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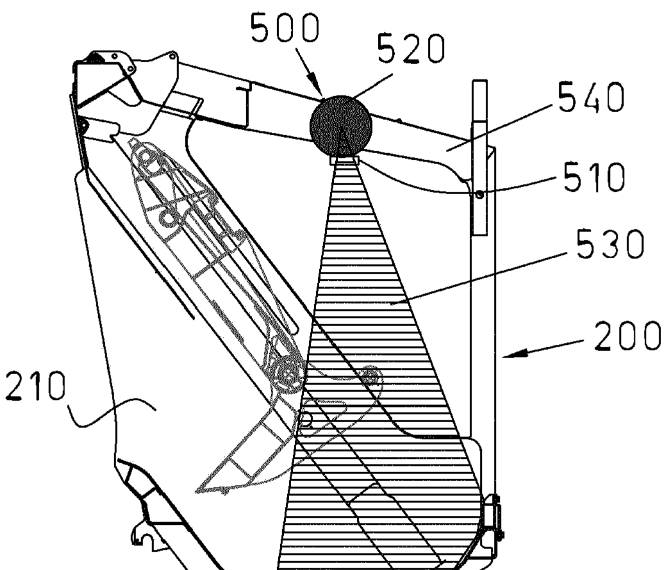
(54) **GARBAGE TRUCK**

(57) The garbage truck (100) comprises a hopper (200) for collecting refuse, a compactor (400) for compacting refuse inside the hopper (200), machine vision means (500), and a control unit (600) connected to the machine vision means (500) and configured for monitoring an area of the interior (210) of the hopper (200) so as to determine a volume of refuse present inside the hopper (200) for controlling the compactor (400) according to a given operating mode depending on the volume of refuse present in the hopper (200).

FIG.3

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## Description

**[0001]** The present disclosure relates garbage trucks for collecting refuse.

BACKGROUND

**[0002]** Garbage trucks are widely used for collecting, compacting and transporting refuse such as solid urban waste. For example, US20140348621 discloses a garbage truck comprising a truck body, a hopper formed inside the truck body and adapted to receive refuse therein, a compactor comprising a blade movably mounted within the hopper, and a mechanism to lift refuse containers and unload their contents into the hopper. In other known garbage trucks, the compactor may consist of a hydraulic press provided inside the hopper and arranged to press the refuse therein.

**[0003]** The operation of the compactor in current garbage trucks bears the primary responsibility for energy consumption, noise generation and pollutant emission. When the compactor is operated and no or a small amount of refuse is present in the hopper, unnecessary noise and contaminants are undesirably generated, energy is wasted, and parts and consumables of the truck such as oil, bearings, etc., are unnecessarily worn out.

**[0004]** A need therefore exists for optimizing the operation of garbage trucks while reducing costs.

SUMMARY

**[0005]** The present disclosure relates to a garbage truck with which the above need is met and with which additional advantages are further obtained. The present disclosure finds application in a wide range of garbage trucks such as of the rear-loader, side-loader type, etc.

**[0006]** A garbage truck is provided comprising a hopper into which refuse is manually or mechanically loaded and collected, and a compactor for compacting the refuse that is inside the hopper. As used herein, refuse includes any kind of garbage, trash, litter, rubbish, etc. and any matter to be discarded.

**[0007]** According to one important feature of the present garbage truck, machine vision means are provided. The machine vision means may comprise a source of modulated light, a camera sensor, and means for periodically generating geometries corresponding to the interior of the hopper. Since said geometries can be advantageously used for determining relevant characteristics of the refuse in the hopper, a volume of refuse in the hopper can be quantitatively and qualitatively determined.

**[0008]** The source of modulated light is suitable for projecting a beam of modulated light, such as infrared light, for illuminating a volume in the interior of the hopper. The use of infrared light is preferred as it ensures low signal disturbance and provides for easy distinction from natural ambient light. In specific examples, the source of modulated light may be configured to provide a beam of light defining the shape of a cone, or a square based pyramid, or a rectangular based pyramid. Other shapes and combinations of shapes are of course not ruled out. Said shaped light beam is such that the refuse, where it is present in the hopper, will be at least partially enclosed therein. In general, it is preferred that the camera sensor is arranged at one vertex of said cone or pyramid defined by the light beam.

**[0009]** The camera sensor is connected to the source of modulated light and arranged for receiving light that is reflected by the hopper, or by the refuse placed therein. This allows distances from the camera sensor to different points in the hopper to be determined based of a time-of-flight principle (ToF). Based on this principle, distances from the camera sensor to different points in the hopper are accurately determined based on time difference between the emission of modulated light and its return to the camera sensor.

**[0010]** The means for periodically generating geometries corresponding to the interior of the hopper allows geometries to be generated from said determined distances so as to determine a volume of refuse that is present in the interior of the hopper, from relevant characteristics of the refuse in the hopper such as the amount (e.g. weight) of refuse in the hopper, the shape of a volume of the refuse in the hopper, the distribution of the refuse in the hopper, etc. can be determined.

**[0011]** It is to be noted that the means for periodically generating geometries are also capable of generating geometries of the interior of the hopper even in the case where refuse is not present.

**[0012]** A control unit is also provided. The control unit is connected to the machine vision means, and it is configured for monitoring an area of the interior of the hopper so as to determine a volume of refuse that is present in the interior of the hopper. The control unit allows the above mentioned relevant characteristics of the refuse in the hopper, if present, to be determined. The compactor can be thus efficiently controlled by the control unit according to a given operating mode depending on volume, and/or shape and/or distribution of the refuse present in the hopper, that is, depending on at least one of the above mentioned relevant characteristics of the refuse that is present in the hopper.

**[0013]** In one example, the geometry generating means may be suitable for periodically generating three-dimensional geometries corresponding to the interior of the hopper. Of course, bi-dimensional geometries can be also generated as required.

**[0014]** The present disclosure further relates to a method for operating a garbage truck of the above type, that is, comprising a hopper for collecting refuse and a compactor for compacting the refuse.

**[0015]** The present method comprises the following steps.

**[0016]** An interior of the hopper in the garbage truck is illuminated with modulated light. Specifically, a beam of modulated light such as infrared light is projected towards the interior of the hopper. Said projected beam of modulated light defines a volume in the shape of a cone, or a square based pyramid, or a rectangular based pyramid as described above. Other shapes are not ruled out as long as they are suitable for at least partially enclosing refuse present in the hopper.

**[0017]** Distances from a camera sensor to different points inside the hopper are measured based on time difference between the emission of modulated light and its return to the camera sensor. From said measured distances, a mathematic model is generated corresponding to a bi-dimensional or a three-dimensional geometry of the interior of the hopper under a given hopper loading condition, such as for example when no refuse is present in the hopper, for conveniently calibrating the machine vision means, or when at least an amount of refuse is present in the hopper.

**[0018]** A volume of refuse present in the hopper can be then determined according to said mathematic model of the interior of the hopper. If a determined volume of refuse present in the hopper meets a predetermined condition, the compactor is actuated according to one mode of operation, such as automatic-cycle, manual-cycle, or semi-automatic-cycle, etc. If a determined volume of refuse present in the hopper does not meet said predetermined condition, the compactor is disabled.

**[0019]** Examples of predetermined conditions may include exceeding a predetermined threshold (e.g. a refuse volume threshold) or a predetermined refuse distribution associated to the presence of strange elements in the hopper. Said threshold of determined volume of refuse present in the hopper may be constant or variable. Other examples of predetermined conditions may also include the refuse distribution in the hopper. In this case, where a refuse distribution in the hopper is identified by the control unit to be strange such that it can be associated for example to the presence of strange elements, such as living beings, persons, furniture, demolition waste etc. the compactor is enabled to operate according to a mode in which it is manually operated by an operator. Other predetermined conditions for operating the compactor are of course possible.

**[0020]** The present garbage truck and operating method thereof allow energy consumption to be advantageously reduced since the compactor is only operated as necessary. As a result, generation and emission of pollutants as well as noise are advantageously reduced. In addition, wearing of associated mechanic parts such as parts of the compactor, the engine, power take off etc. is also reduced.

**[0021]** Additional objects, advantages and features of examples of the present garbage truck will become apparent to those skilled in the art upon examination of the description, or may be learned by practice thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0022]** Particular non-limiting examples of the present garbage truck will be described in the following, with reference to the appended drawings, in which:

Figure 1 is a side elevational view of one example of a rear-loader garbage truck according to the present disclosure;

Figure 2 is a rear elevational view of the garbage truck shown in figure 1;

Figures 3 and 4 are side elevational views of the hopper of the present garbage truck according to two different examples where the sensor camera can be located;

Figures 5-7 are rear views of the hopper of the present garbage truck according to further examples where the sensor camera can be located; and

Figure 8 is an operating diagram that diagrammatically illustrates the garbage truck operation according to the present method.

DETAILED DESCRIPTION OF EXAMPLES

**[0023]** In the non-limiting examples shown in figures 1 and 2 of the drawings, a rear-loader garbage truck is illustrated which has been denoted as a whole by reference numeral 100. The present disclosure is of course applicable in many other types of garbage trucks such as for example of the front-loader or side-loader type.

**[0024]** According to the drawings in figures 1 and 2, the garbage truck 100 comprises a truck body 110 with a hopper 200 installed at the rear of the garbage truck 100 defining an interior volume 210 for receiving refuse. The garbage truck 100 further includes a hydraulically powered tailgate 540, and a mechanism 300 to lift refuse containers (not shown) and unload their contents into the hopper 200. Inside the hopper 200, a compactor 400 is also provided comprising a hydraulic press suitable for compacting the refuse therein.

**[0025]** Referring to figures 3-7 of the drawings, machine vision means 500 are provided. The machine vision means 500 are suitably configured for generating bi-dimensional or three-dimensional geometries of the interior 210 of the hopper 200. From said generated geometries, a volume of refuse that is present in the hopper 200 can be accurately determined. From the volume of refuse that is determined, relevant features thereof such as amount, for example weight of refuse in the hopper, the shape of a volume of refuse in the hopper, the distribution of the refuse in the hopper, and even changes in the position of the refuse can be obtained.

**[0026]** The machine vision means 500 in the example shown in the drawings comprise a source of infrared light 510 and a camera sensor 520. The camera sensor 520 in the example shown in figures 3-7 of the drawings is arranged at the vertex of a cone defined by a light beam 530 that is projected by the source of infrared light 510.

Other shapes and combinations of shapes of the light beam 530 such as square based pyramid, or rectangular based pyramid are also possible.

**[0027]** The camera sensor 520 may be mounted in different positions in the garbage truck 100. In the example shown in figures 3-7, the camera sensor 520 is mounted on the tailgate 540 of the garbage truck 100. Specifically, in the example shown in figure 3, the camera sensor 520 is mounted on a central part of a tailgate 540 of the garbage truck 100. In the example shown in figure 4, the camera sensor 520 is mounted on a lower part of a tailgate 540 of the garbage truck 100. Figures 5-7 show examples where the camera sensor 520 is mounted on a left-hand, central and right-hand upper parts of a tailgate 540 of the garbage truck 100, respectively. Other locations for the camera sensor 520 are possible as long as refuse in the interior 210 of the hopper 200, if present, can be at least partially illuminated.

**[0028]** The camera sensor 520 is connected to the source of infrared light 510. The source of infrared light 510 is configured to project said cone shaped beam of infrared light 530 towards the interior 210 of the hopper 200. The light beam 530 projected by the source of infrared light 510 towards the interior 210 of the hopper 200 is reflected by the hopper 200 itself or by surfaces of any refuse matter present therein into the camera sensor 520.

**[0029]** Means are also provided for periodically generating geometries corresponding to the interior 210 of the hopper 200 based on light projected by the source of infrared light 510. Specifically, the hopper geometry generating means (not shown in the drawings) together with the camera sensor 520, connected to the source of infrared light 510, allows distances from the camera sensor 520 to different points in the hopper 200 to be accurately determined. This is carried out through a time-of-flight principle (ToF) using a time difference between the emission of infrared light towards the interior 210 of the hopper 200 and its return to the camera sensor 520.

**[0030]** The present garbage truck 100 further includes a control unit 600 that is connected to the machine vision means 500. The control unit is configured for monitoring an area of the interior 210 of the hopper 200 so as to determine a volume of refuse that is present therein.

**[0031]** As a result of the distances that have been determined, geometries corresponding to the interior 210 of the hopper 200 can be accurately generated. The obtained geometries of the interior 210 of the hopper 200 allow a volume of refuse in the interior 210 of the hopper 200 to be quantitatively and qualitatively determined. Quantitatively and qualitatively determining geometries of the interior 210 of the hopper 200 whether refuse is present or not, involves obtaining information on relevant characteristics of the refuse in the hopper 200 such as amount, for example weight of refuse in the hopper 200, shapes of volume of refuse in the hopper 200, distributions of refuse in the hopper 200, and even changes in the position of refuse in the hopper 200. Other ant characteristics of the refuse in the hopper 200 can be also determined through the machine vision means 500.

**[0032]** From said obtained geometries of the interior 210 of the hopper 200 and relevant characteristics of the refuse therein, the compactor 400 can be then controlled by the control unit 600 according to a given operating mode. In addition, or alternatively, the obtained geometries of the interior 210 of the hopper 200 can be shown to an operator through a display (not shown) or suitable equipment, for example remotely. The relevant characteristics of the refuse that is present in the interior 210 of the hopper 200 can be received both by the control unit 600 and the operator in order to automatically and/or manually operate the compactor 400 accordingly.

**[0033]** In operation, and according to the operating diagram shown in figure 8, the source of infrared light 510 projects a cone shaped beam 530 of infrared light as shown in figures 3-7 for illuminating the interior of the hopper 200 of the garbage truck 100. Distances from the camera sensor 520 to different points of the interior 210 of the hopper 200 are calculated by the machine vision means 500 based on time difference between the emission of modulated light (infrared light in this example) and its return to the camera sensor 520.

**[0034]** From said distances, a mathematic model is generated. This mathematic model corresponds to bidimensional or three-dimensional geometries of the interior 210 of the hopper 200. This operation is first carried out in a first step 1000 for an empty condition of the hopper 200, that is, when no refuse is present in the hopper 200, so as to suitably calibrate the machine vision means 500.

**[0035]** In a further step 1010, additional distances from the camera sensor 520 to different points of the interior 210 of the hopper 200 are subsequently and periodically measured by the machine vision means 500 while the compactor 400 can be in use.

**[0036]** Volume differentials are then calculated relating to refuse left in the hopper 200 from which a volume of refuse present in the hopper 200 can be determined according to said geometries of the interior 210 of the hopper 200. Said volume of refuse in the hopper 200 can be then quantitatively and qualitatively determined, that is, not only amounts of refuse present in the hopper 200 can be calculated but also shapes and distributions of refuse in the hopper 200, etc.

**[0037]** In a step 1020, a volume of refuse present in the interior 210 of the hopper 200 is compared with a predetermined threshold, such as for example amount, weight, volume, and the like. If a volume of refuse present in the interior 210 of the hopper 200 does not exceed a predetermined threshold, then the compactor 400 is disabled according to step 1030. If a volume of refuse present in the interior 210 of the hopper 200 exceeds a predetermined threshold, then a step 1040 is performed.

**[0038]** In said step 1040, a volume of refuse present in the interior 210 of the hopper 200 is analysed for determining whether a profile of a volume of refuse in the hopper 200 is considered normal. If the profile of a volume of refuse in the hopper 200 is considered to have a normal distribution, for example when compared to a predetermined volume profile whose distribution is considered notmal, then a step 1050 is performed in which the compactor 400 is operated either automatically or manually by an operator, according to a specific mode of operation, such as automatic-cycle, manual-cycle, or semi-automatic-cycle. Instead, if the profile of a volume of refuse in the hopper 200 is considered not to have a normal distribution, for example a distribution that can be associated to the presence of strange elements in the hopper, such as living beings, persons, furniture, demolition waste etc., then a step 1060 is performed in which the compactor 400 is automatically set by the control unit 600 according to a mode in which it is manually operated by an operator.

**[0039]** The step 1010 may be repeated for periodically performing additional distances from the camera sensor 520 to different points of the interior 210 of the hopper 200.

**[0040]** Although only a number of particular examples of the present garbage truck have been disclosed herein, it will be understood by those skilled in the art that other alternative examples and/or uses and obvious modifications and equivalents thereof are possible. The present disclosure covers all possible combinations of the particular examples described. The scope of the present disclosure should not be limited by particular examples, but should be determined only by a fair reading of the claims that follow.

**[0041]** Reference signs related to drawings and placed in parentheses in a claim, are solely for attempting to increase the intelligibility of the claim, and shall not be construed as limiting the scope of the claim.

## Claims

1. Garbage truck (100) comprising a hopper (200) for collecting refuse, a compactor (400) for compacting refuse inside the hopper (200), machine vision means (500), and a control unit (600) connected to the machine vision means (500) and configured for monitoring an area of the interior (210) of the hopper (200) so as to determine a volume of refuse present inside the hopper (200) for controlling the compactor (400) according to a given operating mode depending on the volume of refuse present in the hopper (200).

2. Garbage truck (100) according to claim 1, wherein the machine vision means (500) comprise:

   - a source of modulated light (510) arranged for illuminating a volume in the interior (210) of the hopper (200) with modulated light;
   - a camera sensor (520) connected to the source of modulated light (510) and arranged for receiving light reflected by the hopper (200) so as to determine distances from the camera sensor (520) to different points in the hopper (200) based on time difference between the emission of modulated light and its return to the camera sensor (520); and
   - means (540) for periodically generating geometries corresponding to the interior (210) of the hopper (200) from said determined distances so as to determine a volume of refuse present in the hopper (200).

3. Garbage truck (100) according to claim 2, wherein said geometry generating means (540) are suitable for periodically generating three-dimensional geometries corresponding to the interior (210) of the hopper (200).

4. Garbage truck (100) according to any of the preceding claims, wherein the control unit is configured to operate the compactor (400) according to one operating mode based on the determined volume of refuse present in the hopper (200).

5. Garbage truck (100) according to claim 4, wherein said mode of operation of the compactor (400) is one of automatic-cycle, manual-cycle, or semi-automatic-cycle.

6. Garbage truck (100) according to any of the preceding claims, wherein the source of modulated light (510) is configured to provide a light beam in the shape of a cone, or a square based pyramid, or a rectangular based pyramid.

7. Garbage truck (100) according to any of the preceding claims, wherein the source of modulated light (510) is configured to project infrared light.

8. A method for operating a garbage truck (100), the garbage truck (100) comprising a hopper (200) for collecting refuse and a compactor (400) for compacting the refuse, **characterized in that** the method comprises the steps of

   - illuminating an interior (210) of the hopper (200) with modulated light;
   - measuring distances from a camera sensor (520) to different points inside the hopper (200) based on time difference between the emission of modulated light and its return to the camera sensor (520);
   - generating, from said measured distances, a mathematic model corresponding to a geometry of the interior (210) of the hopper (200) under a given hopper loading condition;
   - determining a volume of refuse present in the

interior (210) of the hopper (200) according to said mathematic model of the interior (210) of the hopper (200);
- if a determined volume of refuse present in the interior (210) of the hopper (200) meets a predetermined condition, actuating the compactor (400) according to one mode of operation.

**9.** The method of claim 8, wherein said predetermined condition includes exceeding a predetermined threshold.

**10.** The method of claim 8 or 9, wherein said predetermined condition includes a predetermined refuse distribution associated to the presence of strange elements in the interior (210) of the hopper (200).

**11.** The method of any of the claims 8-10, wherein said mode of operation of the compactor (400) is one of automatic-cycle, manual-cycle, or semi-automatic-cycle.

**12.** The method of any of the claims 8-11, wherein the source of modulated light (510) is configured to project modulated light defining a volume in the shape of a cone, or a square based pyramid, or a rectangular based pyramid.

**13.** The method of any of the claims 8-12, wherein said threshold of determined volume of refuse present in the interior (210) of the hopper (200) is constant or variable.

**14.** The method of any of the claims 8-13, wherein said geometry of the interior (210) of the hopper (200) that is generated by said measured distances is a three-dimensional geometry.

**15.** The method of any of the claims 8-14, wherein said given hopper loading condition involves no refuse present in the hopper (200), or at least an amount of refuse present in the hopper (200).

FIG.1

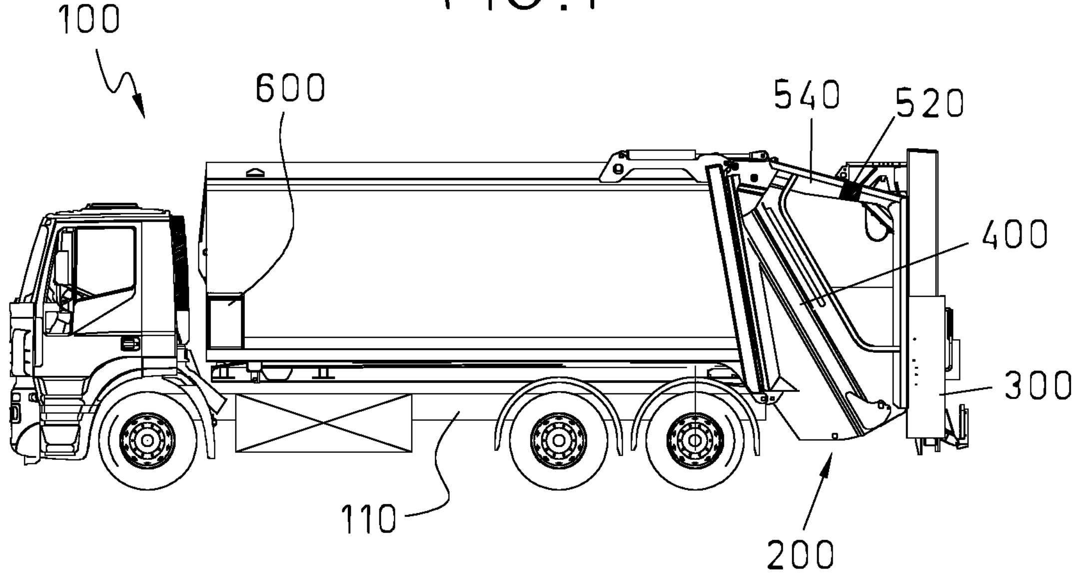



FIG.2

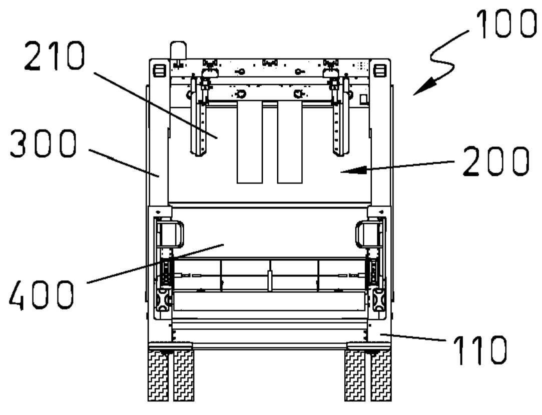


FIG.3

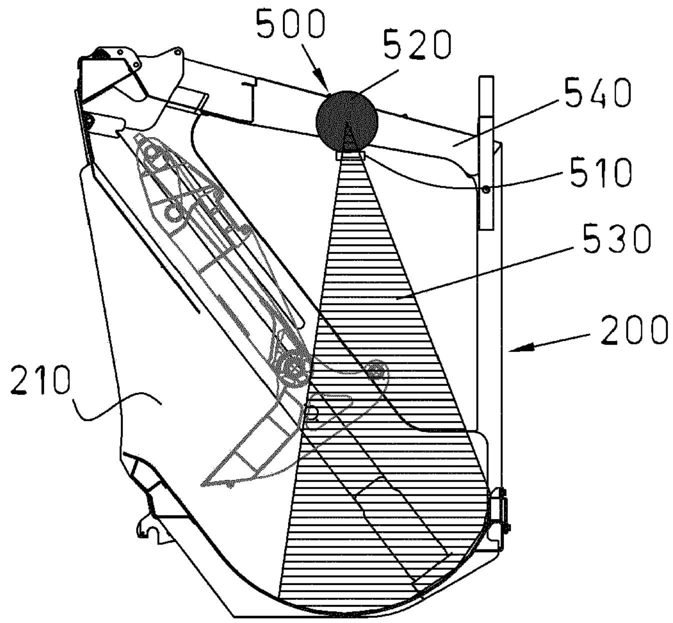



FIG.4

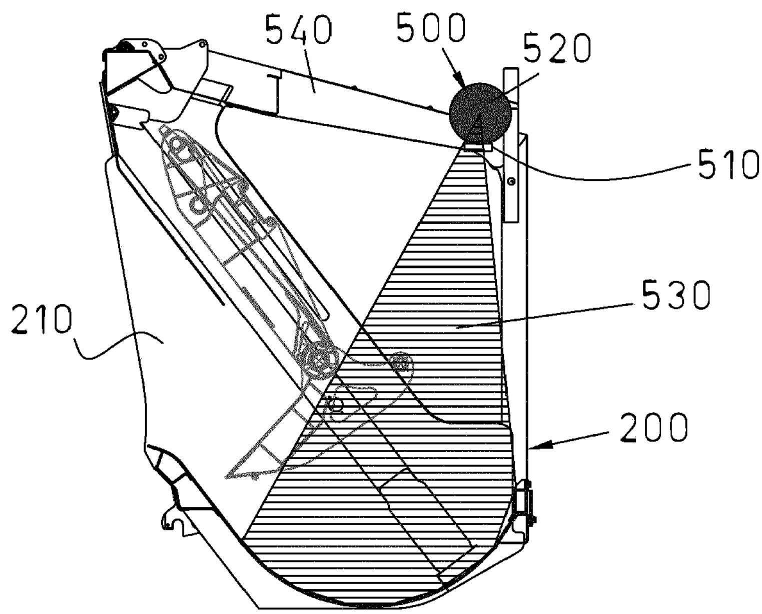


FIG.5

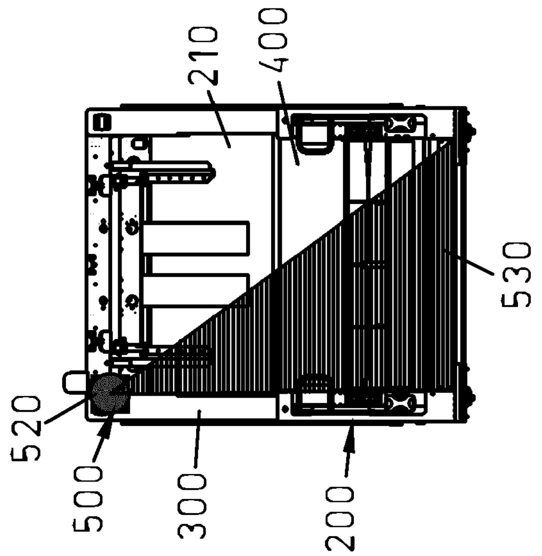



FIG.6

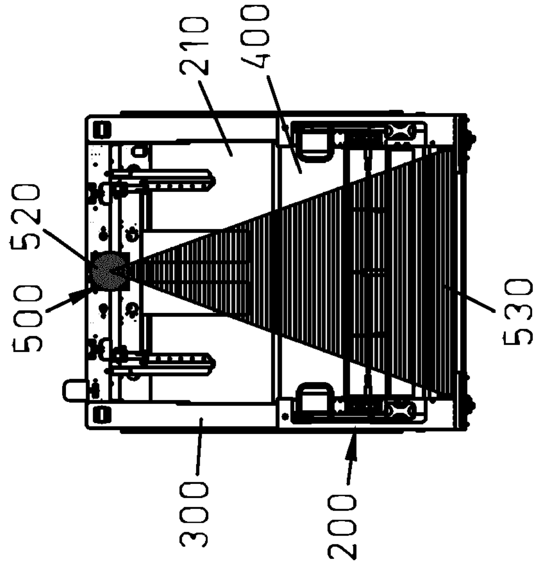



FIG.7

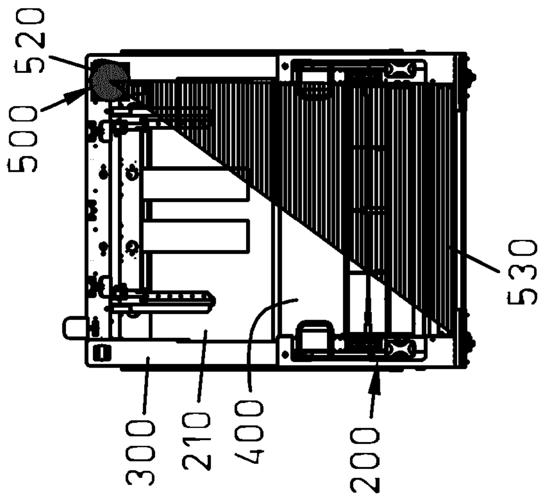
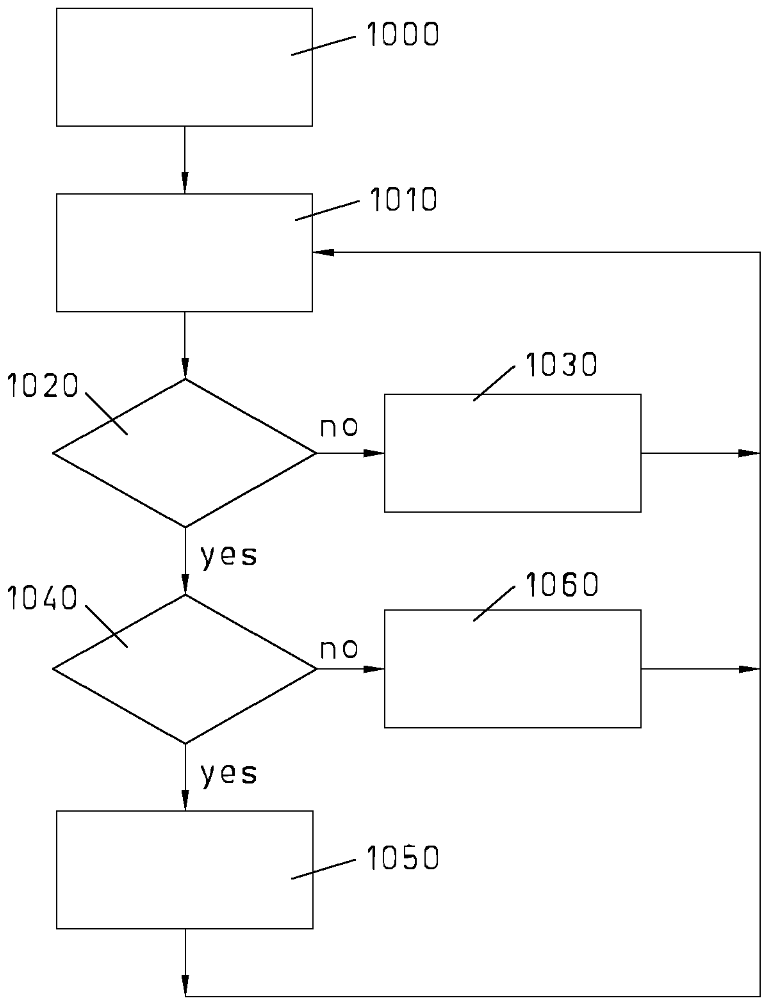


FIG.8



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# EUROPEAN SEARCH REPORT

Application Number
EP 17 38 2767

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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TECHNICAL FIELDS SEARCHED (IPC)

B65F

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 24 April 2018 | Luepke, Erik |

CATEGORY OF CITED DOCUMENTS

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