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(71) Applicant: **VOLVO CONSTRUCTION EQUIPMENT AB** [SE/SE]; S-631 85 Eskilstuna (SE).

(72) Inventor; and

(71) Applicant (*for US only*): **RUDGE, Brian** [US/US]; 107 Bellows Dr., Carlisle, Pennsylvania 17015 (US).

(74) Agents: **SCHIVLEY, G. Gregory** et al.; Harness, Dickey & Pierce, P.L.C., P.O. Box 828, Bloomfield Hills, Michigan 48303 (US).

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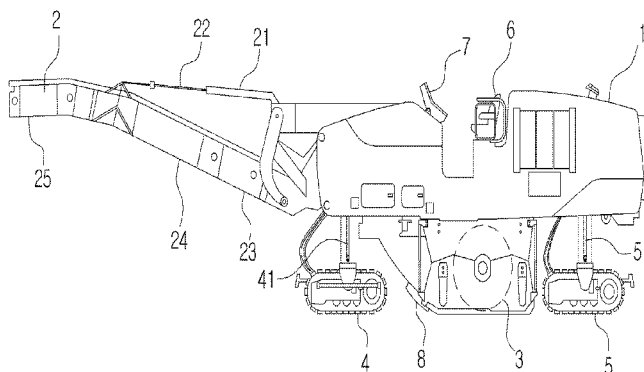


Figure 1

(57) Abstract: The present invention provides a convenient and inexpensive method for weighing truck load limit and a road milling machine having devices for providing such weighing and warning to a user when the load is close to a truck load limit set by the user.

WEIGHING SYSTEM FOR A ROAD MILLING MACHINE

Technical Field

The present invention relates to a road milling machine, in particular, providing
5 a convenient and inexpensive method for weighing truck load limit and a road milling
machine having devices for providing such weighing and warning to a user.

Background Art

Generally, a road milling machine is configured for use in degrading formations.
10 The road milling machine comprises a rotary degradation drum disposed on the
underside of the machine and arranged transverse to the working direction. The rotary
degradation drum comprises a plurality of picks. In milling operation, such road
milling machines traverse over ground, with the milling rotor submerging into the
ground and milling off the soil material with the help of the milling picks arranged on the
15 rotating milling rotor. In milling operation, the road milling machine thus moves in the
working direction and traverses over the soil to be processed. Such road milling
machines are also preferably designed as self-propelled machines, thus eliminating the
need for separate transporting vehicles.

An important aspect in the operation of such road milling machines is the
20 handling of the milled material, i.e. the material milled by the cutting drum. In many
areas of application, it is necessary that the milled material is transported away from the
milling location by means of a suitable transporting device, for example, a truck. To
this end, the road milling machines usually has a conveyor by means of which the milled
material can be transported during the milling operation of the road milling machine
25 from the area of the milling rotor to the transporting container of the transporting vehicle.

Various embodiments are known in the industry regarding the specific
arrangement of the conveyor device to the transporting vehicle. Apart from the
possibility that the conveyor transports the milled material to the rear (rear-loader) or to
the side (side-loader), a conveyor belt directed to the front (front-loader) has particularly
30 proven suitable for milling devices designed as road milling machines. Front-loader
has the advantage that during milling operation the transporting vehicle may drive in
front of the milling device on the ground still to be milled.

However, especially front-loader normally places heavy requirements on the milling machine operator. For example, the visibility of the preceding transporting vehicle is poor and the milling machine operator cannot see the loading trough in full. The driver of the transporting vehicle cannot see the loading conveyor as well.

5 Traditional machine configurations do not provide the machine operator with data about the weight and volume of material that is being conveyed. This is of particular importance on some road construction projects that occur in areas with strict regulations of truck loads. In these circumstances, specific truck weight limits and weight distributions relative to the vehicle axles are required and enforced through fines. The

10 lack of accurate data about the material being conveyed often causes trucks to be under-filled which has obvious impacts on productivity and cost. Further, the operator is also responsible for safe work process, particularly road safety and personal safety. In the mean time, the operator has to precisely control the loading process for proper removal of the milled material.

15 Prior art shows that a measuring method with human senses to measure weight or volume of vehicle load material reaches a height that is visible and relying on the machine and the transporting vehicle operators' experience to approximate when the weight limit is reached. However, this measurement is not accurate according to types of materials. Also, relying too much on an operator, who might not have that much

20 experience, may interrupt operators' safe operation.

Prior art shows another method to measure the transporting vehicle load. The weight of a truck fill materials can be measured by a conveyor belt scales purchased as part of a third party troughing roller assembly. However, it is an expensive option than the present invention and the location of scale on conveyor belt can limit design

25 flexibility and add complexity to harness routing. Also, if the conveyor with scale is not initially attached to the road milling machine, it is hard to be adopted later on.

Further, prior art provides a method using a secondary conveyor belt lift cylinder pressure to determine the load being conveyed. The conveyor drive motor speed sensor is additionally used along with weight and a material density table to calculate material

30 volume. This prior art has to be equipped with a secondary conveyor belt lift cylinder pressure sensor but the present invention does not require additional sensors except that are already used in conventional road milling machines.

Disclosure

Technical Problem

The standard layout and design of road milling machines places the operator in a position that makes it very difficult to gain adequate visibility of the end of the secondary conveyor and the inside of the truck being loaded. In addition, traditional machine configurations do not provide the machine operator with data about the weight and volume of material that is being conveyed. This is problematic where the road construction projects occur in areas with strict regulations of truck loads. These regulations require specific truck weight limits and weight distributions relative to the vehicle axles where violations would result fines. The avoidance of overloading often causes trucks to be under-loaded which will compromise productivity and cost-effectiveness. Further, these measurements of weight and volume of materials loaded on a transporting vehicle has to be inexpensive and easy to adopt.

15 Technical Solution

In order to achieve the aforementioned objects, the present invention employs the following arrangement.

According to one aspect of the present invention, there is provided a method of controlling volume or weight of material loaded into a transporting container from a road milling machine, wherein the road milling machine comprises a conveyor through which milled material is transported to the transporting container, a microprocessor for controlling said machine, comprising the steps of:

- a) inputting transporting container load limit in the form of volume or weight, and material type;
- 25 b) detecting drive motor speed and material height via sensor devices;
- c) calculating material weight via said microprocessor;
- d) activating alarm system when a predetermined load limit of said transporting container is met in material weight or in material volume.

It is preferable that the method further comprising the step of:

- 30 e) displaying loaded material volume and/or material weight of step c) at display panel.

It is also preferable that in step c), the following steps occur:

- 1) calculating material cross sectional area using detected material height and known conveyor dimensions;

2) calculating volume with calculated material cross sectional area and detected drive motor speed;

3) calculating material weight by using volume and material density, according to the material type of the milled material, found in a predetermined material density table.

5 It is also preferable that a method according to claim 1, wherein, in step d), said
It is It is preferable that the alarm system provides visual alarm and/or audible alarm.

According to another aspect of the present invention, a method of controlling volume or weight of material loaded into a transporting container from a road milling
10 machine, wherein the road milling machine comprises a conveyor through which milled material is transported to the transporting container, a microprocessor to control said machine, comprising the steps of:

- a) inputting transporting container load limit as forms of weight or volume, and material type;
- 15 b) detecting drive motor speed and material cutting depth via sensor devices;
- c) calculating material weight via said microprocessor;
- d) activating alarm system when a predetermined load limit of said transporting container is met in material weight or material volume.

It is preferable that a method further comprising the step of:

- 20 e) displaying loaded material volume and/or material weight of step c).

It is also preferable that a method according to claim 5, wherein, in step c), the following steps occur:

- 1) calculating material cross sectional area using detected cutting depth and the cutting drum width;
- 25 2) calculating material volume with calculated material cross sectional area, detected drive motor speed and time;
- 3) calculating material weight by using calculated volume and material density, according to the material type of the milled material, found in a predetermined material density table.

30 It is also preferable that a method, wherein, in step 1) cutting depth is determined by tracking the position of the lift cylinders where front wheel side lift cylinder located on the precut road surface and rear wheel side lift cylinder located on the milled road surface.

According to yet another aspect of the present invention, there is provided a road milling machine with a transporting vehicle load detecting device, comprising:
a conveyor through which the milled material is transported to a transporting container;
a microprocessor that controls calculation of weight or volume of the milled material and
5 determines when to activate alarm unit; and
sensor devices detecting drive motor speed, and material height of milled material transported in said conveyor.

It is preferable that said sensor devices includes a drive motor speed sensor that can detect speed of said conveyor drive speed and a material height sensor that can be
10 attached at laminar portion of said conveyor top to detect material height of the milled material.

It is also preferable that a road milling machine with transporting vehicle load limit detecting unit according to claim 9, wherein said sensor devices includes cutting depth detecting sensor device which determines the depth by tracking the difference of
15 position of the lift cylinders where front wheel side lift cylinder located on the precut road surface and rear wheel side lift cylinder located on the milled road surface.

According to yet another aspect of the present invention, there is provided a road milling machine with a transporting vehicle load detecting device, comprising:
a conveyor through which the milled material is transported to a transporting container;
20 a microprocessor that controls calculation of weight or volume of the milled material and determines when to activate alarm unit;
sensor devices detecting drive motor speed, and cutting depth of the road.

It is also preferable that the cutting depth can be determined by tracking position difference of front wheel side lift cylinder and rear wheel side lift cylinder where the
25 front wheel side lift cylinder located on the precut road and the rear wheel side lift cylinder located on the milled road.

It is also preferable that said cutting depth can be determined by tracking position difference of the real moldboard and the side skirts where the side skirts located on the precut road and the moldboard is located on the milled road.

30 It is also preferable that said position differences can be determined by using position sensors, limit switches, or rope sensors.

The present invention provides a method for measuring weight of truck load materials with conveyor drive motor speed sensor currently attached to a road milling machine, with conveyor cross sectional area and a material density table.

5 Advantageous Effects

The present invention provides easy and affordable transporting vehicle load calculation without additional devices on the machine. It is easy to adopt, cost-efficient, and useful for providing relatively accurate weight measurement for a road milling machine. The present invention also can provide warning signs to a user when the
10 material load is close to preset percentage of the truck load limit so that a user can stop or slow down the operation.

Description of Drawings

Fig. 1 illustrates a side view of a road milling machine.

15 Fig. 2 shows a flow chart for calculating weight by using conveyor cross-sectional area.

Fig. 3 shows a cross sectional view of the conveyor belt of the road milling machine measurements thereof would be used to calculate cross sectional area of loaded materials on the conveyor belt using the material height.

20 Fig. 4 shows a simplified cross sectional view of the conveyor belt of the road milling machine.

Fig. 5 shows a flow chart for calculating weight by using cutting depth of the milling machine.

Fig. 6 illustrates a schematic view of lift cylinders of the road milling machine.

25 Fig. 7 shows rear moldboard and side skirts of the road milling machine and its parts in detail.

Best Mode

Reference will be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings. While the present invention will be described in conjunction with the following embodiments, it will be understood that they are not intended to limit the present invention to these embodiments alone. On the contrary, the present invention is intended to cover alternatives,
30

modifications, and equivalents which may be included within the spirit and scope of the present invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, 5 embodiments of the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the present invention.

Any discussion of the prior art throughout the specification should be in no way 10 be considered as an admission that such prior art is widely known or forms part of common knowledge in the field.

In referring Fig. 1 which is a side view of a road milling machine according to prior arts, the road milling machine comprises a main body 1, a conveyor 2 connected to front part of the main body 1. The main body contains mechanical components of the 15 machine. The main body 1 further comprises two rotating wheels 4, 5 under the machine part of the main body 1. Rotary cutting drum 3 with a plurality of picks is located between two rotating wheels 4,5 of the machine. An operator would sit on the operation seat 6 and will get the required information from the control panel 7.

The conveyor 2 is roughly divided by gathering portion 23 and discharging 20 portion 25. The speed of each portion can be quite different since the gathering portion 23 receives milled material from the cutting drum 3. The milled material in the gathering portion 23 shows turbulent flow with generally higher speeds. However, passing through laminar portion 24 of the conveyor, the flow gets steadier till the discharge portion 25. The conveyor can be folded around the end of holding rope 22 so 25 that it can be carried easily while the machine moves to a job site.

Prior art conveyor using conveyor roller weight sensor would have sensors on laminar portion of the conveyor. However, there are only limited numbers of points where the roller weight sensors can be located, design flexibility would be significantly harmed and complexity of the harness routing would make design very difficult. Also, 30 these types of conveyor with weight sensors have to be ordered to a third party producing troughing roller assembly. These are usually more expensive and if the conveyor with weight sensors is not initially included in the road milling machine, it is hard to be included later on.

However, height sensor of the present invention can be placed anywhere along the top surface of the conveyor cover. It is preferable to put the height sensor toward center of the conveyor width. The height sensor according to the present invention can be attached to laminar flow region of the conveyor which is 24, 25 in Fig. 1. Also, it
5 can be used to almost any types of conveyor. Some conveyor already has height sensors as default so it is not needed to include them to utilize the present invention.

Referring Fig.2 which shows a flow chart for calculating weight by using conveyor cross-sectional area, the microprocessor of the road milling machine discloses a method of calculating material volume or weight of the transporting vehicle by using
10 material height in the conveyor and conveyor drive motor speed.

An operator would input information of desired truck load limit of a transporting vehicle and a type of material that the operator would mill with the road milling machine, to the microprocessor of the road milling machine. Then, the microprocessor would calculate material volume and weight using sensor-detected material height of the
15 conveyor and conveyor drive motor speed. We will discuss how the microprocessor calculates material cross sectional area in the conveyor using material height in detail according to the height level of the material in Example section later. Since we know specific measurements of the conveyor used on the specific road milling machine, the microprocessor can compute material cross sectional area using those measurements and
20 the material height detected by a sensor located on the conveyor. Conveyor drive motor speed is usually used in a conventional road milling machine, thus most of the case the present invention can utilize this sensor. Then, the microprocessor can compute material volume using material cross sectional area and conveyor drive motor speed which is distance (length)/time. In other words, material cross sectional area multiplied
25 by length of the conveyor would constitute the material volume.

Then, using the material type that operator inputted and a material density table, material weight can be calculated by the microprocessor. The material density table is preferably providing density listing for types of materials that the road milling machine could conduct a milling process on the road consisting of those material.

30 Then, the microprocessor would determine whether the weight or volume of the milled material is close to the desired truck load limit that the operator inputted before the operation. Preferably, to give some time for the operator to respond to a warning, warning could be given at X% of the truck load limit. It is preferable that the

percentage is about 70% to 95% of truck load limit but it is up to the operator to decide at which point of the truck load, he/she wants to be alarmed.

The microprocessor could control to give an audible or a visible alarm or both to the operator. Otherwise, the information on truck loading can be given on the control panel. Either or both of material weight of the loaded material or material volume can be displayed on the control panel. This control panel warning can be given in addition to the audible or visible alarm or it can be given by itself.

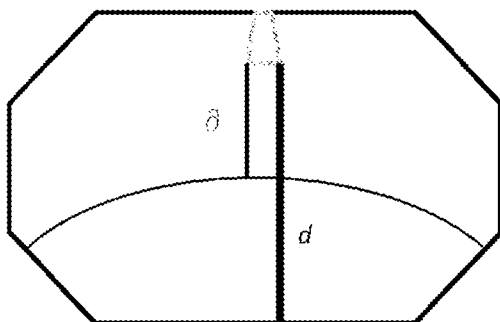
In referring Fig. 3 and 4 that show a cross sectional view and simplified cross sectional view of the conveyor belt of the road milling machine, measurements thereof would be used to calculate cross sectional area of loaded materials on the conveyor using the material height. The height sensor located on top (cover) of the conveyor so that it can measure the height of the material moving on the conveyor 2. Measurements in Fig. 4 can be used to calculate material cross sectional area of material moving on the conveyor as shown below example.

Below is an example of calculating material cross-sectional area according to the present invention. However, any kind of calculating method can be used and the below example is only to show one way to do so.

Example

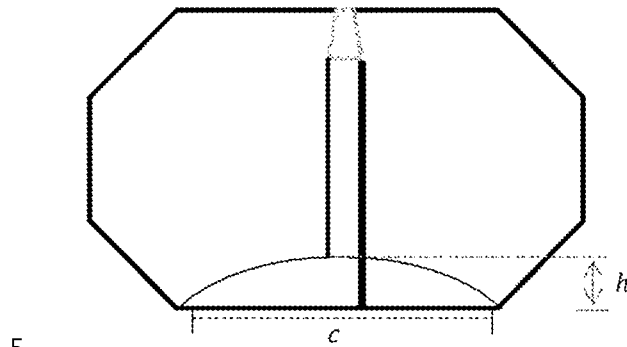
For easier but realistic calculation, it is assumed that the material would not sit on top of the conveyor in a triangular or a pyramidal pattern but a circular pattern with the same area as a triangular section.

An equation would be created for cross-sectional area in terms of angle of surcharge β and height h . It is assumed that height = $d - \partial$ for all calculation, where d is total known height from the sensor of the belt, and ∂ is the sensor output value.



For calculation the cases are divided by three according to the height of the milled material in the conveyor. All three cases will be explained below.

a. For case 1, when the arc of material does not reach the tapered belt edge

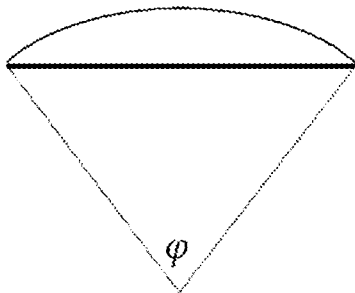


As described in step two of the general solution, first set triangular area equal to circular segment area:

$$\frac{1}{2}w \left[\frac{w}{2} \tan(\beta) \right] = \frac{\left(\frac{w}{2 \sin\left(\frac{\varphi}{2}\right)} \right)^2}{2} [\varphi - \sin(\varphi)]$$

$$\boxed{2 \tan(\beta) = \frac{\varphi - \sin(\varphi)}{\sin^2\left(\frac{\varphi}{2}\right)}}$$

10 In the above equation, w equals base length of the triangular segment, β equals the angle of surcharge of the material, and φ equals the angle of the circular segment, shown in the figure below.



15 Then, general equations for area of a circular segment are used to find the area based on height input. These equations are listed below, where A = Area, c = chord length, R = radius, and h = height:

$$c = 2R \sin\left(\frac{\varphi}{2}\right)$$

$$h = R \left[1 - \cos\left(\frac{\varphi}{2}\right) \right]$$

$$A = \frac{R^2}{2} [\varphi - \sin(\varphi)]$$

Then the above equation is used to put area solely in terms of h and ψ .

$$R = \frac{h}{1 - \cos\left(\frac{\varphi}{2}\right)}$$

$$A = \frac{\left(\frac{h}{1 - \cos\left(\frac{\varphi}{2}\right)} \right)^2}{2} [\varphi - \sin(\varphi)]$$

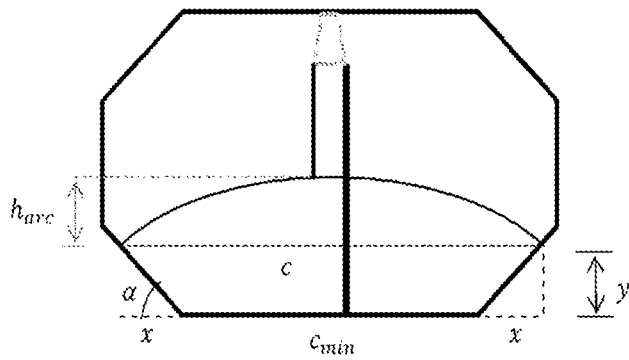
In all the equations in this specification, ψ is defined in radians rather than
 5 degrees. Find the values of h from a known value of c from the part of the road milling
 machine to be used.

$$c_{max} \geq 2R \sin\left(\frac{\varphi}{2}\right)$$

$$c_{max} \geq 2 \left[\frac{h}{1 - \cos\left(\frac{\varphi}{2}\right)} \right] \sin\left(\frac{\varphi}{2}\right)$$

$$h \leq \frac{c_{max} \left[1 - \cos\left(\frac{\varphi}{2}\right) \right]}{2 \sin\left(\frac{\varphi}{2}\right)}$$

**b. For case 2, when the arc of material ends at some point along the tapered
 10 edge as the figure below.**



Since ψ is based solely on a material property β , ψ will not change with a height. Thus, the equation relating the two terms will not change. In case 2, what was c max in case 1 was reassigned to c min. Additional terms were added. These include α , the belt angle that was previously calculated; c , the chord length; h_{arc} , the height of the arc; and x and y , the horizontal and vertical displacements of the arc.

General equation relating the terms to themselves are defined to solve for y .

$$h = h_{arc} + y$$

$$\tan(\alpha) = \frac{y}{x}$$

$$c = c_{min} + 2x$$

$$c = c_{min} + \frac{2y}{\tan(\alpha)}$$

$$y = \frac{(c - c_{min})\tan(\alpha)}{2}$$

Using equations for h_{arc} in terms of y , plug in the y equation and solve for h

10 total:

$$h_{arc} = h - y = R \left[1 - \cos \left(\frac{\varphi}{2} \right) \right]$$

$$h_{arc} = \left[\frac{c}{2 \sin \left(\frac{\varphi}{2} \right)} \right] \left[1 - \cos \left(\frac{\varphi}{2} \right) \right]$$

$$h_{total} = h_{arc} + y = (h - y) + y$$

$$h_{total} = \left(\frac{c \left[1 - \cos \left(\frac{\varphi}{2} \right) \right]}{2 \sin \left(\frac{\varphi}{2} \right)} \right) + \frac{(c - c_{min}) \tan (\alpha)}{2}$$

After establishing this equation for the total height h_{total} known from the sensor, the value of c would be sought using known values φ , α , h and c_{min} .

Then, solving for the composite area resulting from the trapezoid from c_{min} to c and the arc whose chord length is c and whose height is h_{arc} :

$$A_{arc} = \frac{R^2}{2} [\varphi - \sin (\varphi)]$$

$$A_{arc} = \frac{\left(\frac{c}{2 \sin \left(\frac{\varphi}{2} \right)} \right)^2}{2} [\varphi - \sin (\varphi)]$$

$$A_{trap} = \left(\frac{c + c_{min}}{2} \right) y$$

$$A_{trap} = \left(\frac{c + c_{min}}{2} \right) \left[\frac{(c - c_{min}) \tan (\alpha)}{2} \right]$$

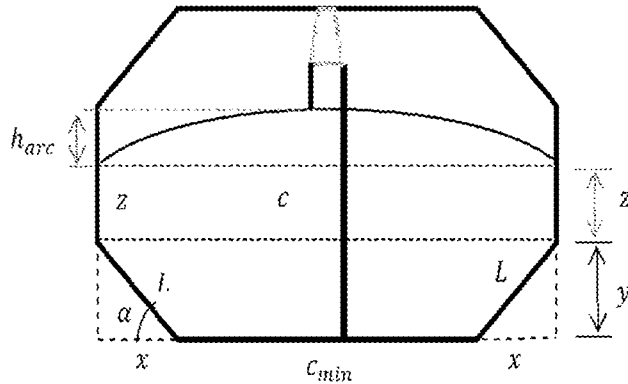
$$A_{total} = A_{arc} + A_{trap}$$

$$A_{total} = \frac{\left(\frac{c}{2 \sin \left(\frac{\varphi}{2} \right)} \right)^2}{2} [\varphi - \sin (\varphi)] + \left(\frac{c + c_{min}}{2} \right) \left[\frac{(c - c_{min}) \tan (\alpha)}{2} \right]$$

The maximum value of h for which this equation is satisfied is dependent on a maximum value of c where the side edge becomes vertical, and this value will depend on the part of the machine that is used. Thus, the maximum height h for which this equation can be used is:

$$h_{total} = \left[\frac{c_{max} \left[1 - \cos\left(\frac{\varphi}{2}\right) \right]}{2 \sin\left(\frac{\varphi}{2}\right)} \right] + \frac{(c_{max} - c_{min}) \tan(\alpha)}{2}$$

C. For case 3, when the material arc exceeds the tapered edge and continues up the wall as the figure below.



New variables are added again to reflect case 3. L is the length of the tapered belt edges, and z represents the vertical distance between the end of the trapezoid and the beginning of the arc.

First, the equation is solved for the area of the trapezoid based on the listed dimensions and variables:

$$\cos(\alpha) = \frac{x}{L}$$

$$c = c_{min} + 2x$$

$$c = c_{min} + 2L\cos(\alpha)$$

$$A_{trap} = \left(\frac{c + c_{min}}{2} \right) y$$

$$A_{trap} = \left(\frac{[c_{min} + 2L\cos(\alpha)] + c_{min}}{2} \right) [L\sin(\alpha)]$$

$$A_{trap} = [c_{min} + L\cos(\alpha)][L\sin(\alpha)]$$

Since z remains unknown, the next step is to solve for the topmost circular segment area, which chord length c and height h arc, and the relation between β and ψ is still the same as in Case 1.

$$A_{arc} = \frac{R^2}{2} [\varphi - \sin(\varphi)]$$

$$A_{arc} = \frac{\left(\frac{c}{2\sin\left(\frac{\varphi}{2}\right)}\right)^2}{2} [\varphi - \sin(\varphi)]$$

$$A_{arc} = \frac{\left(\frac{2L\cos(\alpha) + c_{min}}{2\sin\left(\frac{\varphi}{2}\right)}\right)^2}{2} [\varphi - \sin(\varphi)]$$

$$A_{arc} = \frac{[2L\cos(\alpha) + c_{min}]^2}{8\sin^2\left(\frac{\varphi}{2}\right)} [\varphi - \sin(\varphi)]$$

Then, using the values of h , y , and h_{arc} , write an equation for z that can be used to find rectangular area. Find this area using the relevant equations listed below;

$$A_{rect} = (c)(z), \quad c = c_{min} + 2L\cos(\alpha)$$

$$z = h - y - h_{arc}$$

$$z = h - L\sin(\alpha) - R \left[1 - \cos\left(\frac{\varphi}{2}\right)\right]$$

$$z = h - L\sin(\alpha) - \left[\frac{c}{2\sin\left(\frac{\varphi}{2}\right)}\right] \left[1 - \cos\left(\frac{\varphi}{2}\right)\right]$$

$$z = h - L\sin(\alpha) - \left[\frac{2L\cos(\varphi) + c_{min}}{2\sin\left(\frac{\varphi}{2}\right)}\right] \left[1 - \cos\left(\frac{\varphi}{2}\right)\right]$$

$$A_{rect} = [c_{min} + 2L\cos(\alpha)] \left(h - L\sin(\alpha) - \left[\frac{2L\cos(\varphi) + c_{min}}{2\sin\left(\frac{\varphi}{2}\right)}\right] \left[1 - \cos\left(\frac{\varphi}{2}\right)\right] \right)$$

5

There is no minimum value of h for this case 3 apart from the height of the machine, but practical applications indicate that this height would never be reached. The minimum value of h for this case is when $h = h_{arc} + y$, or the same as the maximum value for case 2.

10 Total area can be written as a summation of the three geometric areas:

$$A_{total} = \sum_{i=1}^3 A_i = A_{trap} + A_{arc} + A_{rect}$$

Then, multiplies Area function by conveyor belt velocity and time to determine exiting volume, where A is one of the above equations as a function of h.

$$V_{total} = (A_{total})(v_{belt})(t)$$

5 The microprocessor of the machine would input values every x number of milliseconds and creates a dataset of a set amount of values y, and calculate average. After this average for a set amount of time is calculated, the microprocessor would use the above equations to calculate volume of passing material. Once this volume for the time frame is calculated, the microprocessor would begin collecting new information for
10 the next time frame, again calculating average and solving for volume. This will account for real-time increases in height due to increases in belt speed or reduction of milling belt angle.

15 In referring Fig. 5, a flow chart for calculating weight by using cutting depth of the milling machine is described below.

20 An operator would input information of desired truck load limit of a transporting vehicle and a type of material that the operator would mill with the road milling machine, to the microprocessor of the road milling machine. Then, the microprocessor would calculate material volume and weight using sensor-detected conveyor drive motor speed and cutting depth of the road milling machine.

25 Since we would know cutting depth of the road milling machine from the calculation and the cutting drum width, we can determine material cross sectional area of the material that is milled by the machine. Then, we also can detect conveyor drive motor speed which is usually detected in conventional road milling machines. Then, the microprocessor can compute material volume by using material cross sectional area and conveyor drive motor speed which is distance (length) /time. In other words, material cross sectional area multiplied by length the machine is working would constitute the material volume the road milling material milled during a specific time.

Then, using the material type that operator inputted and a material density table, material weight can be calculated by the microprocessor. Material density equals weight/volume and we know volume and material density, thus we can get material weight easily by the microprocessor. The material density table is preferably providing
5 density listing for types of material where the road milling machine could conduct a milling process on.

Then, the microprocessor would determine whether the weight or volume of the milled material is close to the desired truck load limit that the operator inputted before the operation. Preferably, to give some time for the operator to respond to a warning,
10 warning could be given at X% of the truck load limit. It is preferable that the percentage is about 70% to 95% of truck load limit but it is up to the operator to decide at which point of the truck load, he/she wants to be alarmed.

The microprocessor could control to give an audible or a visible alarm or both to the operator. Otherwise, the information on truck loading can be given on the control
15 panel. Either or both of material weight of the loaded material or material volume can be displayed on the control panel. This control panel warning can be given in addition to the audible or visible alarm or it can be given by itself.

In referring Fig. 6 that shows a schematic view of lift cylinders of the road milling machine, the method of determining cutting depth with these lift cylinders will
20 be explained below.

Referring Fig.1, conventional road milling machines have four wheels as we can see two wheels 4, 5 from one side of the machine and there will be another set of two wheels on the other side of the machine. Fig. 6 shows lift cylinders for all four wheels. Since the lift cylinders are connected to the wheels we can detect wheel position by
25 tracking lift cylinder position. For a road milling machine (front-loader), the front tracks are sitting on the precut ground plane and the rear tracks are sitting on the milled road surface. Cutting drum will be located between front lift cylinders 41, 81 and rear lift cylinders 51, 91. Thus, front lift cylinders 41, 81 are located on a road which is not milled yet but the rear lift cylinders 51, 91 are located on an already milled road. Thus
30 we can determine cutting depth by tracking the position of the lift cylinders. Position sensors, limit switches, rope sensors, or any kind of sensors that can detect height difference can be used to determine the height difference between the front and rear lift cylinders, or we can monitor the position of the lift cylinder relative to a zero-plane.

In referring Fig. 7, a way to determine cutting depth with rear moldboard and side skirts of the road milling machine according to the present invention is disclosed. The side skirts 12 rest on the precut ground plane, and the moldboard 11 is resting on the milled road surface.

5 In detail, a road milling machine generally includes a body, a cutting drum rotatably mounted to the frame for removing material (e.g. asphalt, concrete) from a roadbed, and a conveyor. The cutting drum is connected with the body by a drive assembly that includes a shaft, and operates by rotatably engaging with a road surface to remove material there from. As the material is removed, the depth of engagement of
10 the drum generally must be increased in order to remove a desired quantity of material. Typically, adjustment of the drum depth is achieved by vertically moving the body and thereby moving the connected drum assembly.

Further, road milling machines generally include an enclosure or housing for retaining material cuttings about the drum until the material can be conveyed to a
15 transporting vehicle. Such housings include one or more containment walls or "side skirts" that enclose the area about the drum, each skirt being typically vertically moveable relative to the drum. As such, the side skirts are typically vertically moveable relative to the drum. As such, the side skirts are able to either remain vertically stationary when the drum depth is adjusted or to move vertically in order to
20 remain disposed on a sloping base surface during machine travel. The rear moldboard is usually attached to the rear side of the cutting drum and also vertically moveable between a retracted position and an extended position. Thus, the side skirts would remain on precut surface and the rear moldboard which is located behind the cutting drum will be disposed on top of the milled road surface and there is a height difference
25 between two elements.

Cutting depth can be determined by tracking the position of the rear moldboard relative to the side skirts. Position sensors, limit switches, rope sensors or any kinds of known detector can be used to determine the height of the rear moldboard. The height of the side skirt is currently tracked with a rope sensor.

30

Industrial Applicability

5 The present invention provides easy and affordable transporting vehicle load calculation without additional devices on the machine. It is easy to adopt, cost-efficient, and useful for providing relatively accurate weight measurement for a road milling machine. The present invention also can provide warning signs to a user when the material load is close to preset percentage of the truck load limit so that a user can stop or slow down the operation.

10 Although the invention has been described with reference to the preferred embodiments in the attached figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

CLAIMS

Claim 1 A method of controlling volume or weight of material loaded into a transporting container from a road milling machine, wherein the road milling machine comprises a conveyor through which milled material is transported to the transporting container, a microprocessor for controlling said machine, comprising the steps of:

5 a) inputting transporting container load limit in the form of volume or weight, and material type;

 b) detecting drive motor speed and material height via sensor devices;

 c) calculating material weight via said microprocessor;

10 d) activating alarm system when a predetermined load limit of said transporting container is met in material weight or in material volume.

Claim 2 A method according to claim 1, further comprising the step of:

 e) displaying loaded material volume and/or material weight of step c) at display panel.

15

Claim 3 A method according to claim 1, wherein, in step c), the following steps occur:

 1) calculating material cross sectional area using detected material height and known conveyor dimensions;

20 2) calculating volume with calculated material cross sectional area and detected drive motor speed;

 3) calculating material weight by using volume and material density, according to the material type of the milled material, found in a predetermined material density table.

25 Claim 4 A method according to claim 1, wherein, in step d), said alarm system provides visual alarm and/or audible alarm.

Claim 5 A method of controlling volume or weight of material loaded into a transporting container from a road milling machine, wherein the road milling machine comprises a conveyor through which milled material is transported to the transporting container, a microprocessor to control said machine, comprising the steps of:

30 a) inputting transporting container load limit as forms of weight or volume, and material type;

b) detecting drive motor speed and material cutting depth via sensor devices;
c) calculating material weight via said microprocessor;
d) activating alarm system when a predetermined load limit of said transporting container is met in material weight or material volume.

5

Claim 6 A method according to claim 5, further comprising the step of:
e) displaying loaded material volume and/or material weight of step c).

Claim 7 A method according to claim 5, wherein, in step c), the following steps
10 occur:

1) calculating material cross sectional area using detected cutting depth and the cutting drum width;

2) calculating material volume with calculated material cross sectional area, detected drive motor speed and time;

15 3) calculating material weight by using calculated volume and material density, according to the material type of the milled material, found in a predetermined material density table.

Claim 8 A method according to claim 7, wherein, in step 1) cutting depth is
20 determined by tracking the position of the lift cylinders where front wheel side lift cylinder located on the precut road surface and rear wheel side lift cylinder located on the milled road surface.

Claim 9 A road milling machine with a transporting vehicle load detecting
25 device, comprising:

a conveyor through which the milled material is transported to a transporting container;

a microprocessor that controls calculation of weight or volume of the milled material and determines when to activate alarm unit; and

30 sensor devices detecting drive motor speed, and material height of milled material transported in said conveyor.

Claim 10 A road milling machine according to claim 9, wherein said sensor devices includes a drive motor speed sensor that can detect speed of said conveyor drive speed and a material height sensor that can be attached at laminar portion of said
5 conveyor top to detect material height of the milled material.

Claim 11 A road milling machine according to claim 9, wherein said sensor devices includes cutting depth detecting sensor device which determines the depth by tracking the difference of position of the lift cylinders where front wheel side lift
10 cylinder located on the precut road surface and rear wheel side lift cylinder located on the milled road surface.

Claim 12 A road milling machine with a transporting vehicle load detecting device, comprising:
15 a conveyor through which the milled material is transported to a transporting container;
a microprocessor that controls calculation of weight or volume of the milled material and determines when to activate alarm unit;
sensor devices detecting drive motor speed, and cutting depth of the road.

20

Claim 13 A road milling machine with transporting vehicle load limit detecting unit according to claim 12, wherein,
said cutting depth can be determined by tracking position difference of front wheel side lift cylinder and rear wheel side lift cylinder where the front wheel side lift
25 cylinder located on the precut road and the rear wheel side lift cylinder located on the milled road.

Claim 14 A road milling machine with transporting vehicle load limit detecting unit according to claim 12, wherein,
30 said cutting depth can be determined by tracking position difference of the real moldboard and the side skirts where the side skirts located on the precut road and the moldboard is located on the milled road.

Claim 15 A road milling machine with transporting vehicle load limit detecting unit according to claim 13, wherein,

 said position difference can be determined by using position sensors, limit switches, or rope sensors.

5

Claim 16 A road milling machine with transporting vehicle load limit detecting unit according to claim 14, wherein,

 said position difference can be determined by using position sensors, limit switches, or rope sensors.

10

Figure 1

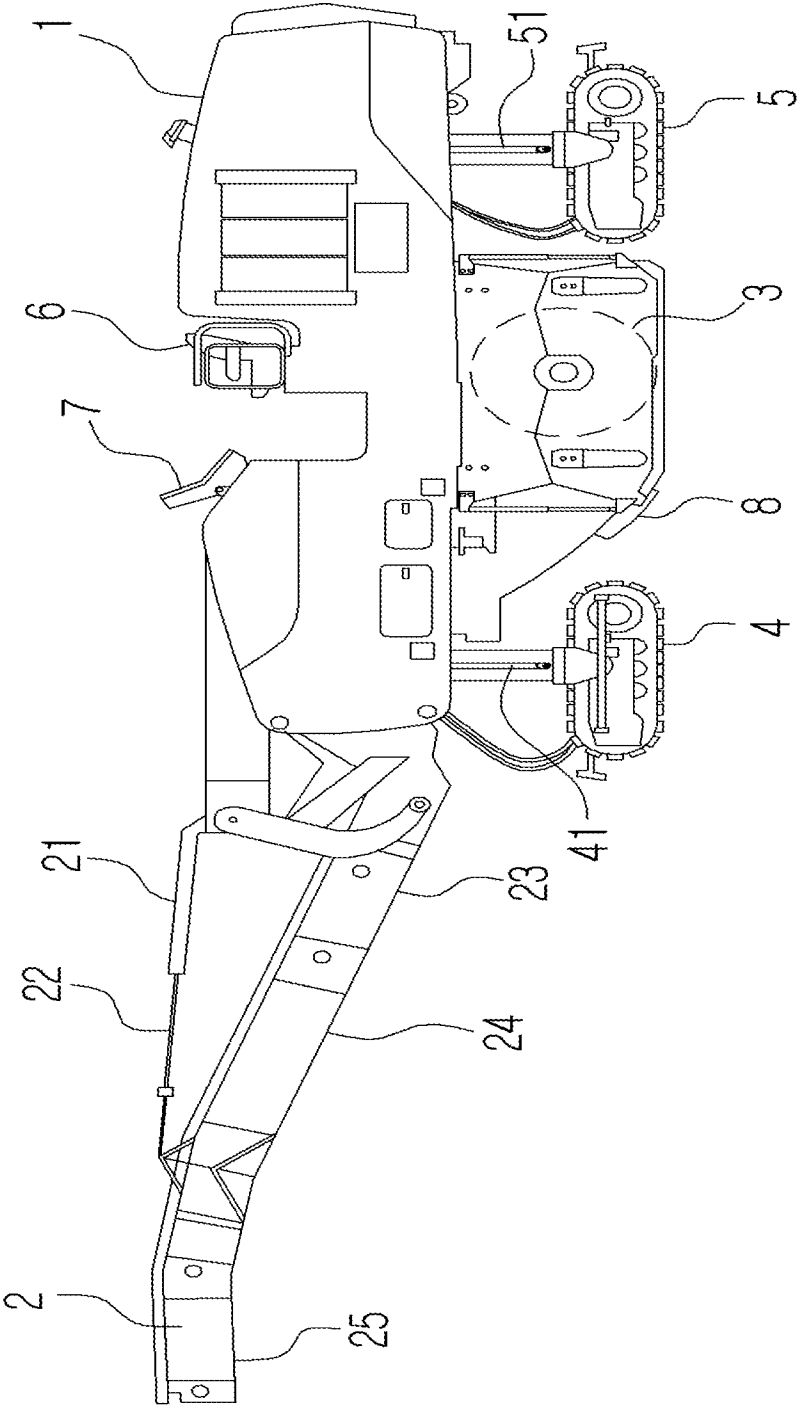


Figure 2

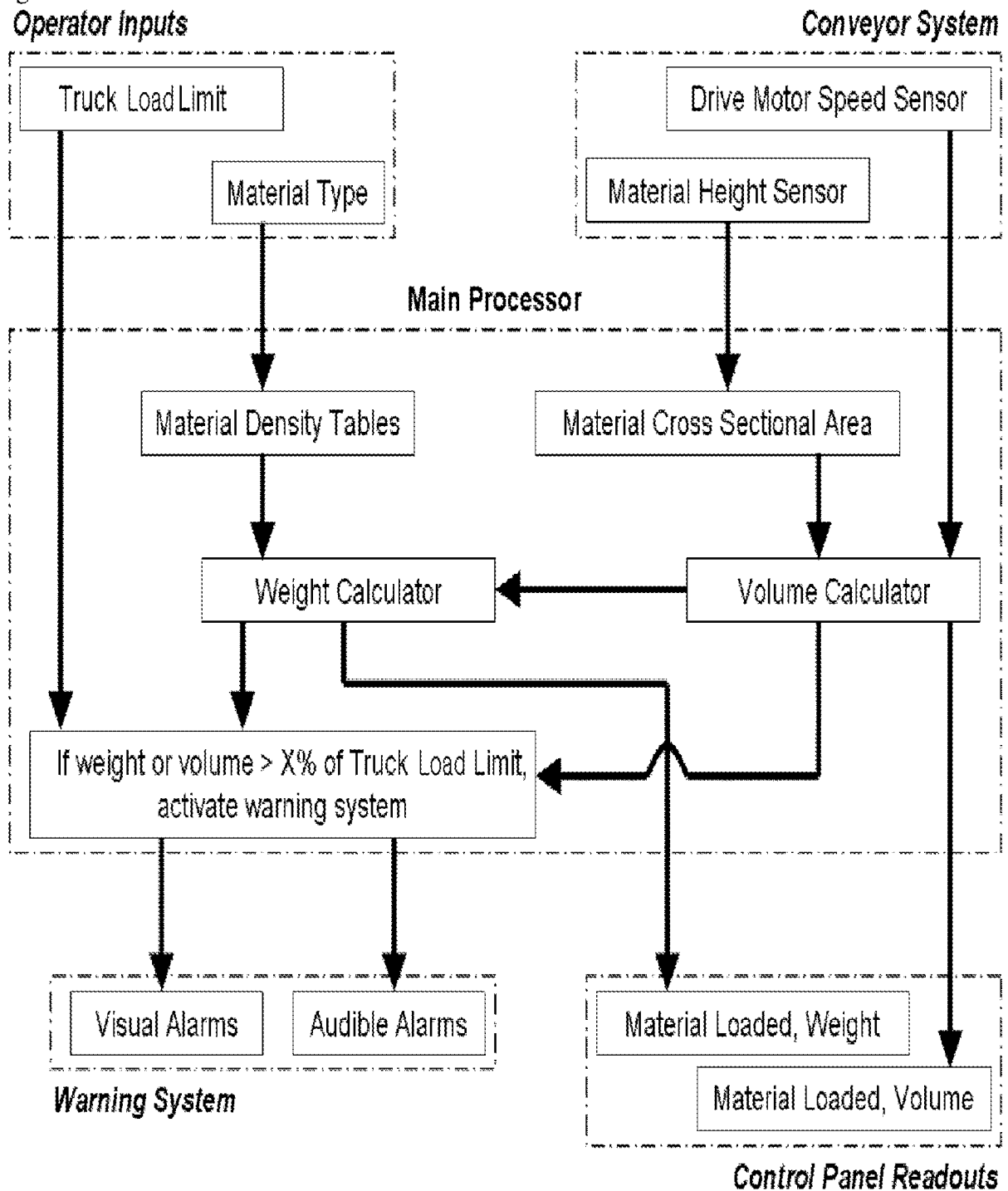


Figure 3

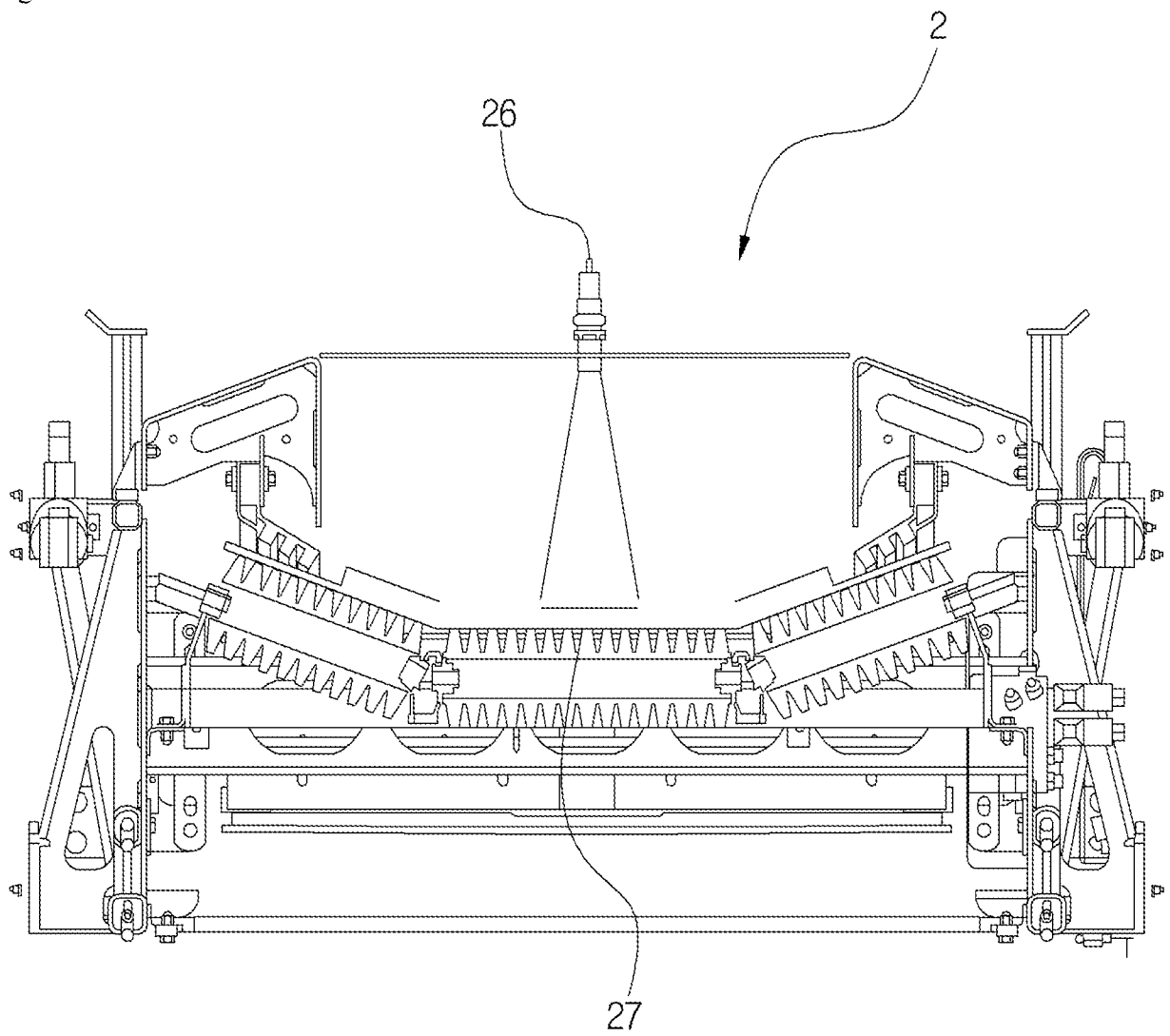


Figure 4

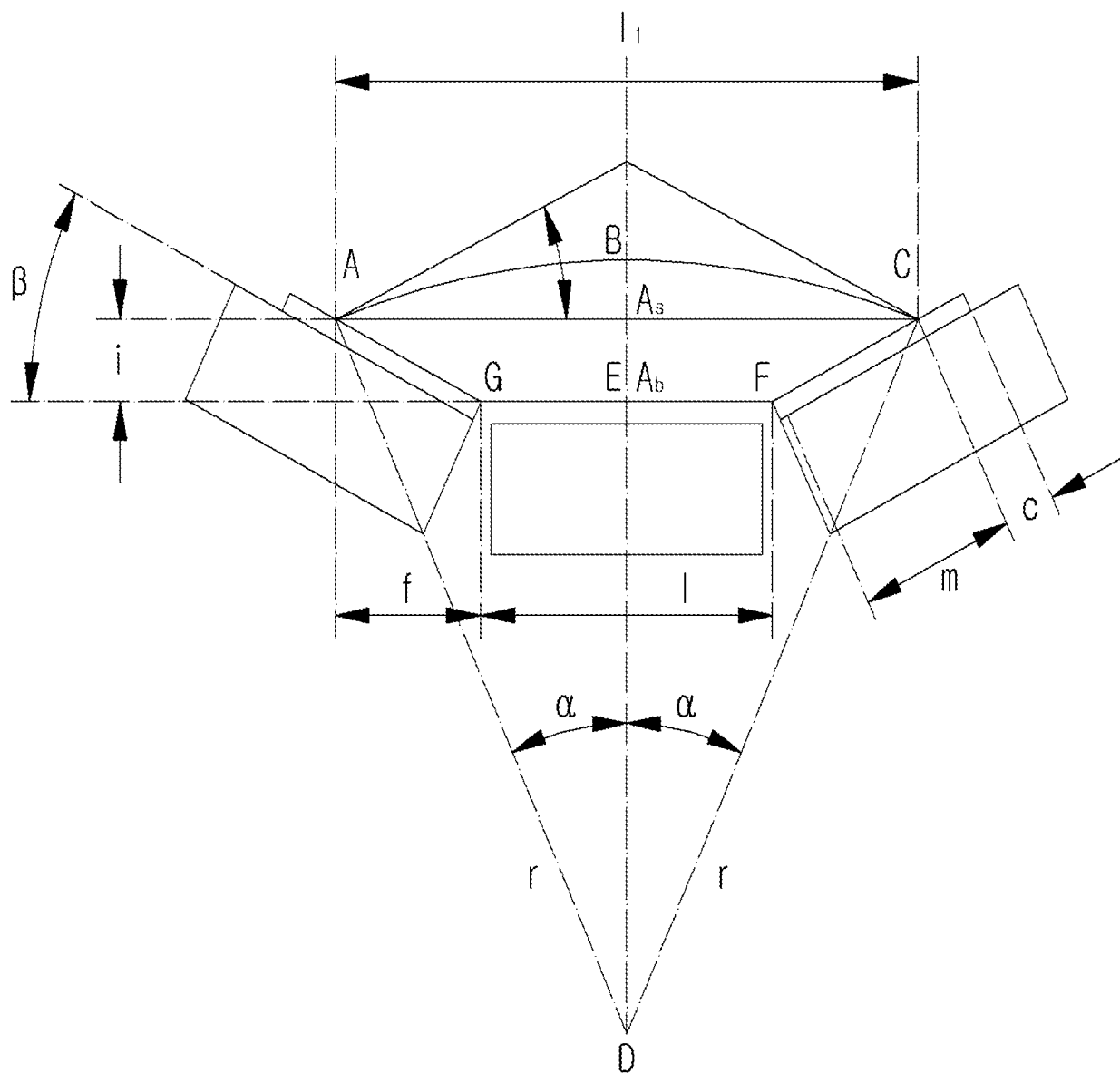


Figure 5

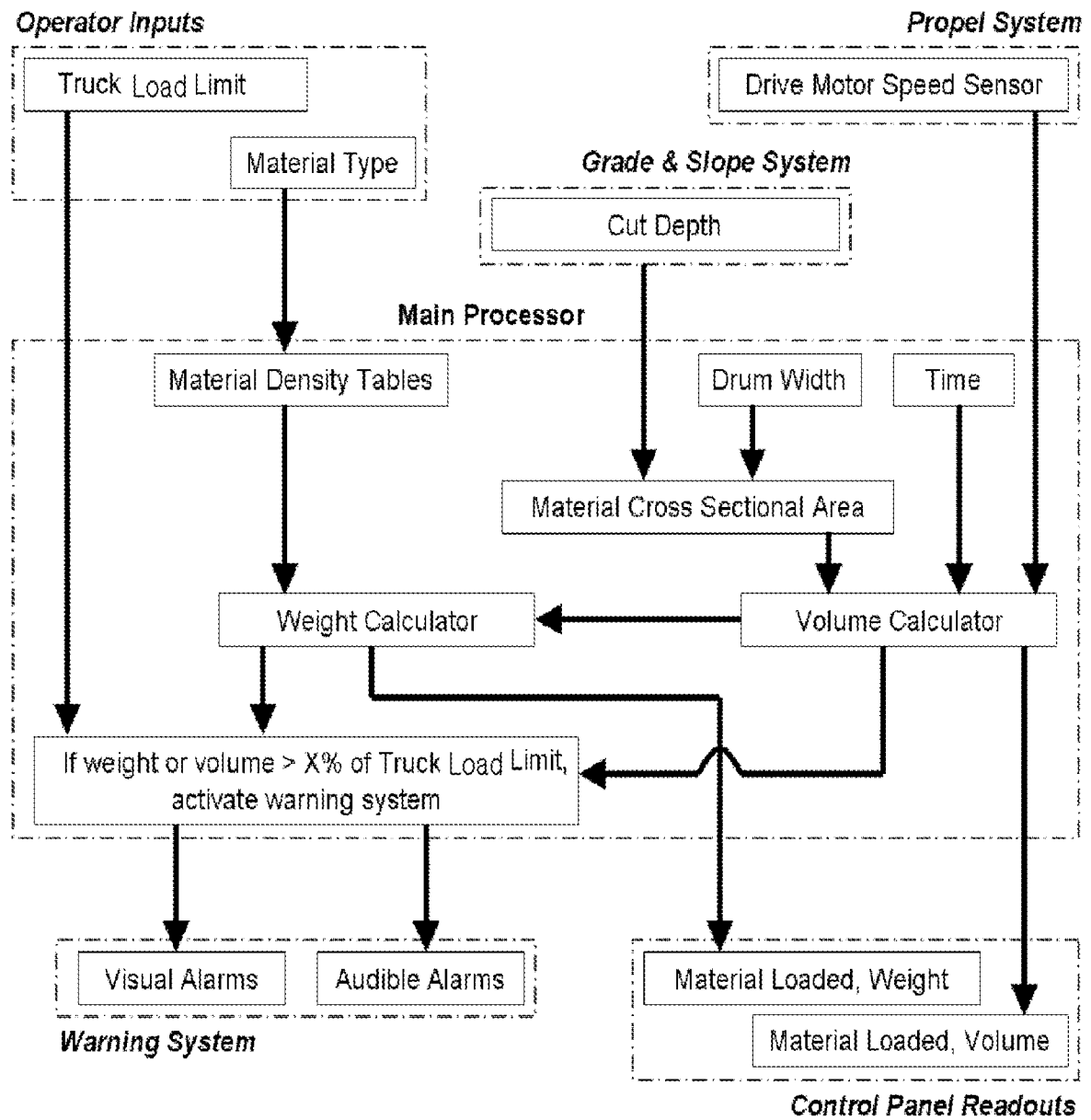


Figure 6

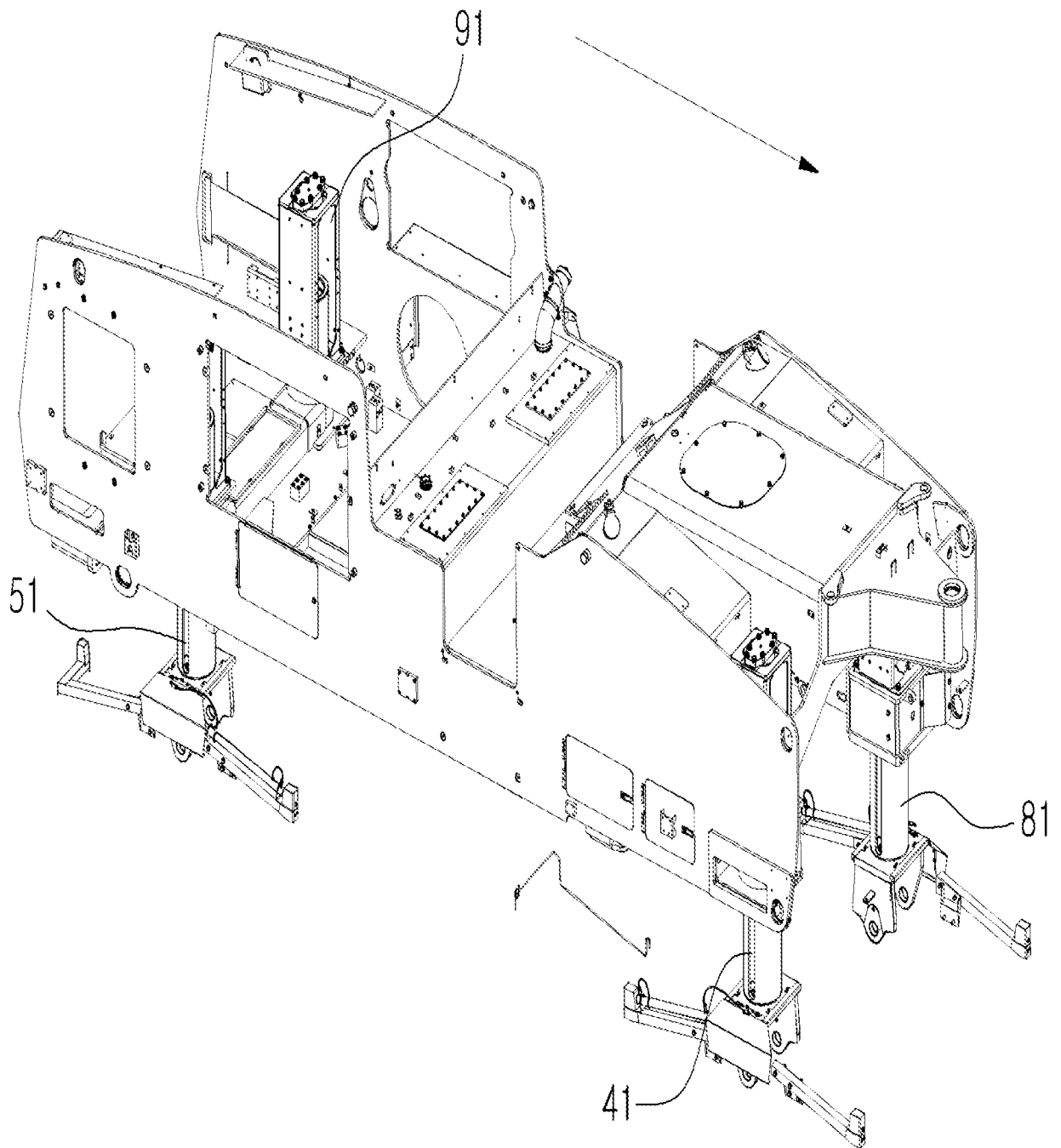
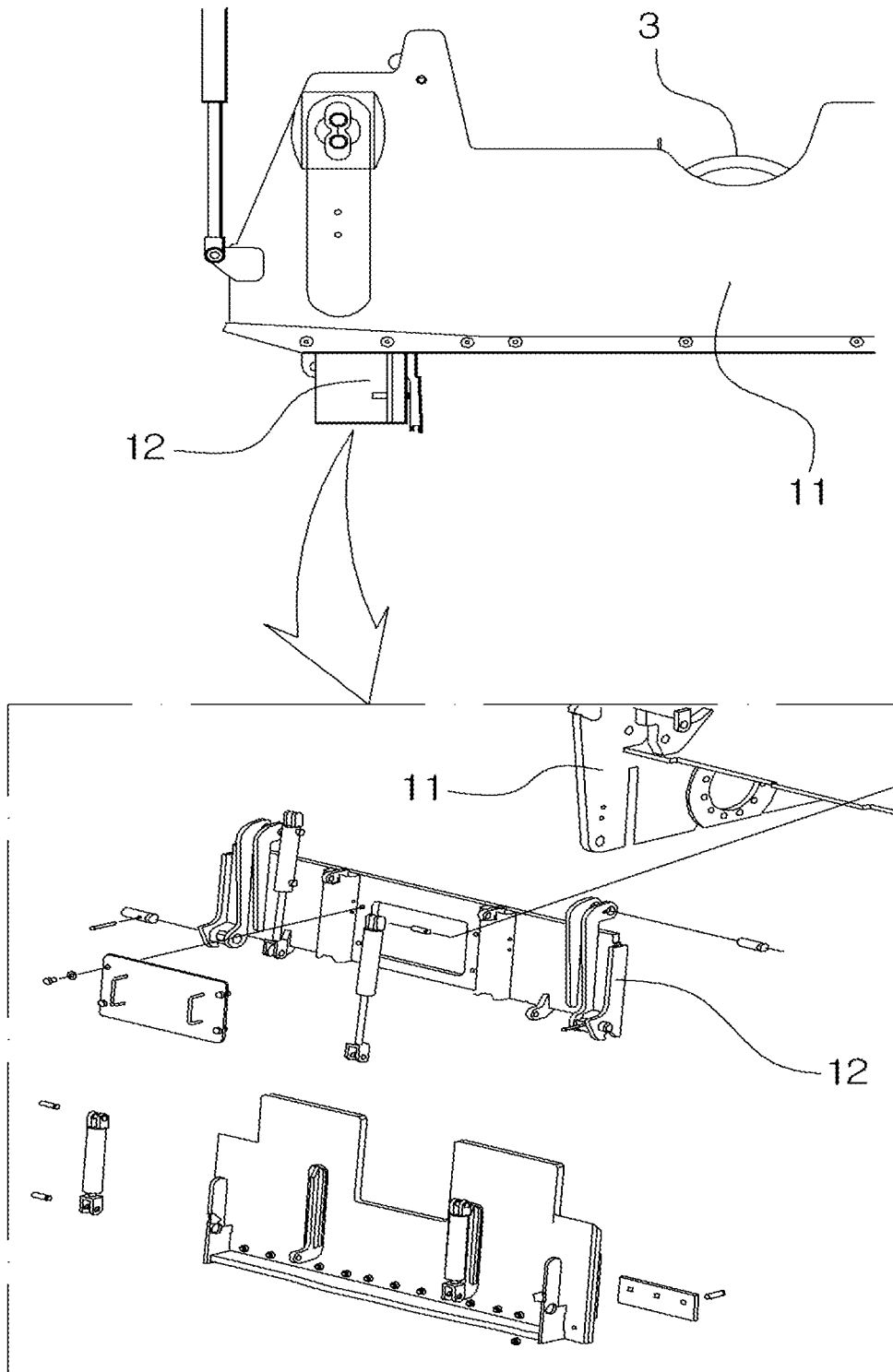


Figure 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/058202**A. CLASSIFICATION OF SUBJECT MATTER****E01C 23/088(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E01C 23/088; E01C 23/07; E21C 25/06; E01C 23/12; E01C 21/00; E01C 19/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: weighing system, milling machine, sensor, speed, cutting depth, conveyor, and alarm

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011-0121633 A1 (HALL et al.) 26 May 2011 See paragraphs [0004], [0020]-[0030], [0034]-[0037] and figures 1-2d, 5a-6.	1-16
A	EP 1012396 B1 (WIRTGEN GMBH) 19 June 2002 See claims 1-3, 7-9 and figures 1-2.	1-16
A	US 6244782 B1 (BITELLI, ROMOLO) 12 June 2001 See column 3, lines 34-53, claims 1-3, and figures 1-2.	1-16
A	US 5269626 A (SOLIMAN et al.) 14 December 1993 See column 3, lines 50-66, claims 1, 5, 15, and figure 1.	1-16
A	US 2012-0200138 A1 (MENZENBACH et al.) 09 August 2012 See paragraphs [0047]-[0052] and figures 1-5.	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 May 2014 (13.05.2014)

Date of mailing of the international search report

14 May 2014 (14.05.2014)

Name and mailing address of the ISA/KR

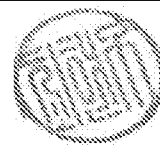
International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

CHOI, Hyun Goo

Telephone No. +82-42-481-8288



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/058202

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