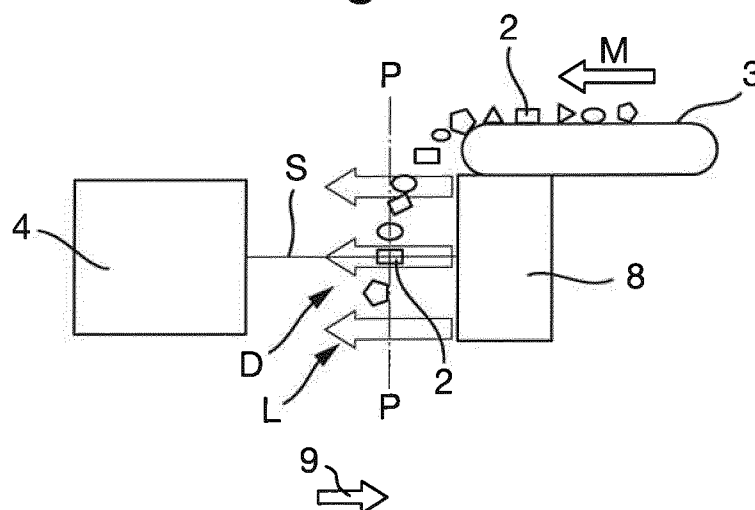
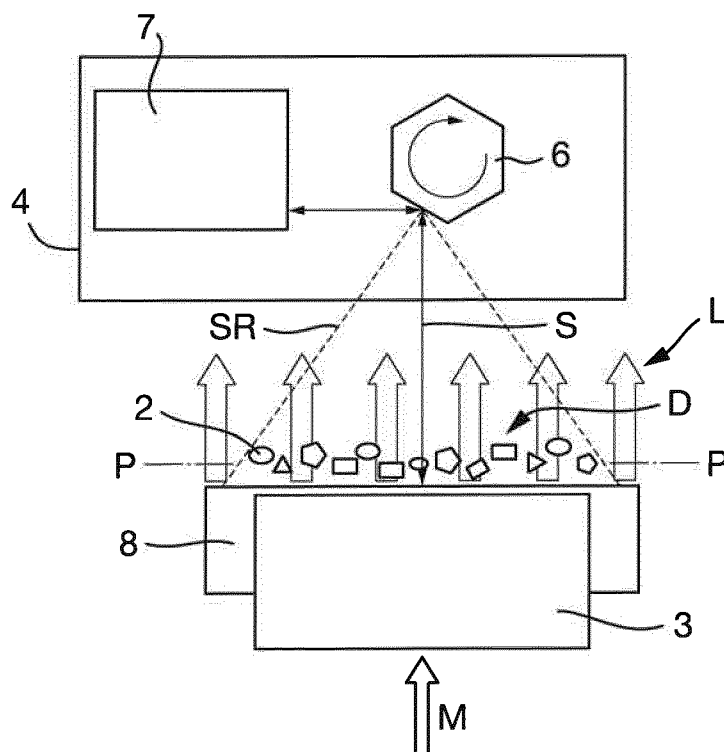


Fig. 1b



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Fig. 2

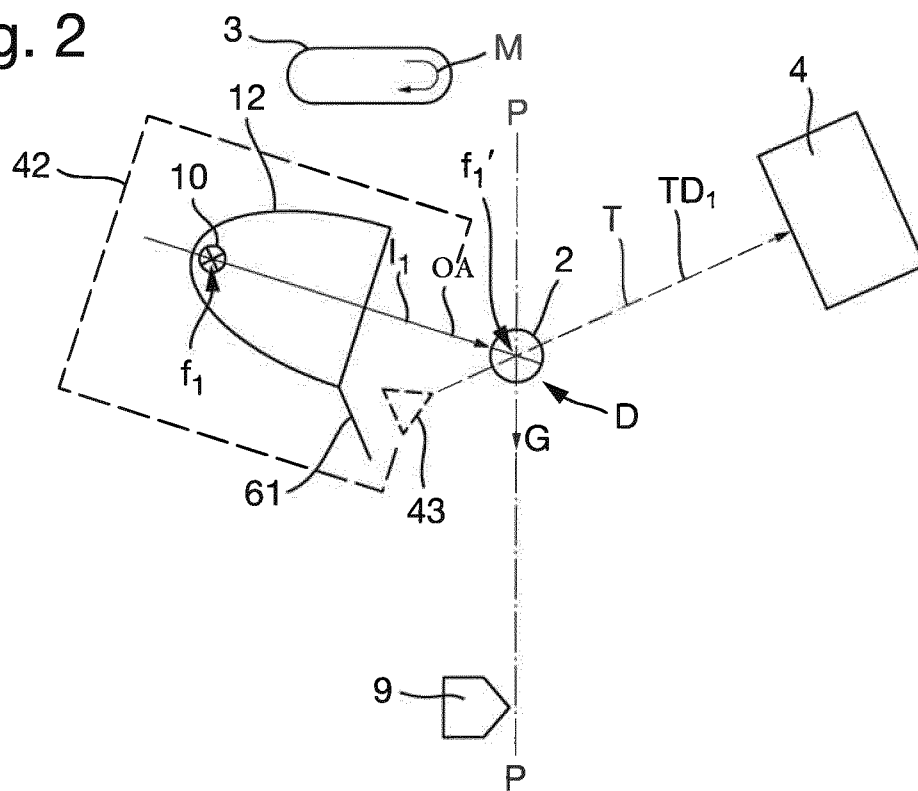
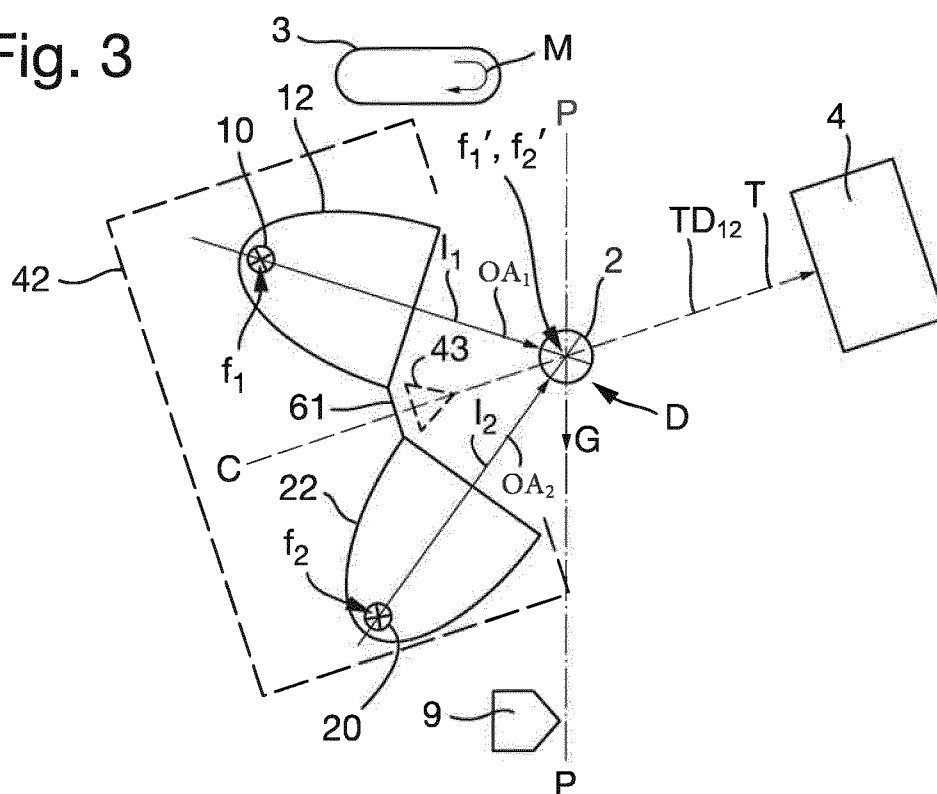


Fig. 3



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Fig. 4

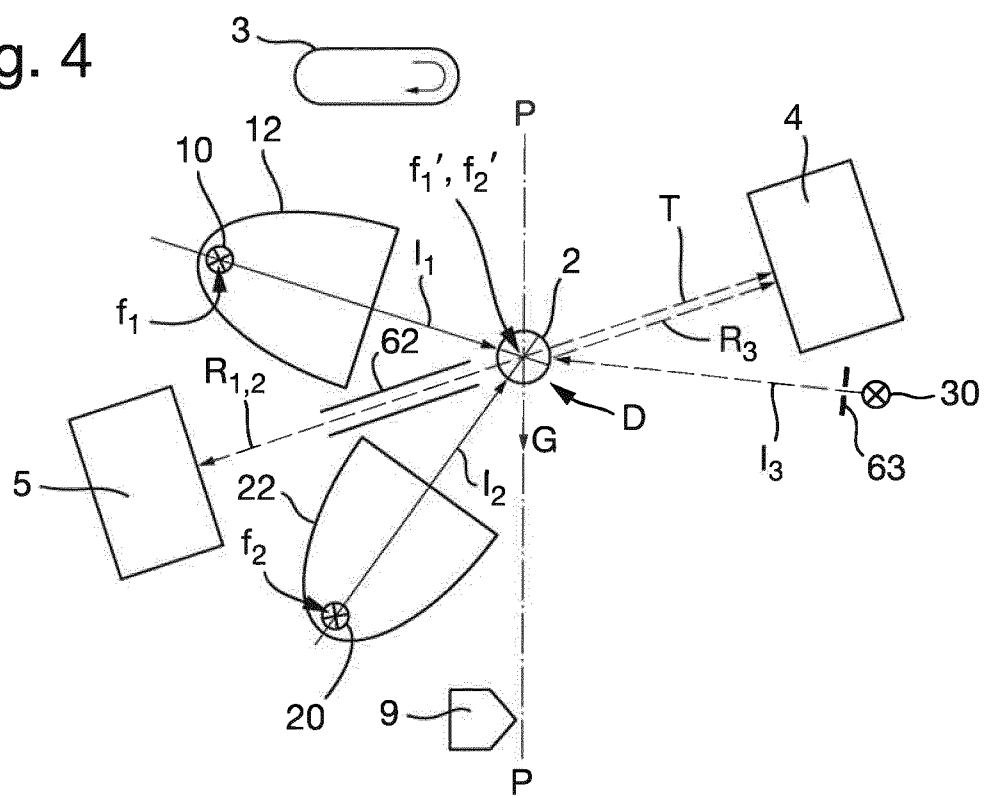


Fig. 5

