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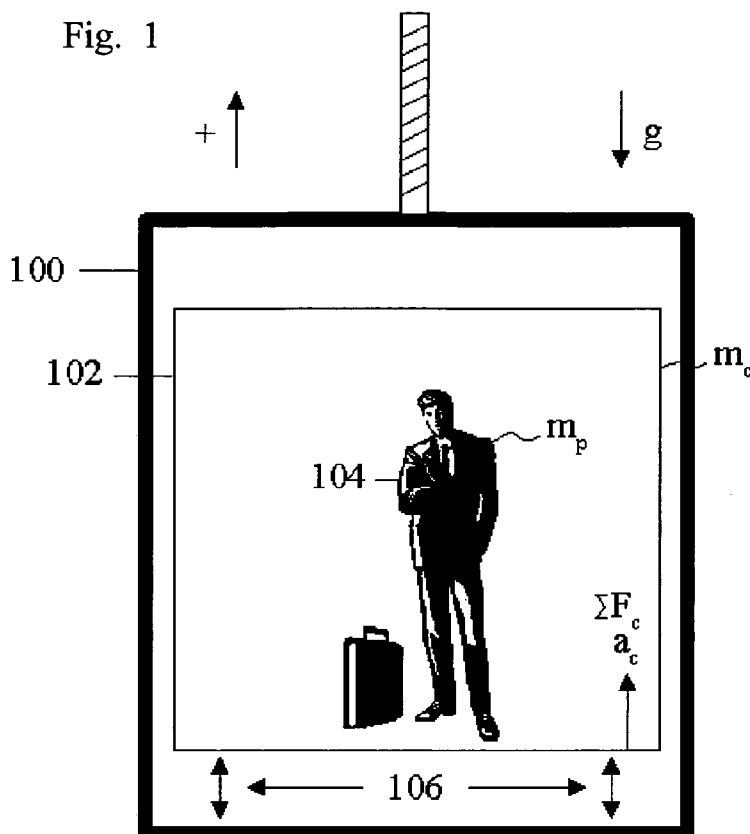
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(54) Title: ELEVATOR SYSTEM



(57) Abstract: The present invention discloses a solution for improving the accuracy of a load weighing signal in an elevator system. In the invention the load weighing signal expressing the sum of the forces exerted on the elevator car or on the drive machinery or on the elevator car and the car sling is received from the load weighing arrangement; the measuring signal about the vertical acceleration of the elevator car when the elevator car is moving or stationary is received from the measuring means of acceleration fixed in connection with the elevator car or with the car sling; and the load weighing signal is compensated with the acceleration signal measured by the measuring means of acceleration.



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ELEVATOR SYSTEM**FIELD OF THE INVENTION**

The present invention relates to elevator systems. More particularly, the present invention relates to a method, a computer program and a system for improving the quality of the load weighing signal of an elevator.

BACKGROUND OF THE INVENTION

10 In elevator systems a weighing arrangement is often used to determine the mass of the passengers. Measurement of the mass is performed e.g. with a floor load weighing device, a car load weighing device, an overhead beam load weighing device or a drive
15 machinery load weighing device. In measurement based on a car load weighing device, the car sling of the elevator car is suspended e.g. hanging on a flexible rope. The elevator car, for its part, rests e.g. on top of the flexible suspension inside the car sling.
20 The sensors connected to the weighing are disposed in the area between the elevator car and the car sling. In the case of an overhead beam load weighing device, the load weighing device measures the deflection of the top part of the car sling e.g. with strain gauges.
25 In other words it weighs the whole car sling i.e. the mass of the elevator car and of the passengers. At the same time the static frictions and kinetic frictions of the guides and guide rails influence the weighing result. In the case of a drive machinery load weighing
30 device, the weighing sensors are disposed in the fixing elements of the drive machinery or of the drive motor of the elevator such that they measure the usually downward directed force exerted on the drive

machinery by the ropes used to support the elevator car and any counterweight.

5 The measurement results of load weighing devices are also often used for measuring the movements and amount of passengers. On the basis of the load weighing signal it is endeavored to detect the people entering the elevator car and likewise the people leaving the elevator car.

10

One problem with prior art is that when the elevator decelerates when arriving at a floor, the opening of the doors of the cars is often started when the elevator car is still moving. Furthermore, the
15 elevator car often jerks before finally stopping at the destination floor. When these facts are combined with the fact that the passengers inside the elevator car simultaneously move about inside the elevator car, various interferences from different sources are
20 transmitted to the weighing signal of the load weighing device.

Since the load weighing signal is used elsewhere in the elevator system than in counting the passengers, a
25 load weighing signal containing interference causes difficulties to all these operational applications. In addition, e.g. accelerations and decelerations cause an offset of the zero point of the load weighing signal.

30

It has earlier been endeavored to smooth a load weighing signal containing interference e.g. by averaging, calculating e.g. a sliding average. Using averaging does not however remove e.g. the offset of

the zero point during e.g. acceleration and deceleration nor is the detection of changes of speeds occurring in the load weighing signal possible.

5 SUMMARY OF THE INVENTION

The purpose of the invention is to eliminate the aforementioned drawbacks. More particularly, the purpose of the invention is to disclose a new kind of solution for filtering and significantly improving the
10 load weighing signal of an elevator.

The method, the computer program, and the system according to the invention are characterized by what is disclosed in the characterization part of claims 1,
15 8 and 10. Other embodiments of the invention are characterized by what is disclosed in the other claims. Some inventive embodiments are also presented in the drawings in the descriptive section of the present application. The inventive content of the
20 application can also be defined differently than in the claims presented below. The inventive content may also consist of several separate inventions, especially if the invention is considered in the light of expressions or implicit sub-tasks or from the point
25 of view of advantages or categories of advantages achieved. In this case, some of the attributes contained in the claims below may be superfluous from the point of view of separate inventive concepts. The features of the various embodiments can be applied
30 within the scope of the basic inventive concept in conjunction with other embodiments.

In accordance with the first aspect of the invention, a method for improving the accuracy of a load weighing
35 signal in an elevator system is presented. In the

method a load weighing signal expressing the sum of the forces exerted on the elevator car or on the drive machinery or on the elevator car and the car sling is received from the load weighing arrangement, the
5 measuring signal about the vertical acceleration of the elevator car is received from the measuring means of acceleration fixed in connection with the elevator car or with the car sling, and the load weighing signal is compensated with the acceleration signal
10 measured by the measuring means of acceleration.

In accordance with the second aspect of the invention a computer program is presented, which is arranged to perform the method presented in some of the method
15 claims when run on a data processing appliance. The computer program can be stored on a medium that is readable with a data processing appliance.

According to the third aspect of the invention a
20 system for improving the accuracy of a load weighing signal in an elevator system is presented. The system comprises at least one elevator, a load weighing arrangement of an elevator, which is arranged to measure the sum of the forces exerted on the elevator
25 car or on the drive machinery or on the elevator car and the car sling, and means for measuring the vertical acceleration of the elevator car fixed in connection with the elevator car or with the car sling. In addition the system comprises an analysis
30 system, which is arranged to receive a load weighing signal expressing the sum of the forces exerted on the elevator car or on the elevator car and the car sling or on the drive machinery from the load weighing arrangement; to receive a measuring signal about the

vertical acceleration of the elevator car from the means; and to compensate the load weighing signal with the acceleration signal measured by the means.

- 5 In one embodiment of the invention in the compensation phase the load weighing signal is scaled with the sum of the acceleration of the gravity of the earth (acceleration constant g) and the measuring signal of the measuring means of acceleration, and the zero
10 offset caused by the mass of the car is removed from the scaled load weighing signal, in which case the compensated mass measured by the car load weighing device is obtained. In one embodiment of the invention the car mass is estimated in accordance with the
15 following equation:

$$\begin{aligned}\hat{m}_c(k) &= \hat{m}_c(k-1) + S \cdot e(k) \\ e(k) &= G_{est} [(m_{LWD0}(k) - \hat{m}_c(k-1)) - m0_{LWD}] \\ S &= \{ \text{hissi tyhj\AA} \wedge (\text{ovi auki} < X \text{ mm}) \}\end{aligned}$$

- where $\hat{m}_c(k)$ is an estimate for the mass of the car with the sample number k , $m0_{LWD}$ is the target weight for the empty car displayed by the load weighing device, $t=k \cdot \Delta t$
20 and Δt is the sampling interval, $S=[0,1]$, X is the predetermined parameter describing the degree of opening of the door of the car and G_{est} is confirmation of the estimation.

- 25 In another embodiment of the invention the load weighing signal is scaled with the sum of the acceleration constant g and the measuring signal of the measuring means of acceleration, and the zero offset caused by the moving masses, such as e.g. the
30 mass of the elevator car, the car sling, the roping and/or the counterweight, is removed from the scaled

load weighing signal, in which case the compensated mass measured by the car load weighing device is obtained. In one embodiment of the invention the friction component caused by the guides and guide
5 rails are also removed from the scaled load weighing signal.

In one embodiment of the invention the elevator car is driven between two floors, data about the shaft
10 frictions exerted on the car during the run between the floors is collected and the collected data is used as a condition monitoring indicator.

In one embodiment of the invention passengers arriving
15 in the elevator car and/or leaving from it are detected on the basis of the compensated load weighing signal.

One of the advantages of the present invention is that
20 it is possible, depending on the load weighing device type, to effectively compensate the load weighing device measurement for the phenomena caused by acceleration by measuring the acceleration of the elevator car and/or the car sling. The method
25 disclosed in the present invention also applies to floor, car and overhead beam load weighing devices as well as to drive machinery load weighing devices and the method can be applied when the elevator car is moving as well as when it is stationary.

30

Owing to the present invention the offset of the zero point caused by accelerations and decelerations of the elevator can be removed from the load weighing signal. Further, the vibrations of the system excited by the

movements of passengers are removed from the load weighing signal. In the case of an overhead beam load weighing device and a drive machinery load weighing device the offset of the zero point caused by friction
5 can also be compensated.

As a result of the present invention e.g. the detection and counting of passengers is remarkably easy from a clear signal that is free of interference.
10 As a result of the invention passenger counting is facilitated in particular when openings of the doors are started before the final stooping of the elevator car at the floor (so-called advance opening). Since advance opening increases the service capacity of an
15 elevator, it is possible with the solution according to the invention to also favorably affect the service capacity of the elevator.

LIST OF FIGURES

20 Fig. 1 presents one embodiment of the system according to the invention.

Fig. 2a presents the behavior of an uncompensated load weighing signal in the different phases of operation
25 of the elevator in the case of a car load weighing device.

Fig. 2b presents the behavior of a compensated load weighing signal in the different phases of operation
30 of the elevator in the case of a car load weighing device.

Fig. 3 presents another embodiment of the system according to the invention.

Fig. 4a presents an example of compensated and of uncompensated weighing in the case of an overhead beam load weighing device.

5

Fig. 4b presents an example of acceleration-compensated and friction-compensated load weighing device measurements in the case of an overhead beam load weighing device.

10

Fig. 5 presents an embodiment according to the invention for estimating the car mass.

Fig. 6 presents a flow chart example of the structure of the system according to the present invention.

15

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 presents one embodiment of the system according to the invention. In the embodiment presented by Fig.

20 1 the phenomena caused by the vertical acceleration of the car is compensated out of the measurement of the car load weighing device 106, such as the offset of the zero point produced by acceleration and deceleration as well as the vibrations generated by
25 the masses of the car and their suspensions. The measuring and compensation can be performed both while the elevator car is moving between floors and while the elevator car is stopped e.g. at a floor. After the compensation the measurement result corresponds to the
30 weighing performed with a fixed floor. The acceleration data needed for the compensation is obtained from the acceleration sensor fixed to the elevator car 102 or to the car sling 100. The sensors of the car load weighing device 106 are disposed in

the area between the elevator car 102 and the car sling 100.

The car load weighing device 106 measures the sum of
 5 the forces exerted on the elevator car 102, in which case with the markings of Fig. 1 the following can be written:

$$\sum F_c(t) = (m_p(t) + m_c)(g + a_c(t)) \quad (1)$$

10

where $m_p(t)$ is the mass of the passengers 104 at the time t , m_c is the mass of the car, g is the acceleration of the gravity of the earth (acceleration constant g) and $a_c(t)$ is the
 15 acceleration of the car at the time t . If the car is suspended with flexible suspension, the force exerted on the elevator car 102 can be measured e.g. as the displacement of the car with respect to the sling 100. Depending on the construction, this can be done
 20 e.g. with strain gauges, by inductive remote measurement. Alternatively it is possible to measure the force directly, e.g. hydraulically with pressure sensors.

25 In order to obtain the mass from the force, the force measurement (1) must be scaled with g :

$$\begin{aligned} m_{LWD0}(t) &= \frac{\sum F_c(t)}{g} = (m_p(t) + m_c) \frac{g + a_c(t)}{g} \\ &= m_p(t) + m_c + \frac{a_c(t)}{g} (m_p(t) + m_c) \end{aligned} \quad (2)$$

30 In addition to this the zero offset, which is caused by the mass m_c of the car, must be removed from the

load weighing measurement. In practice the actual m_c is not necessarily known, but instead it must be replaced with the $\hat{m}_c$ estimated from the data (in other words, $\hat{m}_c \approx m_c$). In this case the mass measured
 5 by the car load weighing device 106 becomes

$$\begin{aligned} m_{LWD}(t) &= m_{LWD0}(t) - \hat{m}_c \\ &= m_p(t) + \frac{a_c(t)}{g}(m_p(t) + m_c) \end{aligned} \quad (3)$$

In equation (3) the acceleration of the elevator car
 10 102 brings an interference term dependent on the mass of the elevator car 102 and the combined mass of the passengers 104 with it to the measurement. In other words the car load weighing device 106 measures correctly only when the acceleration $a_c(t)$ of the
 15 elevator car 102 is zero. The acceleration phase and the deceleration phase give an (almost) constant value to a_c , which is seen as an offset of the zero point of the car load weighing device 106 during a change of speed. In a loading situation the passengers excite
 20 the system to vibrate at its natural frequency.

Fig. 2a presents the behavior of an uncompensated load weighing signal in the different phases of operation of the elevator. The bottom part of Fig. 2a presents
 25 the car load weighing device signal when the elevator initially moves at 1.6 m/s upwards, slows at a floor, two passengers leave and one arrives, and finally the elevator continues its journey upwards. The zero point offsets caused by acceleration and deceleration are
 30 clearly seen, as well as the reaction of the mechanical vibration circuits to the steps of the

passengers and to their moving between the car and the floor.

The phenomena in the car load weighing measurement caused by the acceleration of the car is compensated, e.g. such that the acceleration of the car is measured and by means of it the interference caused by the acceleration of the car that is included in the load weighing measurement is eliminated. Previously in equation (2) the acceleration constant g was used in the scaling. In the case of compensation, the load weighing signal is scaled with the term $g + \hat{a}_c(t)$:

$$m_{LWD0}(t) = \frac{\sum F_c(t)}{g + \hat{a}_c(t)} = (m_p(t) + m_c) \frac{g + a_c(t)}{g + \hat{a}_c(t)} \quad (4)$$

where $\hat{a}_c(t)$ is the measurement of the acceleration sensor. In the following it is assumed that the signal produced by the acceleration sensor installed in its position describes with sufficient accuracy the actual acceleration of the car, in other words $\hat{a}_c(t) \approx a_c(t)$. In this case (4) is reduced to the simple form:

$$m_{LWD0}(t) = m_p(t) + m_c \quad (5)$$

In equation (5) nothing surplus remains except the zero offset caused by the mass of the car, which is corrected as in the method presented earlier:

$$m_{LWD}(t) = m_{LWD0}(t) - \hat{m}_c = m_p(t) \quad (6)$$

Fig. 2b presents a compensated load weighing signal. At the top the speed of the elevator is presented, in the center the uncompensated and the acceleration-compensated load weighing signal in the same coordinate system are presented. At the bottom just the compensated signal is presented. With the method presented above the interference caused by the acceleration of the car can be compensated out of the load weighing signal.

10

In one embodiment of Fig. 2b the compensated load weighing signal can still be filtered e.g. with a non-linear median filter, which preserves the steep edges of the signal but removes random interference peaks.

15

If the elevator car contains a floating floor and the load is measured from the force exerted on the floor, what is presented above applies directly, only the mass of the car is replaced with the considerably smaller mass of the floating floor.

20

Fig. 3 presents another embodiment of the system according to the invention. In Fig. 3 an overhead beam load weighing device is used as a load weighing device, which measures the deflection of the top part of the sling typically with strain gauges. In other words, it measures the total mass of the sling, the car and the passengers. Simultaneously, the static frictions and kinetic frictions of the car guides and guide rails also affect the weighing result. The passengers are not directly visible to the overhead beam load weighing device, but instead the elastic dampers of the suspension of the car are between.

25
30

The situation examined in Fig. 3 is simplified in that the elevator car 302 and the car sling 300 are defined as a single mass. In this case the situation otherwise corresponds to the case of the car load weighing device (Fig. 1). In addition in the embodiment of Fig. 3 the friction of the guide rails b_g is taken into account in the compensation.

In the example of Fig. 3 it is further assumed that the car and the sling are fixed securely to each other. The case of the overhead beam load weighing device 306 can thus be treated correspondingly to the preceding car load weighing device. With the markings of Fig. 3 the following is obtained for the compensated mass at the time t :

$$m_{LWD}(t) = \frac{lwd(t)}{g} - (\hat{m}_c + \hat{m}_s) \quad (7)$$

$$m_{LWD}(t) = \frac{lwd(t)}{g + \hat{a}_s(t)} - (\hat{m}_c + \hat{m}_s) \quad (8)$$

where $lwd(t)$ is the force measurement received from the overhead beam load weighing device 306 at the time t , $\hat{a}_s(t)$ is the measurement of the acceleration sensor, g is the acceleration of the gravity of the earth, $\hat{m}_c$ is the estimate of the mass of the elevator car and $\hat{m}_s$ is the estimate of the mass of the car sling. Equation (7) is an uncompensated and equation (8) is an acceleration-compensated load weighing device equation.

Fig. 4a presents weighing performed with both methods (uncompensated and compensated weighing with an

overhead beam load weighing device). Owing to the simplification of the mechanical model, the vibrations do not quite fully attenuate. In addition the friction of the guides is seen in the compensated weighing when
 5 the elevator is moving.

Since the model was simplified by assuming that the elevator car and the car sling were a single structure by removing the flexible suspension between them, the
 10 vibrations do not fully attenuate in this model. Also the friction of the guides/guide rails is seen in the weighing result as an offset from the zero point, when the elevator has speed. In the case of roll guides, the friction is mainly rolling friction in nature, in
 15 which case the force resisting movement has the form

$$F_b(t) = -b_G v(t) \quad (9)$$

This frictional force can be compensated out of the
 20 load weighing measurement by adding a term corresponding to it to equations (7) and (8).

$$m_{LWD}(t) = \frac{lwd(t)}{g} - (\hat{m}_c + \hat{m}_s + \hat{b}_G v(t)) \quad (10)$$

$$m_{LWD}(t) = \frac{lwd(t)}{g + a_s(t)} - (\hat{m}_c + \hat{m}_s + \hat{b}_G v(t)) \quad (11)$$

25

where $\hat{b}_G$ is the estimate of the friction of the guides and the guide rails. From the standpoint of estimating parameters, the situation in the case of the overhead beam load weighing device is more
 30 complex compared to a car load weighing device because two parameters must be estimated in the

equations (10) and (11): the combined mass $\hat{m}_c + \hat{m}_s$ of the car and the sling as well as the estimate of friction $\hat{b}_G$. The problem can be solved e.g. as an optimization task.

5

If the problem is solved as an optimization task, a function that minimizes costs is first formed:

$$C(\hat{m}_c + \hat{m}_s, \hat{b}_G) = \sum_{k=1}^K [m_{LWD}(k, \hat{m}_c + \hat{m}_s, \hat{b}_G) - 0]^2 = \min \quad (12)$$

10

The idea in the cost function (12) is that the load weighing measurement, compensated for both acceleration and friction, must with an empty elevator be zero all the time during the run, in which case by minimizing the squared error of the terms deviating from zero the optimal estimates for the unknown parameters are obtained. In practice the task can be solved e.g. when the empty elevator drives a run between two consecutive floors. The run-time K measurement is collected in a data buffer, and after the run has ended (12) is solved e.g. with a prior-art linear optimization algorithm. The parameters thus made represent the average for the particular floor-to-floor distance.

25

A run of an empty elevator, for its part, can be inferred e.g. as follows. When the elevator has stood at a floor free and with the doors closed for a long enough time and when it leaves from there without opening the doors to serve a landing call, it is very probably empty. Apart from that, the parameters to be estimated can be updated via a reasonably long time

30

constant, in which case an individual failed estimation changes the long-term average only a little.

5 Especially in the case of guide shoes it is preferable to estimate the friction parameters and the mass parameters in a single session from the collected data material, because in this case the effect of non-linear static frictions is avoided. In
 10 the case of guide shoes, the friction force is by nature so-called Coulomb friction. In other words, it depends solely on the normal direction of the force against the surface not on speed. In the case of guide shoes the kinetic frictional force resisting
 15 motion has the form $\hat{F}_b = -\text{sign}(v(t)) \cdot \hat{b}_G$. Static friction is difficult to estimate and it varies very much along with the position of the car and other such factors. An estimate can however be given for it e.g. $\hat{F}_b = 5 \cdot \hat{F}_b$.
 $\begin{matrix} v=0 & v>0 \end{matrix}$

20 The preceding equations (10) and (11) also apply with a drive machinery load weighing device if the masses of the roping and any counterweight are added to them.

Fig. 4b presents both acceleration-compensated and
 25 friction-compensated load weighing measurements. In Fig. 4b at the top is the speed of the elevator and in the center is the measurement compensated for both acceleration and for friction. The bottom measurement has also been filtered with a median filter, the
 30 length of the window of which was 0.11 seconds. Filtering has removed vibration, as can be seen from the center section of the lower figure.

In one embodiment of the invention the estimation of average friction factors between the floors is used in condition monitoring. By collecting e.g. a friction table about runs between consecutive floors, a "shaft picture" is obtained of the frictions of the guide rails in the different parts of the shaft. This can be used e.g. as a condition monitoring indicator. The data can be supplied e.g. to a service center, where e.g. long-term monitoring of the trend for frictions can be performed.

Fig. 5 presents an embodiment of the invention for estimating the car mass m_c . The automatic resetting to zero of the load weighing device, in other words estimation of the car mass m_c , can be performed adaptively e.g. when it is known that the car is empty. Conventionally it has been possible to do this e.g. when the car is standing free at a floor with the door closed. In this case it can be assumed that the car is empty and the load weighing device should show zero.

In the solution presented in Fig. 5 the estimation can also be performed when the empty car is moving. In this case the load weighing device should actually show zero all the time because the car is empty. The resetting can be performed when the elevator is standing empty with the doors closed, leaves from this situation to serve a landing call and slows at the floor until the doors are 800mm open.

It is, in fact, preferable that the resetting is performed this way because the system receives excitations during the run. In this case the

adaptation mechanism receives information in the different operating points of the system. In addition the vibration and accelerations during the run keep the suspensions in motion, as a result of which any
 5 (non-linear) static frictions of the suspensions are not able to influence the estimation process.

When the above conditions for the status of the elevator are fulfilled (car empty, door open less
 10 than 800mm), estimation of the parameter m_c can be performed by iterating the samples received from the load weighing device

$$\begin{aligned} e(k) &= G_{est} [(m_{LWD0}(k) - \hat{m}_c(k-1)) - m0_{LWD}] \\ \hat{m}_c(k) &= \hat{m}_c(k-1) + S \cdot e(k) \\ S &= \{ \text{hissi vapaa} \wedge (\text{ovi auki} < 800 \text{ mm}) \} \end{aligned} \quad (13)$$

15

where $\hat{m}_c(k)$ is an estimate for the mass of the car with the sample number k , $m0_{LWD}$ is the target weight for the empty car displayed by the load weighing device, for which a value of 0 kg is normally given.
 20 The dependency $t=k \cdot \Delta t$ binds the sampling time t and the sample k , where Δt is the sampling interval. The state variable S can receive the values 0 or 1. The estimate of the mass of the elevator car is corrected with the estimation error $e(k)$ only when the elevator
 25 is known to be empty. G_{est} is the confirmation of the estimate and determines how quickly the mass of the car adapts towards its final value.

It can be seen from Fig. 5 by way of an example how $\hat{m}_c$
 30 adapts when the elevator is driven with the car empty and when the adaptation mechanism (13) is active. In

this embodiment the mass estimate of the car is intentionally set as 200 kg in the initial situation. In practice an error of this magnitude is only in question when starting up the system for the very first time. In the embodiment presented in Fig. 5, an adequately accurate estimate for the mass of the car is found in approx. four seconds. As is seen in Fig. 5, the compensated load weighing signal reaches zero despite all motion.

10

The estimate of the mass of the car calculated above $\hat{m}_c$ can be used e.g. in the equation (6).

Fig. 6 presents one embodiment of the system according to the invention. The system comprises an analysis system 600, which receives measuring data from the load weighing arrangement 604 and from the means 602 for measuring acceleration. Means 602 for measuring acceleration refers preferably to an acceleration sensor, which is arranged e.g. in connecting with the elevator car or with the car sling. The analysis means 600 is arranged to receive a load weighing signal expressing the sum of the forces exerted on the elevator car or on the elevator car and the car sling or on the drive machinery from the load weighing arrangement 604, to receive a measuring signal about the vertical acceleration of the elevator car from the means 602 and to compensate the load weighing signal with the acceleration signal measured by the means 602 according to one of the preceding embodiments of the present invention.

The analysis system 600 can be implemented with e.g. a computer program, which when run on a data processing

appliance performs the necessary analysis phases. In another embodiment the analysis system 600 can be implemented with a fully suitable appliance or with a combination of an appliance and software. For
5 implementing the hardware and/or software, the analysis system can comprise one or more memories, which contain a computer program that performs the analysis. The memory or memories can also contain other applications and software components, which are
10 not described in more detail in this application. The analysis system 600 can also comprise a central processing unit, which can also comprise a memory or a memory can be connected to it, which memory can contain a computer program (or a part thereof), which
15 when run in the central processing unit performs at least some or the performance phases required by the invention.

The invention is not limited solely to the embodiments
20 described above, but instead many variations are possible within the scope of the inventive concept defined by the claims below.

CLAIMS

1. Method for improving the accuracy of a load weighing signal in an elevator system, in which method:

5 **characterized in that** in the method:

the load weighing signal expressing the sum of the forces exerted on the elevator car or on the drive machinery or on the elevator car and the car sling is
10 received from the load weighing arrangement;

the measuring signal about the vertical acceleration of the elevator car is received from the measuring means of acceleration fixed in connection with the elevator car or with the car sling; and

15 the load weighing signal is compensated with the acceleration signal measured by the measuring means of acceleration.

2. Method according to claim 1,
characterized in that the load weighing
20 arrangement comprises a car load weighing device and in that in the compensation phase of the load weighing signal:

the load weighing signal is scaled with the sum of the acceleration constant g and the measuring signal
25 of the measuring means of acceleration; and

the zero offset caused by the mass of the car is removed from the scaled load weighing signal, in which case the compensated mass measured by the car load weighing device is obtained.

30 3. Method according to any of claims 1 - 2 above, **characterized in that** the car mass is estimated such that:

$$\begin{aligned}\hat{m}_c(k) &= \hat{m}_c(k-1) + S \cdot e(k) \\ e(k) &= G_{est} [(m_{LWD0}(k) - \hat{m}_c(k-1)) - m0_{LWD}] \\ S &= \{ \text{hissi tyhj} \wedge (\text{ovi auki} < X \text{ mm}) \}\end{aligned}$$

where $\hat{m}_c(k)$ is an estimate for the mass of the car with the sample number k , $m0_{LWD}$ is the target weight for the empty car displayed by the load weighing device, , $t=k \cdot \Delta t$ and Δt are the sampling interval, $S=[0,1]$, X is the predetermined parameter describing the degree of opening of the door of the car and G_{est} is confirmation of the estimation.

10 4. Method according to claim 1, **characterized in that** the load weighing arrangement comprises an overhead beam load weighing device and in that in the compensation phase of the load weighing signal:

15 the load weighing signal is scaled with the sum of the acceleration constant g and the measuring signal of the measuring means of acceleration; and

 the zero offset caused by the mass of the elevator car and the car sling is removed from the scaled load weighing signal, in which case the compensated mass measured by the car load weighing device is obtained.

20 5. Method according to claim 4, **characterized in that** in the method further:

 the friction component caused by the guides and guide rails are also removed from the scaled load weighing signal.

25 6. Method according to any of claims 1 - 5 above, **characterized in that** in the method further:

30 the elevator car is driven between two floors;

data about the shaft frictions exerted on the car during the run between the floors is collected; and

the collected data is used as a condition monitoring indicator.

5 7. Method according to any of claims 1 - 5 above, **characterized in that** the passengers arriving in the elevator car and/or leaving it are detected from the compensated load weighing signal.

8. Computer program, which when run in a data
10 processing appliance is arranged to perform any of the methods presented in the method claims 1 - 7.

9. Computer program according to claim 8,
characterized in that the computer program is stored on a medium readable with a data processing
15 appliance.

10. System for improving the accuracy of a load weighing device signal, **characterized in that** the system comprises:

at least one elevator (100, 102, 300, 302);

20 a load weighing arrangement (106, 306, 604) of an elevator (100, 102, 300, 302), which is arranged to measure the sum of the forces exerted on the elevator car or on the drive machinery or on the elevator car and the car sling;

25 means (602) for measuring the vertical acceleration of the elevator car fixed in connection with the elevator car or with the car sling; and

an analysis system (600), which is arranged:

30 to receive the load weighing signal expressing the sum of the forces exerted on the elevator car or on the drive machinery or on the elevator car and the car sling from the load weighing arrangement (106, 306);

to receive the measuring signal about the vertical acceleration of the elevator car from the means (602); and

5 to compensate the load weighing signal with the acceleration signal measured by the means (602).

11. System according to claim 10 above, **characterized in that** the load weighing arrangement (106, 306, 604) refers to a car load weighing device and in that the analysis system (600) is arranged:

to scale the load weighing signal with the sum of the acceleration constant g and the measuring signal of the measuring means of acceleration; and
15 to remove the zero offset caused by the mass of the car from the scaled load weighing signal, in which case the compensated mass measured by the car load weighing device is obtained.

12. Method according to any of claims 10 - 11 above, **characterized in that** the analysis system (600) is arranged to estimate the car mass such that:

$$\begin{aligned}\hat{m}_c(k) &= \hat{m}_c(k-1) + S \cdot e(k) \\ e(k) &= G_{est} [(m_{LWD0}(k) - \hat{m}_c(k-1)) - m0_{LWD}] \\ S &= \{ \text{hissi tyhj\AA} \wedge (\text{ovi auki} < X \text{ mm}) \}\end{aligned}$$

where $\hat{m}_c(k)$ is an estimate for the mass of the car with
25 the sample number k , $m0_{LWD}$ is the target weight for the empty car displayed by the load weighing device, $t=k \cdot \Delta t$ and Δt is the sampling interval, $S=[0,1]$, X is the predetermined parameter describing the degree of opening of the door of the car and G_{est} is confirmation
30 of the estimation.

13. System according to claim 10,
characterized in that the load weighing
arrangement (106, 306, 604) comprises an overhead beam
load weighing device and in that the analysis system
5 (600) is arranged:

to scale the load weighing signal with the sum of
the acceleration constant g and the measuring signal
of the measuring means of acceleration; and

to remove the zero offset caused by the mass of
10 the elevator car and the car sling from the scaled
load weighing signal, in which case the compensated
mass measured by the car load weighing device is
obtained.

14. System according to claim 13,
15 **characterized in that** the analysis means
(600) are further arranged:

to remove also the friction component caused by
the guides and guide rails from the scaled load
weighing signal.

20 15. System according to any of claims 10 - 14
above, **characterized in that** the analysis
system (600) is arranged:

to collect data about the shaft frictions exerted
on the car during the run between the floors; and

25 to use the collected data as a condition
monitoring indicator.

16. Method according to any of claims 10 - 15
above, **characterized in that** the analysis
system (600) is arranged to detect the passengers
30 arriving in the elevator car and/or leaving from it on
the basis of the compensated load weighing signal.

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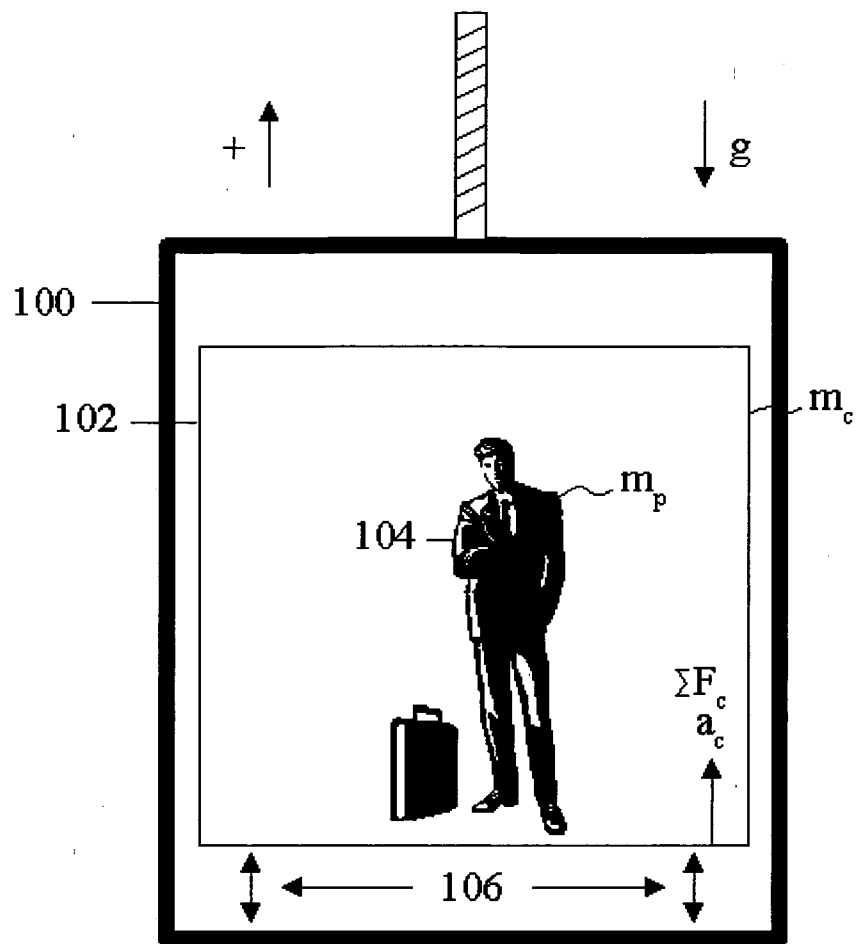


Fig. 1

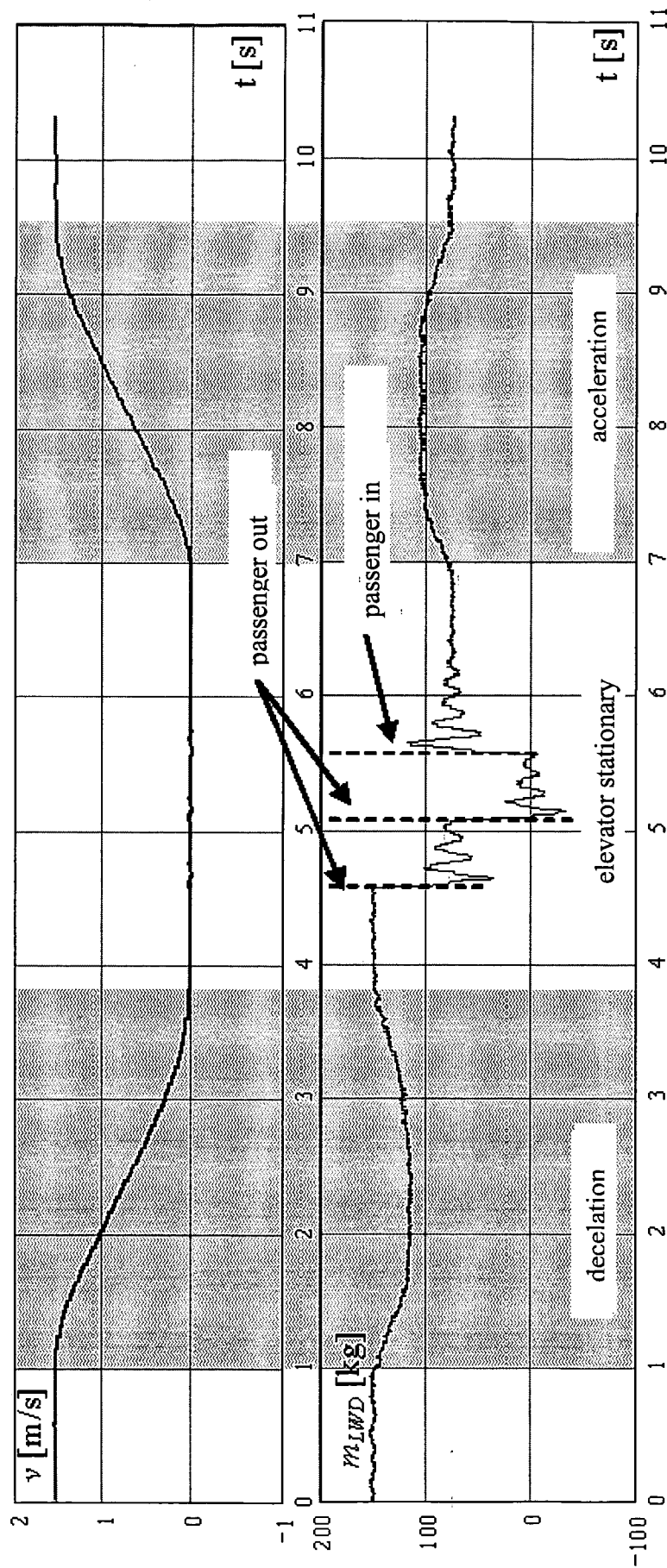


Fig. 2a

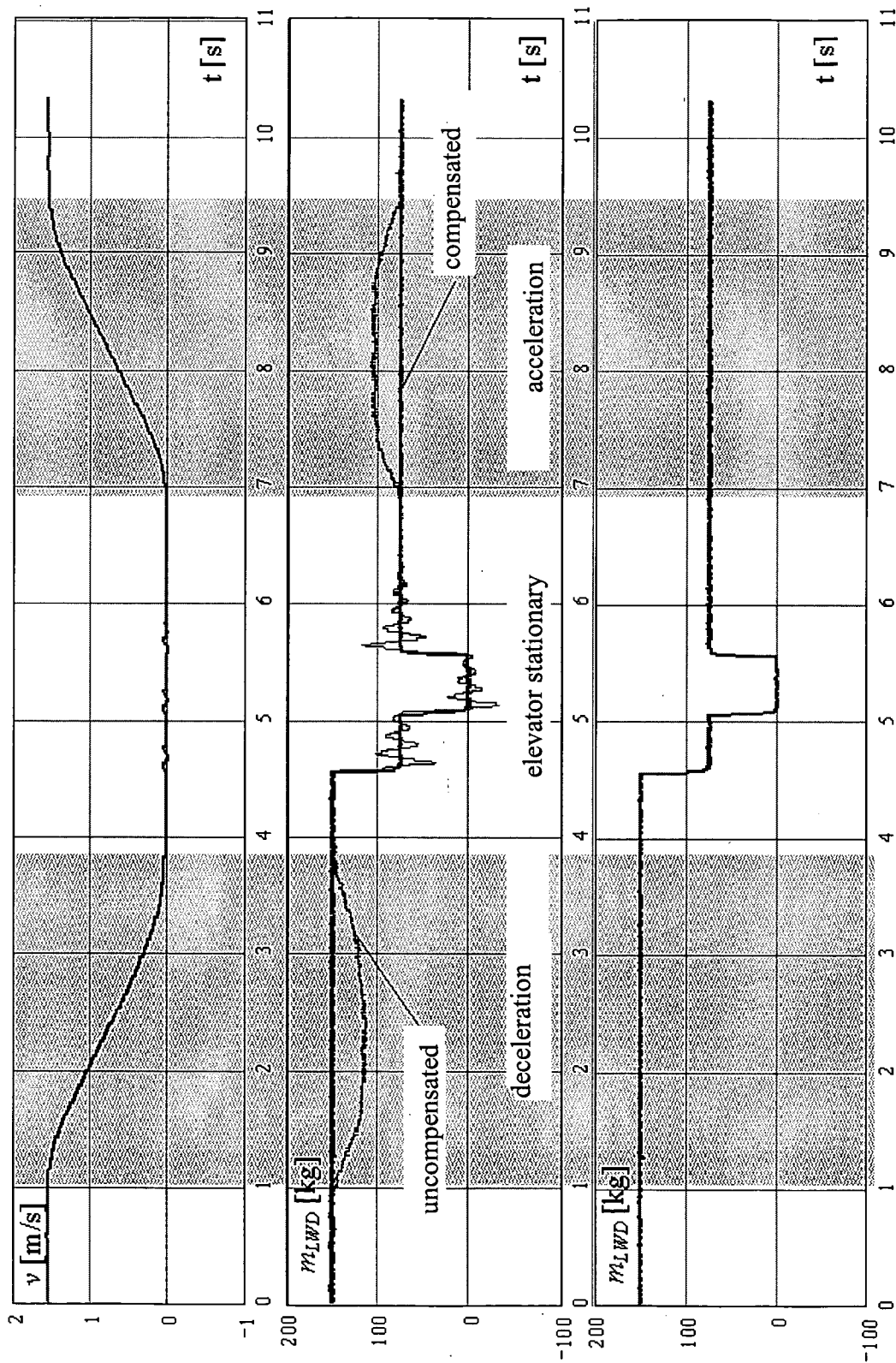


Fig. 2b

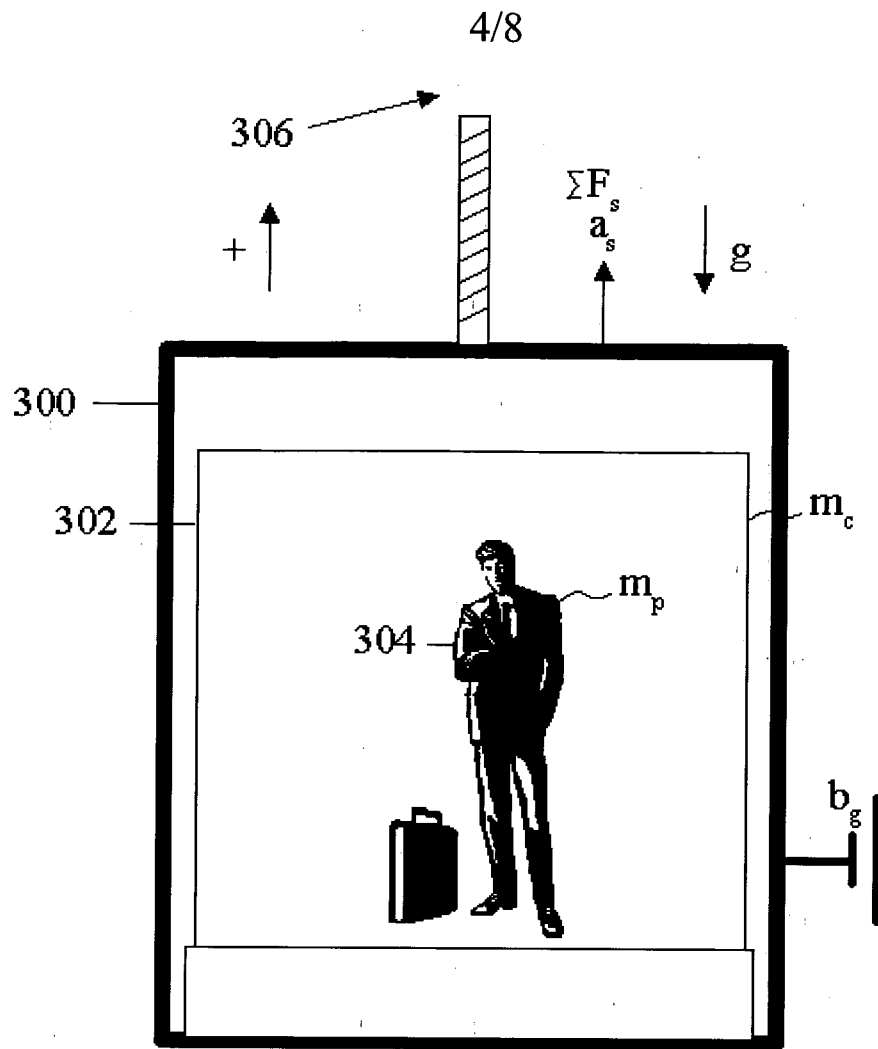


Fig. 3

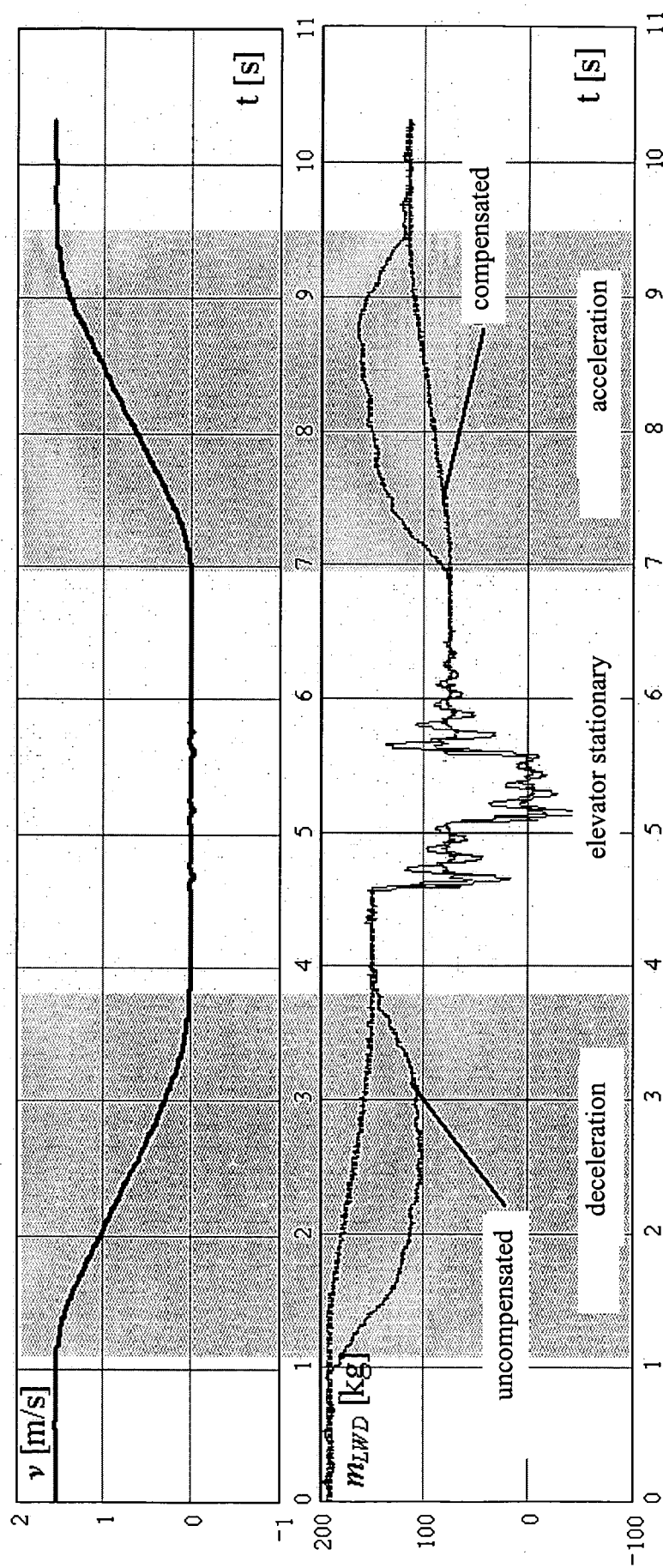


Fig. 4a

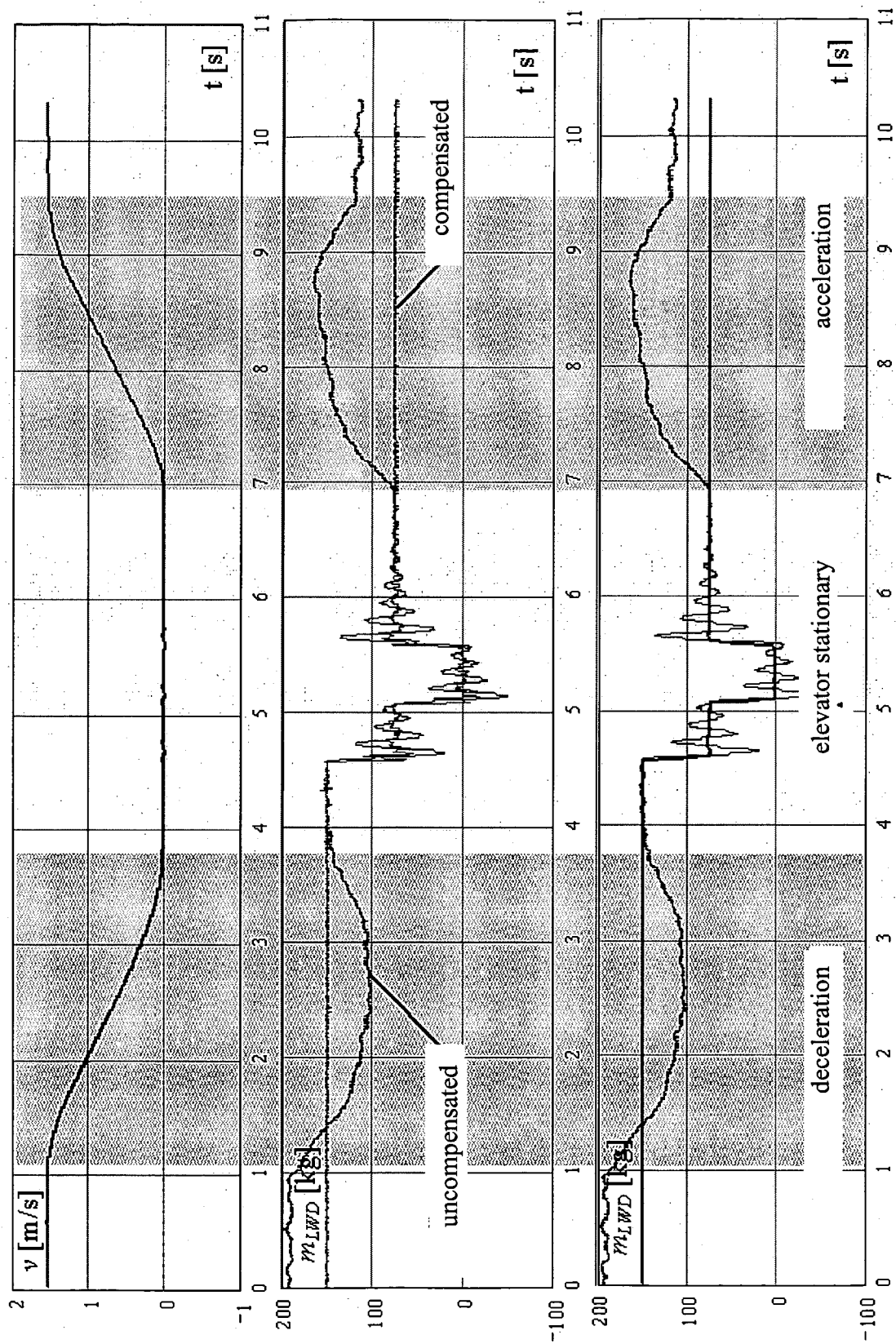


Fig. 4b

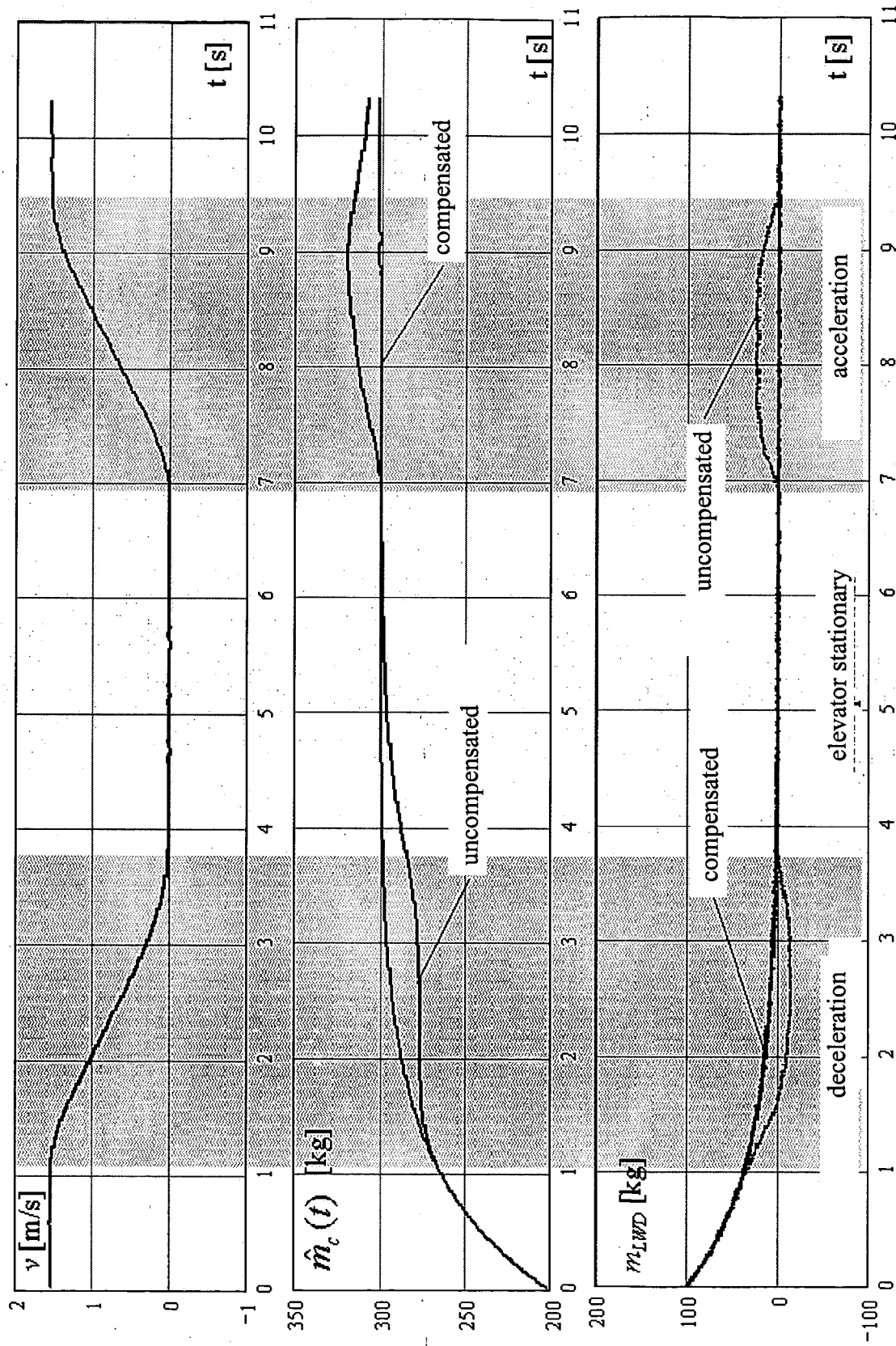


Fig. 5

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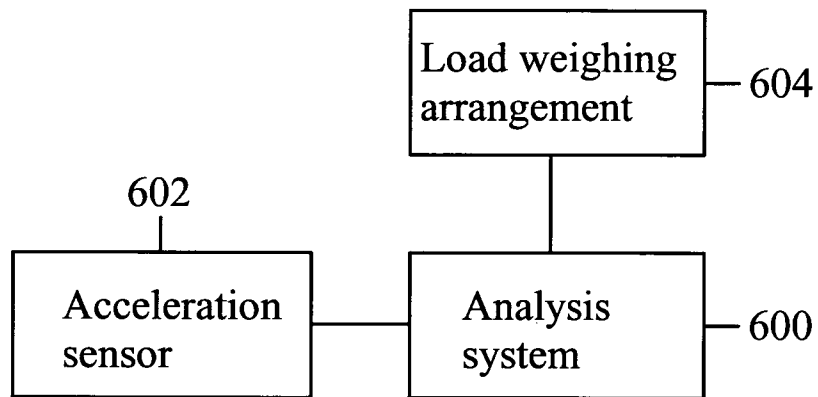


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2008/000067

A. CLASSIFICATION OF SUBJECT MATTER		
See extra sheet		
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)		
IPC8: B66B, G01G		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
FI, SE, NO, DK		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPODOC, WPI, TXTE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2006035101 A2 (KONE CORP et al.) 06 April 2006 (06.04.2006), abstract, page 1, lines 27 - 34, claims, and figures	1, 2, 4, 7 - 11, 13, and 16
Y	WO 02097381 A1 (TRANS LOCK IND AUSTRALASIA PTY et al.) 05 December 2002 (05.12.2002), abstract, claims, and figures	1, 2, 4, 7 - 11, 13, and 16
Y	US 2001052431 A1 (KLAUER A. et al.) 20 December 2001 (20.12.2001), abstract, paragraphs 0005, 0036, claims, and figure 6	1, 2, 4, 7 - 11, 13, and 16
Y	EP 0528188 A1 (KONE ELEVATOR GMBH) 24 February 1993 (24.02.1993), abstract, claims, and figures	7 and 16
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A	US 2003111301 A1 (SITTLER D. et al.) 19 June 2003 (19.06.2003), abstract, claims, and figures	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 "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "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		Date of mailing of the international search report
14 August 2008 (14.08.2008)		20 August 2008 (20.08.2008)
Name and mailing address of the ISA/FI National Board of Patents and Registration of Finland P.O. Box 1160, FI-00101 HELSINKI, Finland Facsimile No. +358 9 6939 5328		Authorized officer Marko Lammintausta Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2008/000067

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	JP 2006321642 A (HITACHI BUILDING SYS CO LTD) 30 November 2006 (30.11.2006), abstract and figures	1 - 16

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JP 2006321642 A	30/11/2006	None	
.....			

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2008/000067

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

B66B 1/34 (2006.01)

G01G 19/14 (2006.01)

B66B 5/14 (2006.01)

B66B 3/00 (2006.01)

G01P 15/08 (2006.01)