(12) UK Patent Application (19) GB (11) 2587641 (13) A

(43) Date of A Publication **07.04.2021**

(21) Application No: **1914239.7**

(22) Date of Filing: **02.10.2019**

(51) INT CL:
G01G 19/08 (2006.01) ***B65F 3/00*** (2006.01)

(56) Documents Cited:
GB 2253066 A **US 4824315 A**

(58) Field of Search:
INT CL **B65F, B66F, G01G**
Other: **WPI, EPODOC, Patent Fulltext**

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(54) Title of the Invention: **Refuse collection vehicle weighing system**
Abstract Title: **Method of and apparatus for measuring weight of refuse deposited in a refuse vehicle using buffered data to define weighing windows**

(57) Method of and apparatus for measuring a weight of waste material deposited into a refuse vehicle comprising provision of a refuse vehicle 30 with mechanical lift-arm 10 to lift waste container 5 to deposit waste material into the vehicle. A transducer-based weighing system (the transducer may be a piezoelectric or compression load-cell) for weighing the container during operation of the lift-arm is configured to output an electrical signal comprising a plurality of data points (380 figure 3) which are buffered to determine at least one weighing window (310, 360 figure 3), before and after the container is emptied, relative to respective trigger points (330, 350 figure 3) which may relate to the rate of change of the data values. The data points are processed to determine the weight of the container within each weighing window, the difference between the weight before and after emptying defining the weight of material deposited.

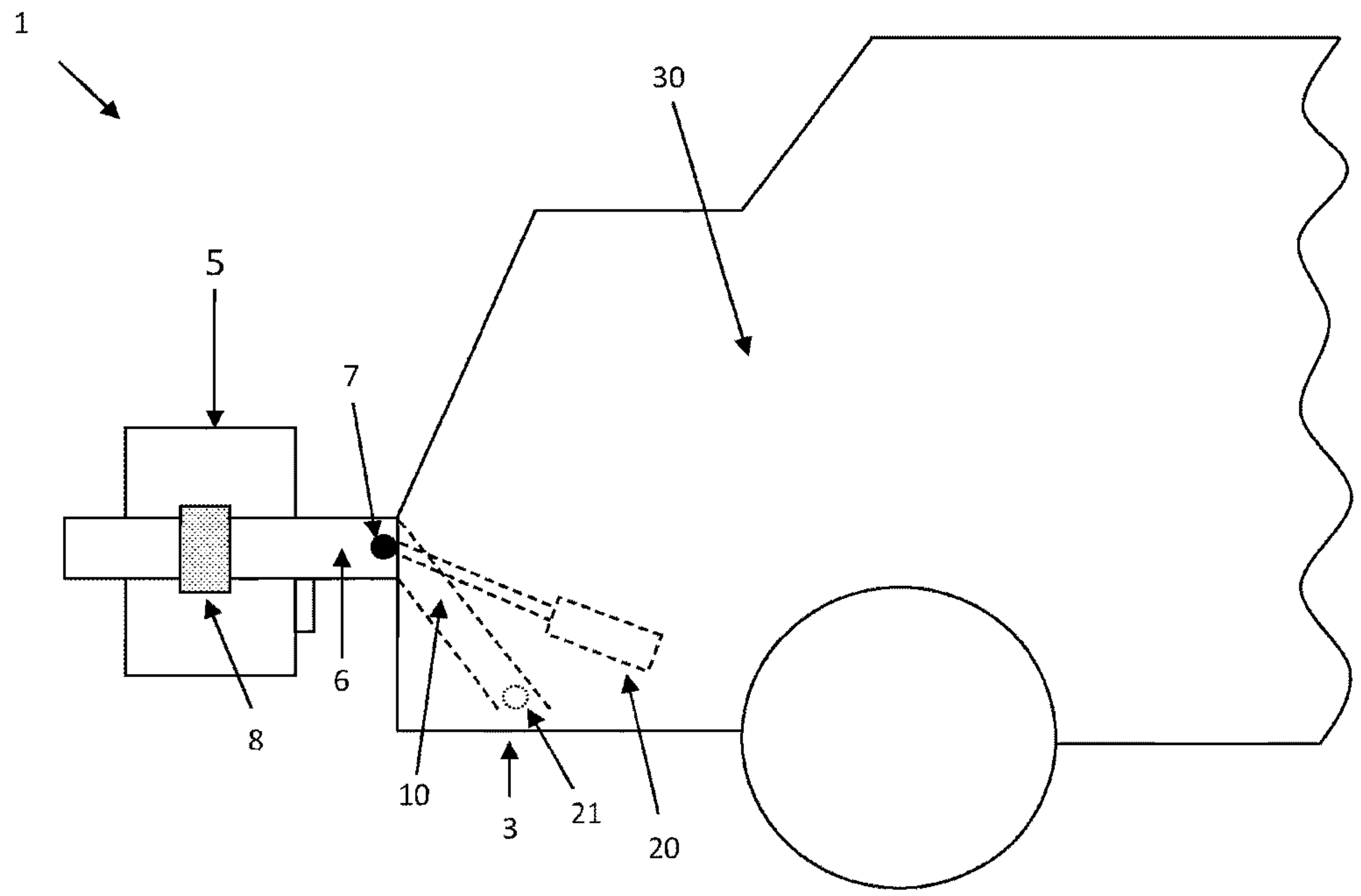

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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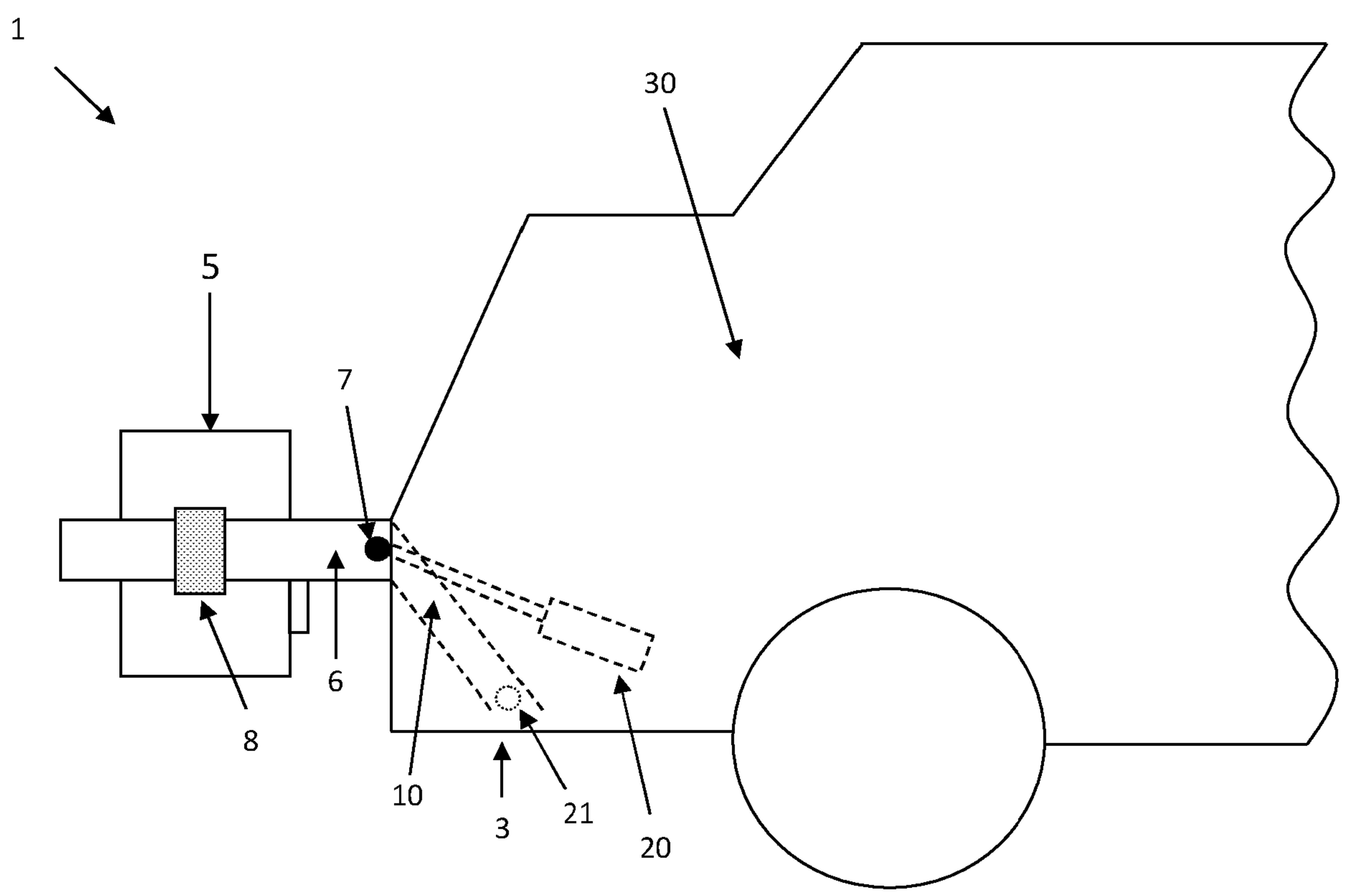


FIG. 1

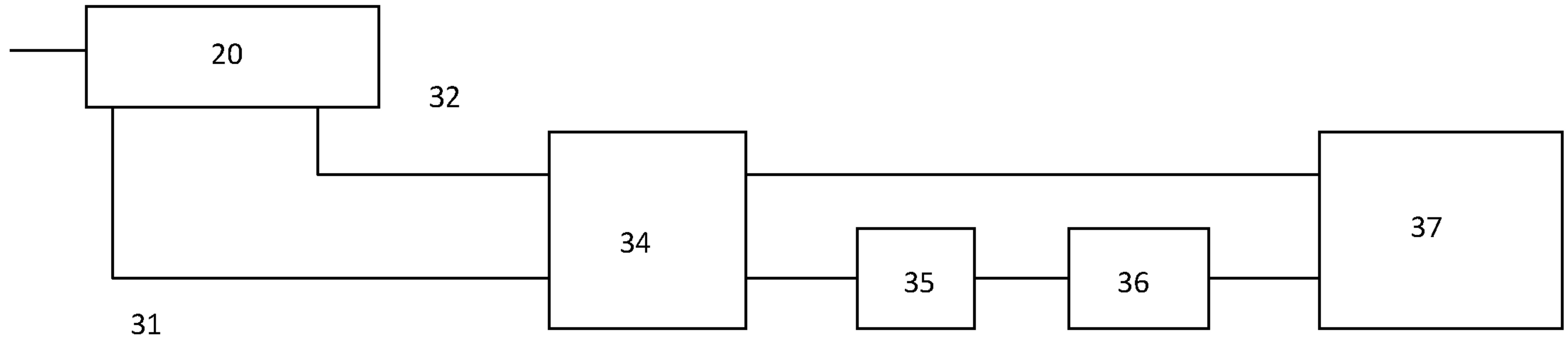
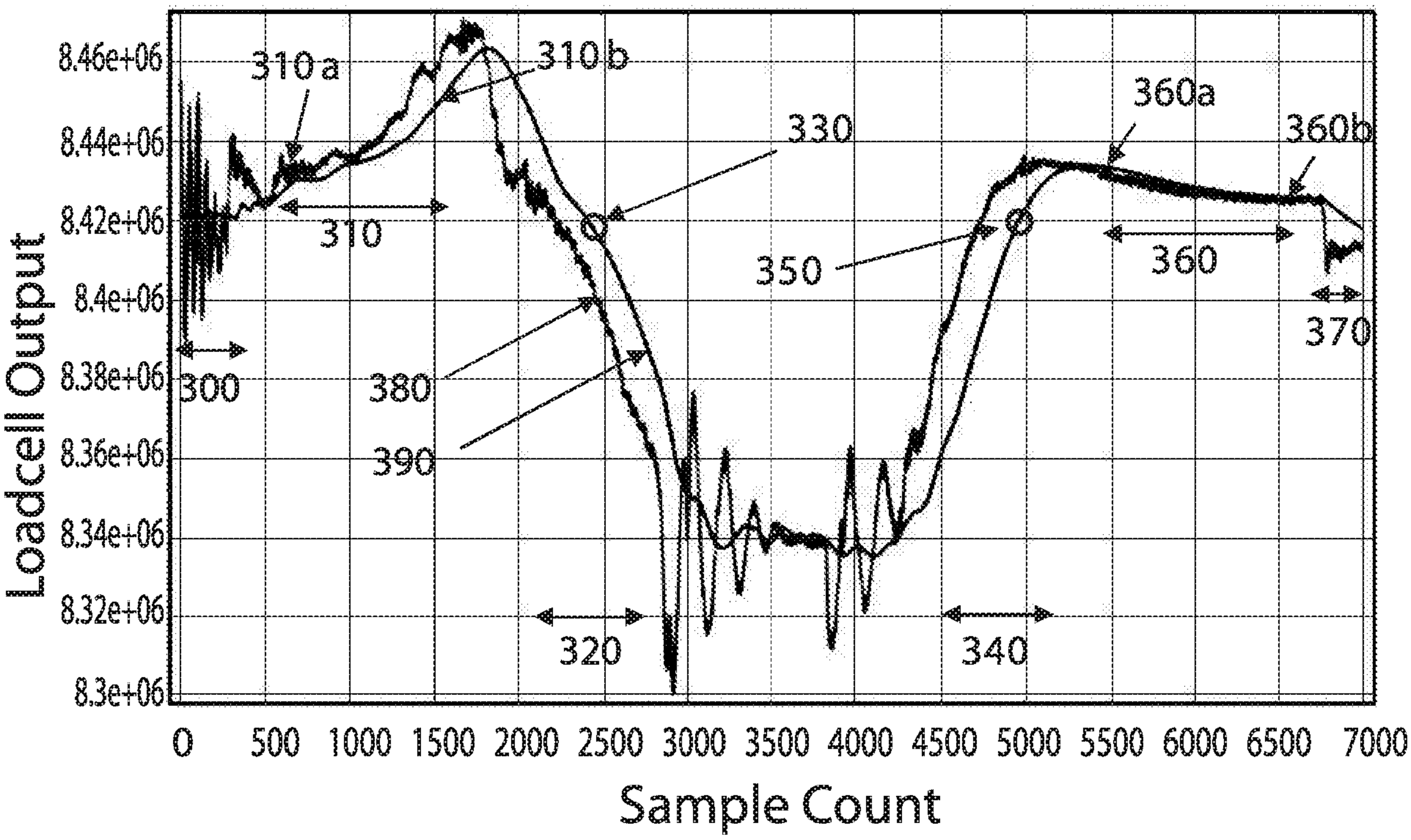


FIG. 2



8.46e+06
8.44e+06
8.42e+06
8.4e+06
8.38e+06
8.36e+06
8.34e+06
8.32e+06
8.3e+06
Loadcell Output
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Sample Count
310 a
310 b
310
330
300
380
390
320
340
350
360a
360b
360
370

FIG. 3

12 12 19

Title

Refuse Collection Vehicle Weighing System

Field

The present application relates to the field of load weighing systems. The invention more particularly relates to the weighing of material in a container being lifted. The invention more particularly relates to statically or dynamically determining the weight of material lifted using a refuse collection lifting system.

Background of The Invention

Municipalities and private waste collectors continue to implement new systems and methods to improve the efficiency of the waste and recyclables collection operation. In order to reduce landfill costs, Pay-As-You Throw (PAYT) programs have been developed. These programs change the waste cost model from a flat fee to a unit fee structure where the total waste cost is dependent on the amount of waste the household presents for collection, and the amount of waste diverted to recycling. A unit fee structure can be either volume-based or weight based. A volume-based waste price structure involves charging the household based on the waste container volume. However, a weight-based price structure rewards the household for continuous improvement in their recycling diversion rate and reduction in total waste generated. This results in a more equitable waste cost structure. By combining bin identification and weighing technology the customer can be billed based on total waste weight. This presents a challenge to the waste industry to provide effective waste container identification and weighing capability. The waste must be dynamically weighed as the waste container is lifted and emptied by the waste truck to avoid negatively impacting the rate of waste collection. It is also important to monitor the load carried by a waste truck to address weight restriction safety requirements and to protect against the resultant fines from trucks being overweight.

In typical refuse collection and weighing systems the collection vehicle stops adjacent to the waste container. The loader engages the waste container. The engagement means are supported on a weighing device such as a load cell. The waste container is uniquely identified through an information exchange between the waste container and the loader. The waste container is lifted by the loader. The waste container is weighed a number of times at predetermined points of the lifting cycle known as the weighing window. The lift mechanism continues to lift the waste container, and partially inverts it to empty the content into a receiving area of the waste collection vehicle. After dumping the empty container is returned to its original position. During the downward cycle the waste container is also weighed. The waste weight is calculated by subtracting the downward reading from the upward reading.

However, there are difficulties in using transducers mounted on the lifting element of a waste collection vehicle. The dynamics of the lift process creates significant vibrations due to the powerful hydraulic system. This presents a challenge to the static weighing of a load. The challenge is magnified when attempting to weigh the load dynamically during the lift operation.

Problems also include the uneven placement of material in the waste/recycle container, the movement of containers during the lifting cycle and the rough action of the hydraulic system with acceleration and deceleration forces that make dynamic weighing very difficult.

Mechanical vibrations and oscillation create noise signals for the weighing system. The time taken for a complete oscillation to occur is known as the oscillatory period. In order to ‘smooth out’ or average the noise effectively a number of periods of the mechanical oscillation must be captured. However, this challenge is further increased due to the inconsistency of the oscillation frequency and amplitude and the limited time available to complete the weighing operation.

Firstly, the oscillation frequency is not consistent. The oscillations vary depending on a number of factors including the weight of the load, load imbalance, engine noise from the waste truck, movement of the mechanical lift arm, uneven friction of mechanical moving parts, and environmental factors such as the strength of the wind.

Secondly, there is a limited time available. The window of opportunity for weighing during the lift cycle can be less than 1 second. In this case, if the mechanical oscillations have a period approaching 1 second, then it is impossible to capture multiple periods in order to enable averaging. Solutions that require slowing down or stopping the lift cycle to allow static weighing have disadvantages because of the reduction in productivity.

In view of the above, the inventors have identified a need for an accurate weight measurement system for a container being lifted.

These and other features will be better understood with reference to the following figures which are provided to assist in an understanding of the teaching of the invention.

Summary

Accordingly, a first embodiment of the application provides a method as detailed in claim 1 and a vehicle as provided in claim 12. Advantageous embodiments are provided in the dependent claims.

Brief Description of The Drawings

The present application will now be described with reference to the accompanying drawings in which:

Figure 1 is a diagram of a waste collection vehicle equipped with a weight measurement system for accurately determining the weight of waste or recyclable material in the waste collection vehicle, according to an embodiment of the present teaching;

Figure 2 is a block diagram of a part of a hydraulic system included in the weight measurement system, according to an embodiment of the present teaching;

Figure 3 is a graph illustrating a typical load cell output from a load weighing system and a weight measurement system according to the present teaching.

Detailed Description of The Drawings

The present teaching has application to any environment where accurate weighing of material in a container is required. Examples of such applications include the lifting of material such as mining ore or the like using hydraulic arms and the transport of that lifted ore to a secondary location. In such environments it is useful to accurately weigh the material that was initially disposed in the container prior to its transfer to the secondary location. In such an exemplary application where the container- typically the bucket of an articulated arm- is well known, one measurement value of the weight will be sufficient in that the bucket is a constant value. For the sake of explanation and not to limit the present teaching to any one application, the teaching will be described with reference to the weighing of waste material such as domestic or commercial refuse which is typically stored in one or more containers which are then lifted during a collection period and the waste previously within the containers is then disposed into the refuse collection vehicle. Such reference to an exemplary waste measurement system will be appreciated as being provided to assist in an understanding of the teaching of the invention and should not be construed as limiting in any fashion.

Figure 1 is a diagram of a waste collection vehicle 1 equipped with a weight measurement system for accurately determining the weight of waste or recyclable material in the waste collection vehicle 1, according to an embodiment of the present teaching. Referring to Figure 1, the weight measurement system includes a hydraulic system 3 including a mechanical lift arm 10 for lifting and emptying a waste container 5, and a transducer-based weighing system for weighing the waste in the waste container 5.

The weight measurement system according to the present teaching can be applied to any type of conventional waste collection vehicle or other vehicle that is used for lifting material and may be used with a side, rear or front loading apparatus. However, for purposes of illustration, the weight measurement system according to the present teaching is described with reference to a rear loading apparatus, and specifically a waste collection vehicle incorporating such a rear loading apparatus.

The hydraulic system 3 may be arranged at the rear of the vehicle 1 and has major components comprising the mechanical lift arm 10 hingedly arranged with the vehicle at a pivot pin 21 and pivotable by operation of a lift cylinder 20 which will be described later. The waste collection vehicle 1 hydraulically pivots the mechanical lift arm 10 by pulling or pushing the lift arm 10.

The lift arm 10 is engageable with the waste container 5 by means of a loader assembly coupled to the lift arm 10. The loader assembly comprises a pivotable engageable arm 6 which is pivoted on the mechanical lift arm 10 at a pivot pin 7. Figure 1 shows only the left side of the vehicle 1 and the right side is not shown since it would be substantially the same because the hydraulic system 3 is generally symmetric.

The operation of the loader assembly is controlled by the hydraulic system 3 which includes appropriate manual controls in the vehicle cab such as an open/close gripping mechanism control unit having a control stick, extend/retract boom control unit having a control stick, and an on/off motor control unit having a control lever. These controls and associated hydraulic circuits are standard and are understood by those of ordinary skill in the art.

The weighing system can be any non-hydraulic weighing system that provides an indication of the weight of the waste or any hydraulic system providing an output in the form of an electrical signal representative of the load on the mechanical lifting device. In this regard, the weighing system may comprise at least one weight transducer 8 which is mounted on the engageable arm 6 for sensing the weight of the waste container 5 and for producing an electrical signal indicative of the weight. The weight transducer 8 may be a load cell such as a strain gauge load cell, a piezo-electric load cell or a compression load cell. However, the weight transducer 8 is not limited thereto. The output from the load cell is supplied by means of either a hard-wired conductor or transmitter to an appropriate decoder and on-board computer which processes this information. In an alternative arrangement, the output may be simply stored on the vehicle or in a cloud server for subsequent processing.

As indicated above, the output from the load cell provides an electrical signal indicative of the weight of the waste container 5. A single reading may be taken at any time during the upward movement of the waste container 5 prior to the dumping operation. Similarly, the weight of the empty waste container 5 or tare weight can be sensed at the load cell output at any time during the downward movement of the empty container 5 prior to placing the container 5 on the ground. It is more efficient to establish the weight readings during the upward and downward movement of the container 5 rather than stopping the container 5 during the cycle and negatively impacting the rate of waste collection. An average weight reading may be obtained, which may be computed from a continuous reading or series of readings taken during a portion of the lifting and lowering cycle. The continuous output of the load cells can be monitored during a selected portion of the container movement in a weighing zone and this continuous reading averaged and processed by the on-board computer or other appropriate processing means. The weighing is performed along a predetermined travel distance of the mechanical lift arm 10.

In some weighing systems, there is provided an arrangement in which a switch such as a limit switch may be operatively connected to the transducer so that the transducer is energized at a point when a full waste container 5 is supported by the mechanical lift arm 10 and when an empty waste container 5 is supported by the mechanical lift arm 10 for the purpose of determining the weight of the refuse in the waste container 5. This will be described in detail below.

The transducer is connected to the switching circuit but the output from the circuit is read during periods determined by the switching. In this way there is no settling of the transducer circuit required prior to taking a measurement. It will be understood that this switching is a result of the physical location of the limit switch and if modification is required this will need a physical movement of the switch. In an alternative arrangement the switch may be a rotary resistor which can be remotely managed through an external communication protocol. In such an arrangement the window of reading data may be changed by dynamically moving the operating region or set point of the rotary resistor. Such a rotary resistor is of course exemplary of the type of switching mechanism that may be employed where a remote changing of the measurement window is required.

The weighing process is performed as follows. The loader assembly engages the waste container 5. The waste container 5 is lifted by the mechanical lift arm 10. In more detail, the hydraulic system 3 used to actuate the mechanical lift arm 10 is itself a mechanical component part of the complete weight measurement system (when the hydraulic system 3 is pressurised), and the entire weight measurement system including the lifting mechanism is mechanically coupled into the hydraulic system 3.

Returning to the operating process, the waste container 5 is weighed a number of times in the weighing zone. The weighing zone may correspond to a time of less than 1 second. The mechanical lift arm 10 continues to lift the waste container 5, and partially inverts it to empty the content into a receptacle 30 of the waste collection vehicle 1. After dumping the empty container 5 is returned to its original position. During the downward cycle the waste container 5 is also weighed. The waste weight is calculated by subtracting the downward reading from the upward reading.

In the system arrangement mentioned above, a rotary resistor may be operatively connected to the load cell transducer so that the output from the transducer may be read at a point or within a window of points when a full container 5 is supported by the mechanical lift arm 10 and when an empty container 5 is supported by the mechanical lift arm 10 for the purpose of determining the weight of the refuse in the container. The rotary resistor may be disposed on the mechanical lift arm 10 and may be directly wired to the load cell transducer or microprocessor.

When the rotary resistor is activated, load cell readings are sampled or taken until the rotary resistor is deactivated. The activation region of the rotary resistor corresponds to the weighing window, and in this way, it will be understood that a plurality of individual readings may be taken during any cycle. These multiple readings taken during the weighing window may then be processed such as by use of a decoder and averaged by the on-board computer. In another arrangement raw data may be stored for subsequent processing. In a configuration whereby the measurement computation is done on-board, the gross weight is automatically captured and retained in memory by the weighing system. The mechanical lift arm 10 brings the container 5 to the dumping position and the refuse and waste materials are dumped into the receptacle 30. When the container 5 is emptied, the operator activates the controls to cause the mechanical lift arm 10 to move the container 5 downwardly until the rotary resistor is activated again to begin the weighing of the empty container until the rotary resistor is deactivated to stop the weighing of the empty container. The waste weight is calculated by subtracting the downward reading from the upward reading. In a configuration whereby the weight of the container is known, then it may not be necessary to weigh on both the up and down cycles of the lift as there is no need to factor in and weigh the empty container- it being a fixed value that can be pre-stored. The means of activating the weighing system is not limited to the above description, and any means of activating the weighing system can be used.

In the above-mentioned system arrangement, the inventors have identified a need to address restrictions and/or limitations to such a system arrangement that utilizes a switching mechanism for triggering a means for identifying a weighing window. In an embodiment of the invention, there is provided a system arrangement in which a switching mechanism is not used as a triggering means for identifying a weighing window. In this embodiment, the output from the load cell is continuously monitored and sampled throughout the course of the lift cycle.

The load cell output provides an electrical signal indicative of the weight of the waste container 5. The electrical signal comprises a plurality of sequential data points, each data point having an associated value indicative of the weight being measured.

A single reading may be taken at any time during the upward movement of the waste container 5 prior to the dumping operation. Similarly, the weight of the empty waste container 5 or tare weight can be sensed at the load cell output at any time during the downward movement of the empty container 5 prior to placing the container 5 on the ground. It is more efficient to establish the weight readings during the upward and downward movement of the container 5 rather than stopping the container 5 during the cycle and negatively impacting the rate of waste collection. An average weight reading may be obtained, which may be computed from a continuous reading or series of readings taken during a portion of the lifting and lowering cycle. The continuous output of the load cells can be monitored during a selected portion of the container movement in a weighing zone and this continuous reading averaged and processed by the on-board computer or other appropriate processing means. The weighing is performed along a predetermined travel distance of the mechanical lift arm 10.

There is provided a transducer-based weighing system for weighing the container during the operation of the mechanical arm before and after a deposit of waste out of the container, the transducer-based weighing system configured to provide an electrical output signal. The transducer output is read during periods determined by an analysis of the electrical output signal. The analysis of the electrical output signal comprises buffering the plurality of sequential data points to determine at least one weighing window before and after the deposit of waste material out of the container into the refuse vehicle, wherein the weighing windows are each determined relative to a respective trigger point, processing sequential data points within each of the at least one weighing windows to determine, within each of the respective at least one weighing windows, the weight of the container; and comparing the determined weight of the container within each of the at least one weighing windows before and after the deposit of waste to define the weight of material deposited into the refuse container. It will be understood that the determination of the location of the weighing windows may be effected in any one of a number of different ways. For example, it could be that each weighing window is spaced at a predetermined number of data points relative to a trigger point. In another arrangement, the location could be based on a time relationship. These and other mechanisms will be appreciated by those of ordinary skill.

As the output is continuously monitored and the values of the output signal are used to define trigger points within the weighing cycle, it will be understood that the present embodiment does not require the use of switches or other external triggers to identify weighing windows and therefore avoids the requirement for additional signals to identify a weighing window(s) or indeed any additional windows or events throughout the course of the lift cycle. The events including a coupling of an engagement arm with the container and a subsequent decoupling of the engagement arm with the container. In the course of the engagement arm being coupled with the container both a tipping and un-tipping event occur. The tipping event is the emptying of the contents of the container out of the container into the refuse vehicle. It will be appreciated that the tipping of the container is an action being performed by the mechanical lift arm as it lifts the container from a vertical position to a horizontal position so as to empty or deposit the waste material into the refuse vehicle- effectively, the container pivots, rotates or otherwise moves relative to a normal axis so as to effect an emptying of its contents. Having effected the tipping, or emptying, action, the container then returns through the same motion to the normal axis- in an un-tipping event. In this way the un-tipping of the container is an action being performed by the mechanical lift arm as it lifts the container from the horizontal position back to the vertical position after deposit of, or having emptied, the waste material into the refuse vehicle.

In this way, it will be appreciated that these tipping of the container into a refuse vehicle and an un-tipping of the container after deposit of the waste into the refuse vehicle are defined events in time. In accordance with the present teaching at least one weighing window is before the tipping of the container into a refuse vehicle and at least one other weighing window is subsequent to the un-tipping of the container.

The present embodiment, the trigger for the weighing window is determined only by the analysis of the electrical output signal from the transducer. The output of the transducer is monitored over the course of the entire lift cycle and the electrical output signal is buffered. The buffered signal is used to identify at least one window within the buffered signal. The at least one window being a weighing window in which the weight of the waste container during that point in time is measured or determined. The rate of change of the buffered signal is monitored to identify at least one trigger point before and after the deposit of waste from the waste container. The trigger points are then used to define a number of sample counts, wherein these number of samples counts comprise the weighing window.

The above-mentioned embodiment in which the analysis of the electrical signal triggers the window(s) and/or weighing window(s) address restrictions, limitation or restrictions and limitations with an arrangement that requires external inputs such as a switch to trigger the weighing window. Said embodiment removes the need to identify a physical location of, for example, a limit switch or rotary switch and avoids situations in which, if modification of the system is required, requires a physical movement of the switch of the system. Furthermore, the embodiment removes the need for remotely managing a switching mechanism through an external communication protocol. Such arrangement may be affected by a loss of communication due to some external factors such as for example interferences that may potentially block transmission/reception of the triggering and therefore the window of opportunity for measuring/weighing a container could be missed and therefore the weight of the container is not recorded due to lack of input from the external triggering mechanism. In such an arrangement that analyses the output signal for triggering the weighing window(s), the window of reading data may be changed based on the buffered output signal alone and does not require dynamically moving the operating region or set point of the rotary resistor. Furthermore, as mentioned above, the window of opportunity for weighing during the lift cycle can be less than 1 second and therefore there is a limited time window for activation of the switch for measurement via the weighing window and therefore a high margin for error may exist in such systems in that the activation of the transducer in a switch mechanism arrangement may potentially result in an activation for measurement which is outside of the window of opportunity or begins and ends too early with regard to the window of opportunity for weighing.

Figure 2 is a block diagram of a part of the hydraulic system 3, according to an embodiment of the present invention. Referring to Figure 2, the hydraulic system 3 includes the lift cylinder 20 which is mechanically coupled to the lift arm 10 for moving the lift arm 10, a hydraulic switch 34 for operating the lift cylinder 20, a hydraulic lift line 31 for conveying hydraulic fluid under pressure to operate the lift cylinder 20 and which is connected between the lift cylinder 20 and the hydraulic switch 34, a hydraulic lowering line 32 for releasing hydraulic fluid from the lift cylinder to lower the lift arm 10 and which is connected between the lift cylinder 20 and the hydraulic switch 34, a pump 36 and a reservoir 37. The hydraulic system 3 may optionally comprise a relief valve 35.

Figure 3 is a graph illustrating a typical load cell output from a load weighing system and a weight measurement system according to an embodiment of the present invention.

Referring to Figure 3, the X-axis shows a number of sample counts during the course of the lift cycle while the Y axis shows analog to digital converter code values representing a continuous output of the load cell during the engagement of a waste container by the load arm of a waste collection vehicle, during the upward lift of the waste container, during a downward lift of the waste container and upon disengagement of the waste container from the load arm of the waste collection vehicle.

The load cell signal information is converted for example, from millivolts into a digital representation using an analog to digital converter and sampled over the course of the lift cycle. Prior to the refuse container engaging with the system, the loadcell signal will show no activity and therefore will appear to show a flatline response indicating that no waste container is present on the system. Once the refuse container is being connected to the lifter, and the load is being sensed via the loadcell, the response curve will fluctuate showing activity and mechanical noise as the waste container settles on the lift chair. In this initial region 300, the initial load cell output fluctuations represent the engagement of the waste container with the mechanical lift arm. At least one weighing zone in the lift cycle is labelled as region 310 which represents the start of the upward lift of the waste container. This represents a window of opportunity to capture the weight of the waste container on the upward lift. As the lifter is moving upwards and the waste container is starting to rotate slowly from vertical, this presents a region of interest within the window of opportunity in which a weighing should be performed within that region. This region of interest 310 represents the window of opportunity to capture the weight of the waste container on the upward lift and defines as a weighing window.

Due to either the force of the clamp, or loadcell rotating into the horizontal position, the loadcell output experiences a large rate of change in its response as shown in the response curve showing a large rate of change or shift in the signal 320. During this transition period indicated by 320, analysis of the load cell output identifies, within a period of time in the sample count, a larger rate of change in the signal response defining a first trigger point 330. It will be appreciated that within this period of time the values of sequential data points decrease rapidly such that by evaluating the relative values of a plurality of sequential data points it is possible to identify when the rate of change decreases at a rate that is above a defined threshold value. This first trigger point is then utilized to determine the weighing window during the upward lift, this weighing window being at a period of time having data points that were output from the transducer before the data points that are used to identify this first trigger point. A number of sample counts prior to the first trigger point are taken to determine a sample count starting point 310a and a sample count end point 310b. The sample count starting point and the sample count end point correlates to the weighing window 310 in the upward lift. The sample count starting point provides a load cell output value and the sample count end point provides another load cell output value, wherein the load cell output for the sample count starting point is different to the loadcell output for sample count end point as can be seen in Figure 3. The loadcell output value at the sample count end point 310b is larger than the loadcell output value at the sample count starting point 310a.

Due to the release of the clamp or the loadcell rotating from the horizontal position and taking the load again as the lifter travels in the downward direction, the loadcell output experiences a large rate of change in its response as shown in the response curve showing a large rate of change or shift in the signal 340. During this transition period indicated by 340, analysis of the load cell output identifies within this period of time the values of sequential data points increasing rapidly such that by evaluating the relative values of a plurality of sequential data points it is possible to identify when the rate of change increases at a rate that is above a defined threshold value. This second trigger point is then utilized to determine the weighing window during the downward lift, this weighing window being at a period of time having data points that were output from the transducer after the data points that are used to identify this second trigger point 350.

This second trigger point is utilized to determine the weighing window during the downward lift. A number of sample counts after/following this second trigger point are taken to determine a sample count starting point 360a and a sample count end point 360b. The sample count starting point and the sample count end point correlates to the weighing window 360 in the downward lift. The sample count starting point provides a load cell output value and the sample count end point provides another load cell output value, wherein the load cell output for the sample count starting point is different to the loadcell output for sample count end point as can be seen in Figure 3, specifically within the window defined by 360. The loadcell output value at the sample count end point 360b is smaller than the loadcell output value at the sample count starting point 360a.

As the waste container is being disconnected from the lifter, additional fluctuations in the signal response 370 occur as a result of the disconnection and removal. The response curve, following the container removal, will return to a flatline response state indicating that no waste container is present on the system

The first and second trigger points are important as they are used as reference points to determine where the weighing operation should be performed. When the lifter is lifting the waste container, the system needs to detect the waste container dump, and then look backwards in the lift cycle measurement to find the correct sample to calculate the weight. When the waste container is returning to the ground, a further need is required in order to detect the transition from the waste container in the dump position to the waste container travelling in a downwards motion towards the ground as identified by the second trigger point, and then using this information to look forward or wait, until the correct sample location in the trace is identified in order to calculate the down weight of the waste container.

The line 380 represents actual analog to digital code, ADC, values that are output from the processing elements of the system of the present teaching. The code values are generated by converting the analog output signal from the loadcell to digital code values using an analog to digital converter in the weighing system. Significant oscillations in the load cell output are observed.

Note that within this illustrated example, a full oscillatory period has not been completed within the weighing zone. As discussed above, averaging of a partial oscillatory period will result in measurement error.

The line 390 represents a software generated moving average output of the analog to digital converter code values from the weight measurement system according to the present teaching.

As discussed previously, not all data output from the load cell is selected for calculating the weight. In this regard, the data used to calculate the weight of the contents is output during a weighing window corresponding to a period in the lift cycle after the container is engaged and has begun to be lifted, and if a second set of measurements corresponding to an empty container are required at another period when the empty container is being lowered back to its original position after the contents of the container have been transferred to a secondary location. As can be seen from Figure 3, the weighing window is selected after the load cell output fluctuations have settled and comprises a period of time or sample counts and as such may comprise a plurality of individual measurements which can be processed for statistical purposes.

As described above, buffering the electrical output signal of the transducer and processing the buffered output signal alone can be employed to trigger the weighing window. Processing the buffered output signal alone has the advantage of being capable of being automatically adapted for each measurement of the weight of material in a container being lifted as the weighing windows(s) are determined by the electrical output signal during periods of movement of the mechanical lift arm for a current measurement without having to be remotely managed through an external communication protocol, third party activation via a mechanical switch and without having to be physically moved. In such an arrangement the window of reading data may be changed by based on the analysed buffered output signal alone. The outputs from the transducer during the weighing window are processed by a processor to determine the weight. More specifically, within each of the at least one weighing windows identified, determining, by a processor, the weight of material in the container, the weight of the material in the container being based on the electrical output signal from the weight transducer.

The actual ADC code value load cell output overestimates the load, while the software generated moving average output according to the present teaching provides a more accurate representation of the final settled load cell output.

The words comprises/comprising when used in this specification are to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

While the present invention has been described with reference to some exemplary arrangements it will be understood that it is not intended to limit the teaching of the present invention to such arrangements as modifications can be made without departing from the spirit and scope of the present invention. In this way it will be understood that the invention is to be limited only insofar as is deemed necessary in the light of the appended claims.

CLAIMS

1. A method of measuring a weight of waste material being deposited into a refuse vehicle, the method comprising:

providing a refuse vehicle having a mechanical lift arm to lift a container with waste material therein so as to deposit the waste material from the container into the refuse vehicle;

providing a transducer-based weighing system for weighing the container during the operation of the mechanical lift arm before and after a deposit of waste material out of the container into the refuse vehicle, the transducer-based weighing system being configured to provide an electrical output signal comprising a plurality of sequential data points;

buffering the plurality of sequential data points to determine at least one weighing window before and after the deposit of waste material out of the container into the refuse vehicle, wherein the weighing windows are determined relative to a respective trigger point;

processing sequential data points within each of the at least one weighing windows to determine, within each of the respective at least one weighing windows, the weight of the container; and

comparing the determined weight of the container within each of the at least one weighing windows before and after the deposit of waste to define the weight of material deposited into the refuse container.

2. The method of claim 1, wherein the transducer-based weighing system comprising at least one weight transducer.

3. The method of claim 1, wherein the at least one weight transducer comprises a load cell.

4. The method of claim 3, wherein the load cell comprises a strain gauge load cell, a piezo-electric load cell or a compression load cell.

5. The method of any preceding claim wherein each of the sequential data points have an associated value.

6. The method of claim 1, wherein the trigger point is determined by evaluating a rate of change of the associated values of sequential data points, a trigger point being defined by determined rates of change being greater than defined threshold values.

7. The method of claim 6, wherein a first trigger point is determined during a period of time following an upward lift of the container with waste material, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points decrease at a rate greater than a defined threshold value.

8. The method of claim 6, wherein a second trigger point is determined during a period of time following a downward lift of the container, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points increase at a rate greater than a defined threshold value.

9. The method of claim 8, wherein the at least one weighing window before the deposit of waste is defined before the first trigger point and the at least one weighing window after the deposit of waste is defined after the second trigger point, the first trigger point being at a period in time before the second trigger point.

10. The method of claim 1, comprising processing the buffered electrical signal to identify distinct events in a weighing cycle, the distinct events including a coupling of an engagement arm with the container and a decoupling of the engagement arm with the container, a tipping of the container into a refuse

vehicle and an un-tipping of the container after deposit of the waste into the refuse vehicle and wherein at least one weighing window is before the tipping of the container into a refuse vehicle and at least one other weighing window is subsequent to the un-tipping of the container.

11. The method of claims 1 to 10 comprising:

using the weighing system to weigh the container on an upward movement and a downward movement of the lift arm;

subtracting the weight of the empty container from that of the loaded container to determine the weight of the material.

12. A refuse vehicle having a mechanical lift arm to lift a container with waste material therein so as to deposit the waste material from the container into the refuse vehicle, the refuse vehicle further comprising a transducer-based weighing system for weighing the container during the operation of the mechanical lift arm before and after a deposit of waste material out of the container into the refuse vehicle, the transducer-based weighing system being configured to provide an electrical output signal comprising a plurality of sequential data points; wherein the transducer-based weighing system further comprises a computer program which when executed on a processor of the weighing system is configured to:

buffer the plurality of sequential data points to determine at least one weighing window before and after the deposit of waste material out of the container into the refuse vehicle, wherein the weighing windows are determined relative to a respective trigger point;

process sequential data points within each of the at least one weighing windows to determine, within each of the respective at least one weighing windows, the weight of the container; and

compare the determined weight of the container within each of the at least one weighing windows before and after the deposit of waste to define the weight of material deposited into the refuse container,

13. The vehicle of claim 12, wherein the transducer-based weighing system comprising at least one weight transducer.

14. The vehicle of claim 12, wherein the at least one weight transducer comprises a load cell.

15. The vehicle of claim 14, wherein the load cell comprises a strain gauge load cell, a piezo-electric load cell or a compression load cell.

16. The vehicle of any one of claims 12 to 15, wherein each of the sequential data points have an associated value.

17. The vehicle of claim 12, wherein the trigger point is determined by evaluating a rate of change of the associated values of sequential data points, a trigger point being defined by determined rates of change being greater than defined threshold values.

18. The vehicle of claim 17, wherein a first trigger point is determined during a period of time following an upward lift of the container with waste material, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points decrease at a rate greater than a defined threshold value.

19. The vehicle of claim 17, wherein a second trigger point is determined during a period of time following a downward lift of the container, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points increase at a rate greater than a defined threshold value.

20. The vehicle of claim 19, wherein the at least one weighing window before the deposit of waste is defined before the first trigger point and the at least one

weighing window after the deposit of waste is defined after the second trigger point, the first trigger point being at a period in time before the second trigger point.

21. The vehicle of claim 12, wherein the computer program is configured to process the buffered electrical signal to identify distinct events in a weighing cycle, the distinct events including a coupling of an engagement arm with the container and a decoupling of the engagement arm with the container, a tipping of the container into a refuse vehicle and an un-tipping of the container after deposit of the waste into the refuse vehicle and wherein at least one weighing window is before the tipping of the container into a refuse vehicle and at least one other weighing window is subsequent to the un-tipping of the container.

22. The vehicle of any one of claims 12 to 21 wherein the computer program is configured to:

use the weighing system to weigh the container on an upward movement and a downward movement of the lift arm;

subtract the weight of the empty container from that of the loaded container to determine the weight of the material.

Amendments have been filed as follows:-

CLAIMS

1. A method of measuring a weight of waste material being deposited into a refuse vehicle, the method comprising:

providing a refuse vehicle having a mechanical lift arm to lift a container with waste material therein so as to deposit the waste material from the container into the refuse vehicle;

providing a transducer-based weighing system for weighing the container during the operation of the mechanical lift arm before and after a deposit of waste material out of the container into the refuse vehicle, the transducer-based weighing system being configured to provide an electrical output signal comprising a plurality of sequential data points;

buffering the plurality of sequential data points to determine at least one weighing window before and after the deposit of waste material out of the container into the refuse vehicle, wherein the weighing windows are determined relative to a respective trigger point;

processing sequential data points within each of the at least one weighing windows to determine, within each of the respective at least one weighing windows, the weight of the container; and

comparing the determined weight of the container within each of the at least one weighing windows before and after the deposit of waste to define the weight of material deposited into the refuse container.

2. The method of claim 1, wherein the transducer-based weighing system comprises a load cell.

3. The method of claim 2, wherein the load cell comprises a strain gauge load cell, a piezo-electric load cell or a compression load cell.

4. The method of claim 1, wherein the trigger point is determined by evaluating a rate of change of associated values of the sequential data points, a

trigger point being defined by determined rates of change being greater than defined threshold values.

5. The method of claim 4, wherein a first trigger point is determined during a period of time following an upward lift of the container with waste material, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points decrease at a rate greater than a defined threshold value.

6. The method of claim 4, wherein a second trigger point is determined during a period of time following a downward lift of the container, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points increase at a rate greater than a defined threshold value.

7. The method of claim 6, wherein the at least one weighing window before the deposit of waste is defined before the first trigger point and the at least one weighing window after the deposit of waste is defined after the second trigger point, the first trigger point being at a period in time before the second trigger point.

8. The method of claim 1, comprising processing the buffered electrical signal to identify distinct events in a weighing cycle, the distinct events including a coupling of an engagement arm with the container and a decoupling of the engagement arm with the container, a tipping of the container into a refuse vehicle and an un-tipping of the container after deposit of the waste into the refuse vehicle and wherein at least one weighing window is before the tipping of the container into a refuse vehicle and at least one other weighing window is subsequent to the un-tipping of the container.

9. The method of claims 1 to 8 comprising:

using the weighing system to weigh the container on an upward movement and a downward movement of the lift arm;

subtracting the weight of the empty container from that of the loaded container to determine the weight of the material.

10. A refuse vehicle having a mechanical lift arm to lift a container with waste material therein so as to deposit the waste material from the container into the refuse vehicle, the refuse vehicle further comprising a transducer-based weighing system for weighing the container during the operation of the mechanical lift arm before and after a deposit of waste material out of the container into the refuse vehicle, the transducer-based weighing system being configured to provide an electrical output signal comprising a plurality of sequential data points; wherein the transducer-based weighing system further comprises a computer program which when executed on a processor of the weighing system is configured to:

buffer the plurality of sequential data points to determine at least one weighing window before and after the deposit of waste material out of the container into the refuse vehicle, wherein the weighing windows are determined relative to a respective trigger point;

process sequential data points within each of the at least one weighing windows to determine, within each of the respective at least one weighing windows, the weight of the container; and

compare the determined weight of the container within each of the at least one weighing windows before and after the deposit of waste to define the weight of material deposited into the refuse container,

11. The vehicle of claim 10, wherein the transducer-based weighing system comprises a load cell.

12. The vehicle of claim 11, wherein the load cell comprises a strain gauge load cell, a piezo-electric load cell or a compression load cell.

13. The vehicle of claim 10, wherein the trigger point is determined by evaluating a rate of change of associated values of the sequential data points, a trigger point being defined by determined rates of change being greater than defined threshold values.

14. The vehicle of claim 13, wherein a first trigger point is determined during a period of time following an upward lift of the container with waste material, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points decrease at a rate greater than a defined threshold value.

15. The vehicle of claim 13, wherein a second trigger point is determined during a period of time following a downward lift of the container, the period of time having a plurality of sequential data points associated therewith and wherein, within the period of time, values of the individual sequential data points increase at a rate greater than a defined threshold value.

16. The vehicle of claim 15, wherein the at least one weighing window before the deposit of waste is defined before the first trigger point and the at least one weighing window after the deposit of waste is defined after the second trigger point, the first trigger point being at a period in time before the second trigger point.

17. The vehicle of claim 10, wherein the computer program is configured to process the buffered electrical signal to identify distinct events in a weighing cycle, the distinct events including a coupling of an engagement arm with the container and a decoupling of the engagement arm with the container, a tipping of the container into a refuse vehicle and an un-tipping of the container after deposit of the waste into the refuse vehicle and wherein at least one weighing

window is before the tipping of the container into a refuse vehicle and at least one other weighing window is subsequent to the un-tipping of the container.

18. The vehicle of any one of claims 10 to 17 wherein the computer program is configured to:

use the weighing system to weigh the container on an upward movement and a downward movement of the lift arm;

subtract the weight of the empty container from that of the loaded container to determine the weight of the material.

Intellectual Property Office

Application No:	GB1914239.7	**Examiner:**	Freddy White
Claims searched:	1-22	**Date of search:**	19 March 2020

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	GB2253066 A (TOTER INC) see particularly WPI abstract (AN: 1992-215930) and figure 11
A	-	US4824315 A (NAAB et al.)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B65F; B66F; G01G

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext

International Classification:

Subclass	Subgroup	Valid From
G01G	0019/08	01/01/2006
B65F	0003/00	01/01/2006