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(54) **A method for determining and displaying a floor level indication.**

(57) A method for determining and displaying a floor level indication, indicating a floor at which a lift car is positioned in a lift shaft, said method uses an accelerometer for determining an acceleration/deceleration imposed on said lift car. On the basis of the measured acceleration/deceleration value the distance travelled by said lift car is determined. On the basis of said distance and a starting floor level indication a destination floor to which said lift car was moved as a consequence of said acceleration is determined.

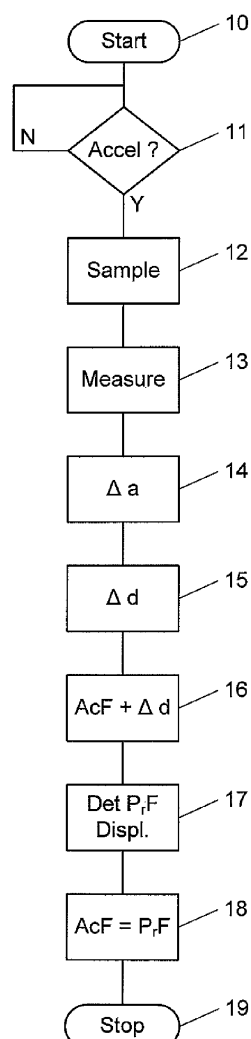


Fig. 2

Description

[0001] The present invention relates to a method for determining and displaying a floor level indication, indicating a floor at which a lift car is positioned in a lift shaft.

[0002] Such a method is generally known and used for indicating to a user at which floor a lift car is positioned in a lift shaft. The floor level is indicated visually and/or by a spoken information. Indicating the floor level at which the lift car is at, also provides to the user an indication on the time to wait until the lift car arrives at the floor on which they currently are waiting.

[0003] A problem is however how to obtain the floor signals and how to forward them to the floor level indicators. In new installations, the interface and the wiring is generally adapted to include such indicators. For upgrading of existing lifts, the problem on the one hand is how to obtain position information, because the lift controller might not provide such output signals, and on the other hand how to transmit those signals to the indicators, because there might not be any spare wires.

[0004] Currently such retrofitted indicators mainly rely on obtaining position indication from the lift controller. Since the controller is in the machine room and the indicator is in the lift car, wires need to be run to transmit the information. This is expensive and time consuming. Furthermore, the controller might be of an old design, not providing floor level output signals. Alternatively an auxiliary position device can be fitted on the lift car to provide the desired position signals. Such device can for instance be a rotary encoder, or a magnetic strip fitted along the shaft. In both cases, the devices are rather expensive and time consuming in installation. When a rotary encoder is used, a dented belt is preferred, because it eliminates the rope slip between the rope and the encoder pulley, which could offset the detected position value.

[0005] It is an object of the present invention to provide a method for determining and displaying a floor level indication, which method is reliable and does not need a time consuming installation.

[0006] For this purpose a method according to the present invention is characterised in that said method comprises :

- detecting by means of an accelerometer of an acceleration/deceleration imposed on said lift car and measuring an value generated by said accelerometer in order to determine an acceleration/deceleration value;
- determining based on said acceleration/deceleration value a distance travelled by said lift car;
- determining, based on said distance and a starting floor level indication, stored in a memory indicating a starting floor on which said lift car was positioned when said travelling started, the destination floor to which said lift car was moved, as a consequence of said acceleration/deceleration;
- attributing to said destination floor an appertaining

floor level indication;

- substituting in said memory said starting floor level indication by said appertaining floor level and displaying said floor level indication.

[0007] The use of an accelerometer enables an easy and reliable manner to determine which acceleration/deceleration the lift car has been subjected to. The acceleration/deceleration value generated by the accelerometer enables an easy determination of the travelled distance. As moreover the acceleration/deceleration value is a vector value, its direction enables to determine in which direction the lift car travels. Based on the travelled distance and the stored starting floor, the new floor reached by the lift car can be determined and displayed. The substitution of the starting floor level by the appertaining floor level enables to update the starting floor level indication. In such a manner, the correct starting floor value is available for the next travel of the lift car, hence offsetting eventual drift or detection errors. As electronic originals are involved, wireless transmission is possible so that no additional wiring is required.

[0008] A first preferred embodiment of a method according to the present invention is characterised in that said measuring of said acceleration/deceleration is realised by measuring a vertical acceleration/deceleration component of an acceleration signal generated by said accelerometer. Since the lift car moves in a vertical direction, it is sufficient to measure the vertical acceleration/deceleration component.

[0009] A second preferred embodiment of a method according to the present invention is characterised in that said detection of said acceleration is realised by detecting a first moment at which said acceleration starts and a second moment at which said deceleration stops, and by determining the time period between said first and said second moment. In such a manner, a reliable determination of the time period during which the lift car moves is possible, which on its turn enables a reliable determination of the distance by integration over the determined time period. This presumes that the nominal travelling speed of the lift remains constant.

[0010] A third preferred embodiment of a method according to the present invention is characterised in that a list of floors to be served by said lift is determined upon installation of said lift, said list being stored in said memory, and wherein said attributing of said appertaining floor level indication is realised by comparing said determined destination floor with said list of floors and selecting among said floors, stored in said list, the one corresponding best with said determined destination. The use of a list of floors/floor-levels to be served enables to compare the determined destination floor-level with existing stored floor levels and thus a verification of the determined destination floor.

[0011] Preferably each time that said determined destination floor corresponds to either the lowest or the highest ranked floor in said list, said accelerometer generated

floor values are calibrated. By calibrating the effect of drift, which might affect the measured values/tables, is minimized.

[0012] A fourth preferred embodiment of a method according to the present invention is characterised in that said acceleration signal is filtered in order to reduce a low frequency drift. This lowers the precision demand on the accelerometer and enables to use the signal generated by the accelerometer also for monitoring purpose. Indeed, the vibration pattern generated by the accelerometer will provide information on how the lift functions. By monitoring the travel vibration pattern and comparing it with an initial vibration pattern, malfunctioning can be readily detected.

[0013] Preferably an initial vibration pattern, generated by said accelerometer during normal travelling of said lift car in said lift shaft, is recorded and stored in said memory, said method further comprising a monitoring program comprising a selection of a travel executed by said lift car and the recordings of a travel vibration pattern generated by said accelerometer during said selected travelling, said monitoring program further comprising a comparison (signature analysis) between said initial and said current travel vibration pattern in order to determine a deviation value between said initial and said travel vibration pattern and generating an alarm signal if said deviation value exceeds a predetermined level. In such a manner, a maintenance service can be alerted before serious problems could occur.

[0014] The invention will now be described in more detail with reference to the drawings illustrating a preferred embodiment of a method according to the invention. In the drawings:

figure 1 illustrates schematically a lift shaft wherein a lift car moves;

figure 2 illustrates by means of a flow chart the different steps of the method for determining and displaying the floor level indication;

figure 3 illustrates an acceleration signal, the speed and distance determined therewith; and

figure 4 illustrates a vibration pattern.

[0015] In the drawings a same reference sign has been allocated to a same or analogous element.

[0016] As illustrated in figure 1, a lift car 2 moves up and down in a lift shaft 1. For the sake of clarity only two floors F0 and F1 have been illustrated, but it will be clear that the present invention is not limited to a method where only two floors can be determined and displayed.

[0017] Inside the lift car a first display 3 is mounted, whereas a second display 4 is mounted, for example above the door 7, at each floor level. An accelerometer 5 is mounted, for example on top of the lift car roof. The accelerometer is provided for measuring the movement imposed by the motor 8 on the lift car 2. The accelerometer is connected to a data processing device 6. The data processing device is provided with a transmitter-receiver

in order to send and receive signals to the accelerometer 5 and the displays 3 and 4. The data processing device further comprises a microprocessor and a memory.

[0018] Figure 2 illustrates by means of a flow chart the different steps of the method for determining and displaying a floor indicator in a lift car. The method is executed under control of the microprocessor. The method is started (10) when for example the movement (11, Accel?) of the lift car takes place, but preferably allows for pre-trigger analysis.

[0019] Once the user has pushed a floor destination button in the lift car 2 or a call button on a floor, the door 7 will be closed, the motor 8 will start running in order to impose either an upward or a downward travel on the lift car, depending on the current floor on which the lift car is and the selected floor to which the user wants to go. The motor will thus impose an acceleration on the lift car, which acceleration will be detected by the accelerometer 5. The accelerometer will now measure the acceleration imposed on the lift car and generate an acceleration signal. As the lift moves either upwards or downwards it is sufficient to measure the vertical acceleration component of the acceleration signal.

[0020] The microprocessor now receives the acceleration signal generated by the accelerometer. Figure 3a illustrates an example of such an acceleration signal. The signal has a distinctive acceleration, a steady state constant speed phase followed by a deceleration peak for braking the lift car when it reaches its destination floor. The microprocessor will now sample (12) the accelerator signal and measure (13) the sampled signal in order to determine (14) an acceleration value (Δa). The microprocessor will preferably also detect (13) a first moment (t_1) at which the acceleration starts and a second moment (t_2) at which said acceleration stops. The time difference ($t_2 - t_1 = \Delta T$) will then be determined in order to determine the time period (ΔT) during which the lift car was moved.

[0021] Based on the acceleration value (Δa), the microprocessor will now determine (15) the distance (Δd) travelled by the lift car. This is for example realised by first mathematically integrating the acceleration value (Δa) over the time period (ΔT) in order to obtain the speed (figure 3b) and integrating this speed again over the time period in order to obtain the distance (Δd ; figure 3c).

[0022] Once the distance has been determined the microprocessor will read (16) in the memory the stored starting floor indication (AcF) indicating the floor level at which the travel of the lift car started. Based on this starting floor level indication (AcF) and the determined distance (Δd), the microprocessor will determine ($AcF + \Delta d$) the destination floor (PrF) at which the lift car was moved as a consequence of the acceleration/deceleration imposed on the lift car. Once the destination floor (PrF) is determined it will be displayed (17) under control of the microprocessor on both the displays 3 and 4. For this purpose the microprocessor will attribute on the obtained value $AcF + \Delta d$ an appertaining floor indication, for example by using a list of floors to be served, this list being stored in

the memory. The microprocessor will also substitute (18) in the memory the stored starting floor level indication by the determined appertaining floor indication, in order to have the starting floor level indication, stored and to enable a correct determination for a subsequent travel of the lift car. The program loop will then be finished (19).

[0023] As already mentioned, a list of floors to be served, is stored in the memory. The storage of this list of floors is preferably realised upon installation of the lift. For this purpose the floor indicators of each floor the lift serves, are sequentially stored in the memory. Due to the presence of this list of floors, the microprocessor when attributing the appertaining floor indication, will compare the determined destination floor ($AcF + \Delta d$) with the floor indicators in the list and select among the latter the one corresponding with the determined destination floor. In such a manner a well defined floor indication will always be displayed.

[0024] In order to avoid low frequency drift, which could occur in the acceleration signal generated by the accelerometer, the acceleration signal is preferably high-pass filtered.

[0025] The determination of the first and second moment at which the acceleration starts, respectively stops is realised by monitoring the acceleration signal in order to observe a positive or negative value in the single integration over a time longer than one second.

[0026] The floor displays 3 and 4 are preferably pre-programmed with the number of floors corresponding to the one in the list. This simplifies the transmission from the processing device 6 to the displays. To avoid drift and off-set over time, the floor reference value is preferably re-calibrated when the determined destination floor corresponds to either the lowest or the highest ranked floor in the list. For this purpose the maximum, respectively the minimum value obtained when determining ($AcF + \Delta d$) the starting floor level indication is set to a corresponding predetermined value.

[0027] The fact that the lift car is equipped with an accelerometer has a further advantage in that it can be used for monitoring the functioning of the lift car. The generated acceleration signal shows a vibration pattern as illustrated in figure 5, where the x, y and z components of the acceleration signal, generated by the accelerometer are illustrated for a downward travel. The vibration pattern will be determined by different components of the lift such as the motor, the rope, the speed, the load, the position in the shaft and wear on mechanical components. The vibration pattern will quantify the quality of the installation as a whole.

[0028] It will now be described how the microprocessor can also perform a reasonable advanced vibration analysis on a lift, how it can determine out-of-ordinary events and how such an event can create an alarm or alert to a remote location. The same processing device can also track long-term changes to the lift, such as wear or gradual deterioration. The application described can be integrated in a lift emergency telephone and uses the existing

processing, storage and communication resources. The additional cost for the described continuous vibration monitoring functions is therefore small. It should however be noted, that a device following the data gathering and analysing principles here described can be incorporated in other lift related products, or be functioning as a stand alone device. What is said here also applies to the monitoring of escalators and moving walk-ways the demands being a sub set of the lift (fewer operational states).

[0029] The lift behaves differently depending on its operational state. Such states can be : idling (standing still), re-levelling, loading, offloading, doors opening, doors closing, starting, stopping, accelerating, decelerating and running at nominal speed. Additional are a number of fault states, such as emergency braking, hitting limits or buffers, failed starts, etc..

[0030] Each of such states has a different vibration pattern. This vibration pattern would also have its distinctive pattern and acceptance limits for normal, relative to abnormal behaviour. Changes in vibration pattern come either as a gradual deterioration as components wear, or as a sudden change in case of immediate failure.

[0031] The vibration information such as present in the vibration pattern is firstly used to determine the state the lift is in (state band). For example for each state the maximum vibration is compared to a maximum allowed value. For this purpose an initial vibration pattern was generated representing a normal travelling of the lift car. The initial vibration pattern is stored in the memory. A monitoring program will be executed by the processing device in order to monitor the functioning of the lift. This maximum allowed value is determined as a multiplier of the value of the initial pattern. This initial pattern typically represents the lift as new or in good shape and is preferably averaged over a considerable time before being stored as initial pattern. The recorded values are also used to generate a rolling average seen as "current" status. This "average" is quantified on a discrete scale, and the values are stored with day stamps (day n, day n - 1, etc), hence avoiding clock synchronisation issues. The three values from each state band, as described above, are used for reporting and for alerting or alarming, depending on the graveness of the fault.

[0032] The digitised raw data is stored in a memory functioning as a ring buffer, which allows pre and/or post trigger data to be analysed. The start of the run or journey of the lift car is preferably considered as the trigger and is determined by a maintained speed integral over several seconds. This prevents load and offload jerks to be seen as false starts. Of course other events such as the opening of the door or the activation of a floor selection button could also be used for triggering the monitoring program. However the start of the journey as a trigger of the monitoring program has the advantage of providing a reliable solution. Indeed, when the lift car starts to run the accelerometer outputs an acceleration signal which can then be integrated over a period of more than one second, as the lift car travels for more than one second

even if only one higher floor level has to be reached. The continuous character of the acceleration signal contributes also to a reliable integration over a period of more than one second. When using the accelerometer signal the stop of the travel can also be reliably detected as the continuous character of the signal has disappeared.

[0033] By the use of the determined start as the trigger, data preceding the start can be analysed in a pre-trigger mode. Hereby events leading up to the start, such as door operation, loading or offloading can be precisely analysed without the need for additional sensors or signals, from for instance door contacts. The same applies to the stop of the lift car, thereby enabling a post-travel monitoring. A lift typically runs some tens of seconds, and thereafter idles for minutes or hours. Hence there is seldom need to perform the data analysis in real time, but merely to record the journey into the ring buffer. Should multiple journeys occur before the data was analysed, the older gets overwritten. If the lift continued to run, there was presumably not much information lost. In the event of a breakdown, the lift is at stand still and no consecutive data is being generated, so the ring buffer does not get overwritten. Data analysis can then be made of the events leading up to the breakdown.

[0034] The execution of the monitoring program further comprises a selection of a travelling executed by said lift car and a recording of a travel vibration pattern generated by said accelerometer during said selected travelling. The monitoring program is preferably started by the starting of the travelling of the lift car, as this can be reliably determined as described here before. However alternative solutions such as the activation of a floor level selection key could also start the monitoring program. The monitoring program further comprises a comparison between the initial travel pattern stored in the memory and the recorded travel vibration pattern in order to determine a first deviation value between said initial and said travel vibration pattern. When the comparison results in the fact that the first deviation value exceeds a first predetermined amount, an alarm signal is generated.

[0035] In order to also enable a monitoring of the lift before respectively after a journey occurred, an initial pre-travel respectively post-travel vibration pattern generated by the accelerometer during a pre-travel period preceding respectively a post-travel period following a normal travelling of the lift car in the lift shaft is recorded and stored in the memory. What period the pre- and post-travel vibration pattern will cover will depend on when the travel pattern used in the monitoring program begins and starts and which parameters have to be monitored. So for example the pre- and post-travel vibration pattern could cover the period between the opening, respectively the closing of the door and the start, respectively the stop of the journey.

[0036] The method comprising a continuous recording of a travel vibration pattern generated by said accelerometer and a storage of said recorded travel vibration pattern into the memory. As already described the mem-

ory is preferably a ring buffer memory which allows an overwriting of stored data. The method also comprises a pre-travel respectively a post-travel monitoring program triggered by said monitoring program and comprising an identification among the recorded travel vibration pattern stored in said memory of that first respectively second fragment of the recorded travel vibration pattern which preceded respectively followed said selected travelling during an execution of said monitoring program. The identification of the concerned fragment is for example realised on the basis of a time criteria such as for example all the data present one minute before the journey selected by the monitoring program started. Once the concerned fragment is identified, the latter is read out of the memory. The pre-travel respectively post-travel monitoring program further comprises a comparison between said initial pre-travel respectively post-travel vibration pattern and said first respectively second fragment in order to determine a second respectively third deviation value between said initial pre-travel respectively post-travel vibration pattern and said first respectively second fragment and generating said alarm signal if said second respectively third deviation value exceeds a second respectively third predetermined amount. The second and third predetermined amount is either of the same value or has a different value.

[0037] Although the monitoring programs are generally realised by the processing device, a relatively simple microprocessor such of the emergency telephone could perform reasonably advanced vibration data analysis. When anomalies are detected, the data in the ring buffer that represents the state where the exception occurred gets stored in a reporting memory. This data can be accessed from remote and downloaded as a sound file. Practically it works so that the device in the lift, sends a ticket stating the fault with details of the anomaly. Such ticket can for instance be: Lift 12345678, A321 (meaning; excessive vibration at door closing). The office or a service technician can later call up the remote device and listen to the noise pattern or download it into a computer. This downloaded file can then be analysed with for instance powerful Fourier transformation algorithms, in order to more precisely determine the cause of failure.

[0038] The invention can also include a self verification function. In the event the lift has been suspected of being immobile by an event of vibration satisfying the alarm criteria described above, the device can in sequence close relay contacts connected to the top and bottom landing call buttons or perform a system reset to the lift controller. If the lift remains not responding to such manipulation, a ticket "suspected out of order" can be sent. In the same manner, a subsequent ticket of "function resumed" is sent when the lift resumes operation (= moves normally).

[0039] Although the monitoring program could be executed by each travelling of the lift car, it is sufficient to execute the monitoring program for a selected number of travels. By execution of the monitoring program, the

data processing device will compare the measured vibration pattern with the stored initial pattern and depending on the predetermined maximum allowed value determine, a duration between the initial and the recorded travel vibration pattern. If the deviation exceeds a predetermined amount, an alarm signal will be generated by the data processing device.

Claims

1. A method for determining and displaying a floor level indication, indicating a floor at which a lift car is positioned in a lift shaft, **characterised in that** said method comprises :

- detecting by means of an accelerometer of an acceleration/deceleration imposed on said lift car and measuring an acceleration value generated by said accelerometer in order to determine an acceleration/deceleration value;
- determining based on said acceleration/deceleration value of a distance travelled by said lift car;
- determining, based on said distance and a starting floor level indication stored in a memory and indicating a starting floor on which said lift car was positioned when said travelling started, a destination floor to which said lift car was moved as a consequence of said acceleration;
- attributing to said destination floor an appertaining floor level indication;
- substituting in said memory said starting floor level indication by said appertaining floor level indication and displaying said floor level indication.

2. The method according to claim 1, **characterised in that** said measuring of said acceleration/deceleration is realised by measuring a vertical acceleration component of an acceleration/deceleration signal generated by said accelerometer.

3. The method according to claim 1 or 2, **characterised in that** said detection of said acceleration is realised by detecting a first moment at which said movement starts and a second moment at which said movement stops, and by determining the time period between said first and said second moment.

4. The method according to claim 3, **characterised in that** said distance is determined by a mathematical integration of said acceleration value over said time period.

5. The method according to any one of the claims 1 to 4, **characterised in that** a list of floors to be served by said lift is determined upon installation of said lift,

said list being stored in said memory, and wherein said attributing of said appertaining floor indication is realised by comparing said determined destination floor with said list of floors and selecting among said floors stored in said list the one corresponding with said determined destination.

6. The method according to claim 5, **characterised in that** each time said determined destination floor corresponds to either the lowest or the highest ranked floor in said list, said accelerometer generated value is re-calibrated.

7. The method according to any one of the claims 1 to 6, **characterised in that** said acceleration signal is filtered in order to reduce a low frequency drift.

8. The method according to any one of the claims 1 to 7, **characterised in that** an initial vibration pattern, generated by said accelerometer during normal travelling of said lift car in said lift shaft is recorded and stored in said memory, said method further comprising a monitoring program comprising a selection of a travelling executed by said lift car and a recording of a travel vibration pattern generated by said accelerometer during said selected travelling, said monitoring program further comprising a comparison between said initial and said travel vibration pattern in order to determine a first deviation value between said initial and said travel vibration pattern and generating an alarm signal if said first deviation value exceeds a first predetermined amount.

9. The method as claimed in claim 8, **characterised in that** an initial pre-travel vibration pattern generated by said accelerometer during a pre-travel period preceding a normal travelling of said lift car in said lift shaft is recorded and stored in said memory, said method further comprising a continuous recording of a travel vibration pattern generated by said accelerometer and a storage of said recorded travel vibration pattern into said memory, said method also comprises a pre-travel monitoring program triggered by said monitoring program and comprising an identification among the recorded travel vibration pattern stored in said memory of that first fragment of the recorded travel vibration pattern which preceded said selected travelling during an execution of said monitoring program and a reading of said first fragment, said pre-travel monitoring program further comprises a comparison between said initial pre-travel vibration pattern and said first fragment in order to determine a second deviation value between said initial pre-travel vibration pattern and said first fragment and generating said alarm signal if said second deviation value exceeds a second predetermined amount.

10. The method as claimed in claim 8, **characterised in that** an initial post-travel vibration pattern generated by said accelerometer during a post-travel period following a normal travelling of said lift car in said lift shaft is recorded and stored in said memory, said method further comprising a continuous recording of a travel vibration pattern generated by said accelerometer and a storage of said recorded travel vibration pattern into said memory, said method also comprises a post-travel monitoring program triggered by said monitoring program and comprising an identification among the recorded travel vibration pattern stored in said memory of that second fragment of the recorded travel vibration pattern which followed said selected travelling during an execution of said monitoring program and a reading of said second fragment, said post-travel monitoring program further comprises a comparison between said initial post-travel vibration pattern and said second fragment in order to determine a third deviation value between said initial post-travel vibration pattern and said second fragment and generating said alarm signal if said third deviation value exceeds a third predetermined amount.
11. The method according to any one of the claims 8 to 10, **characterised in that** said alarm signal is transmitted, in particular via a mobile phone network, to a maintenance station.
12. The method as claimed in any one of the claims 8 to 11, **characterised in that** said travel vibration pattern covers a journey of said lift car.
13. The method according to any one of the claims 9 to 10, **characterised in that** said continuous recorded travel vibration pattern is stored in a ring buffer memory.
14. A device for determining a floor level indication, indicating a floor at which a lift car is positioned in a lift shaft, **characterised in that** said device comprises :
- an accelerometer provided for measuring an acceleration/deceleration imposed on said lift car when travelling in said lift shaft and for generating acceleration/deceleration value generated by said accelerometer;
 - distance determining means connected to said accelerometer and provided for determining based on said acceleration/deceleration value of a distance travelled by said lift car;
 - a memory provided for storing a starting floor level indication indicating a starting floor on which said lift car was positioned when said travelling started
 - floor level indication means connected to said

memory and said distance determining means and provided for determining, based on said distance and said starting floor level indication, a destination floor to which said lift car was moved as a consequence of said acceleration, said floor level indication means being further provided for attributing to said destination floor an appertaining floor level indication and for substituting in said memory said starting floor level indication by said appertaining floor level indication.

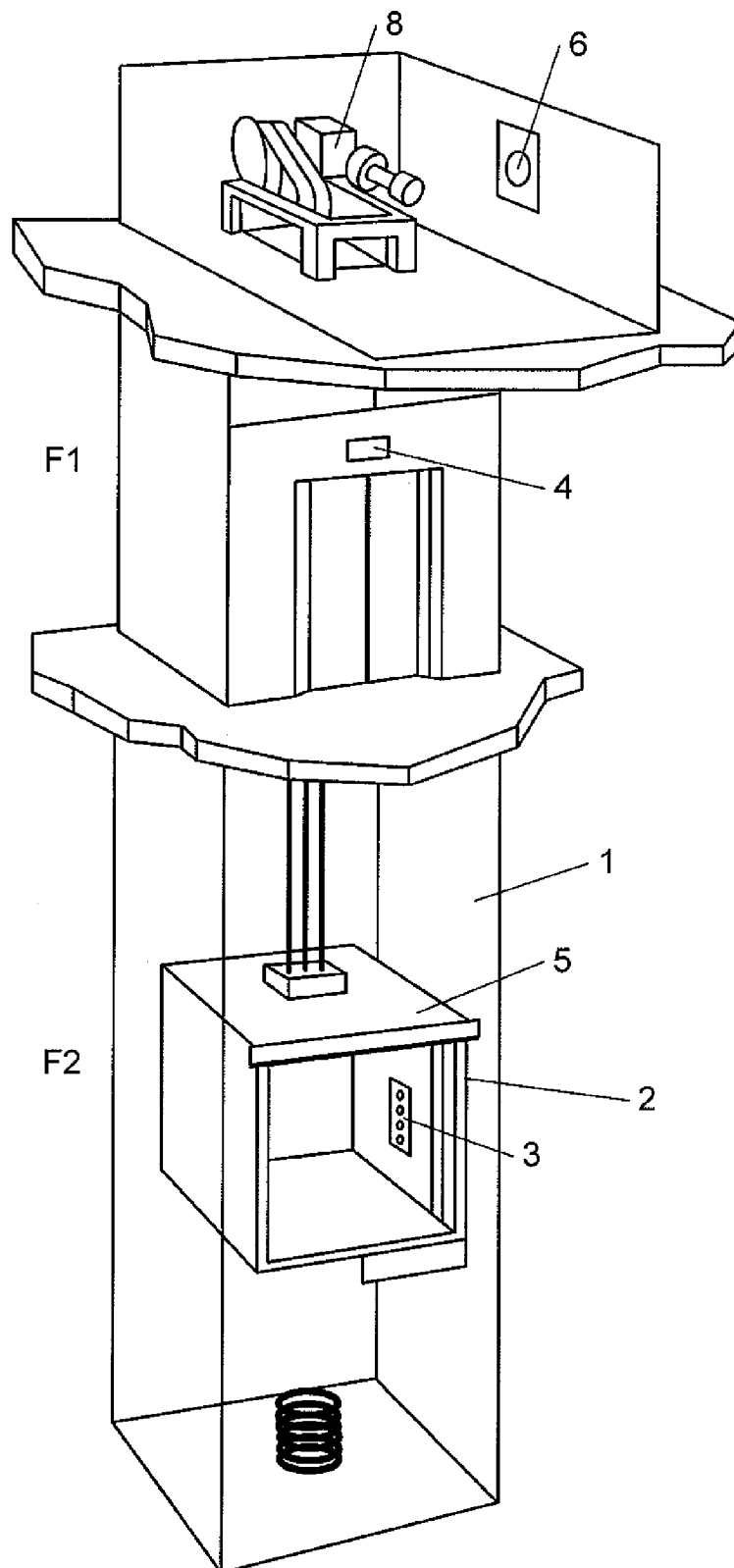
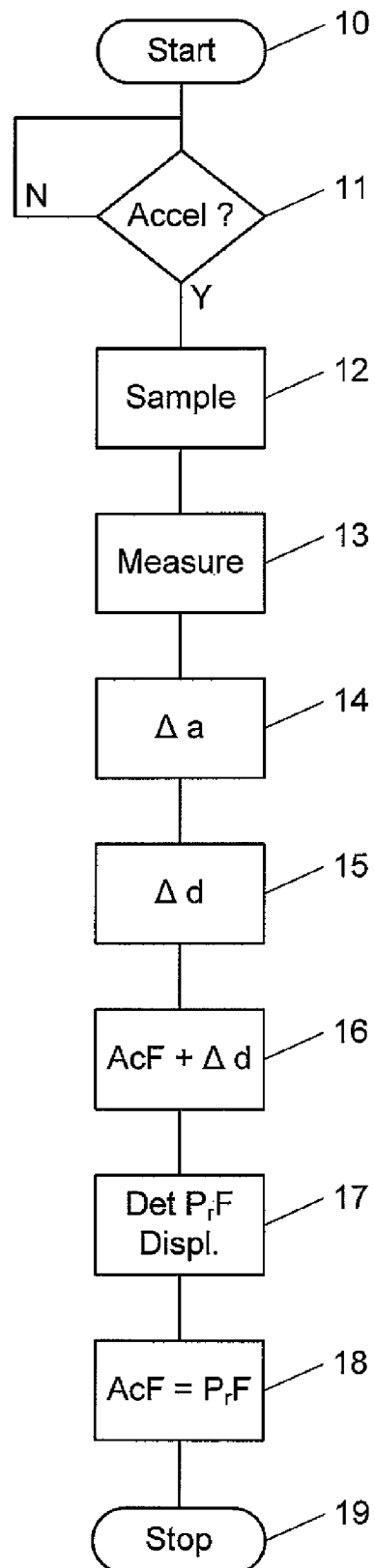


Fig. 1

**Fig. 2**

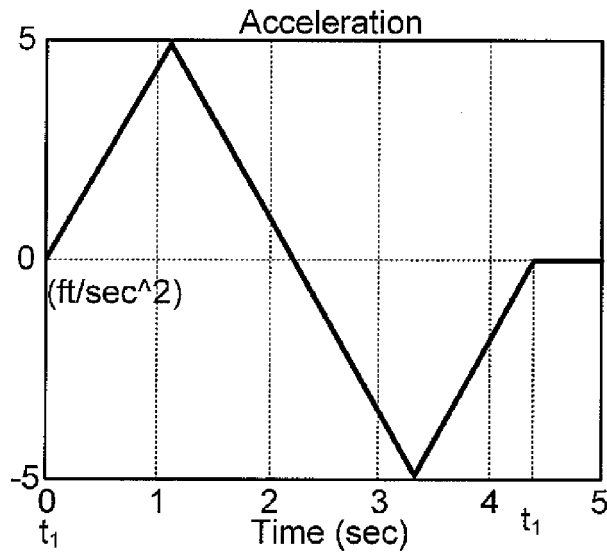


Fig. 3a

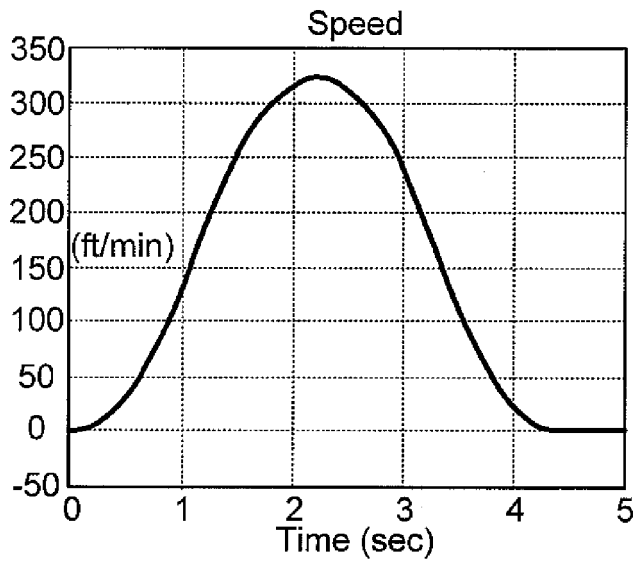


Fig. 3b

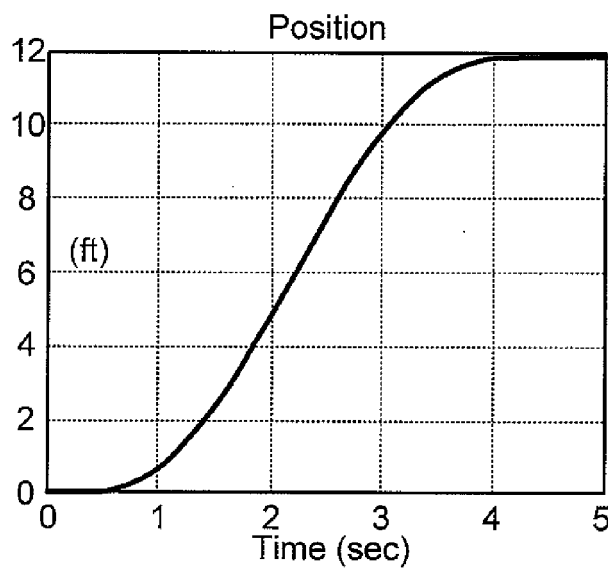


Fig. 3c

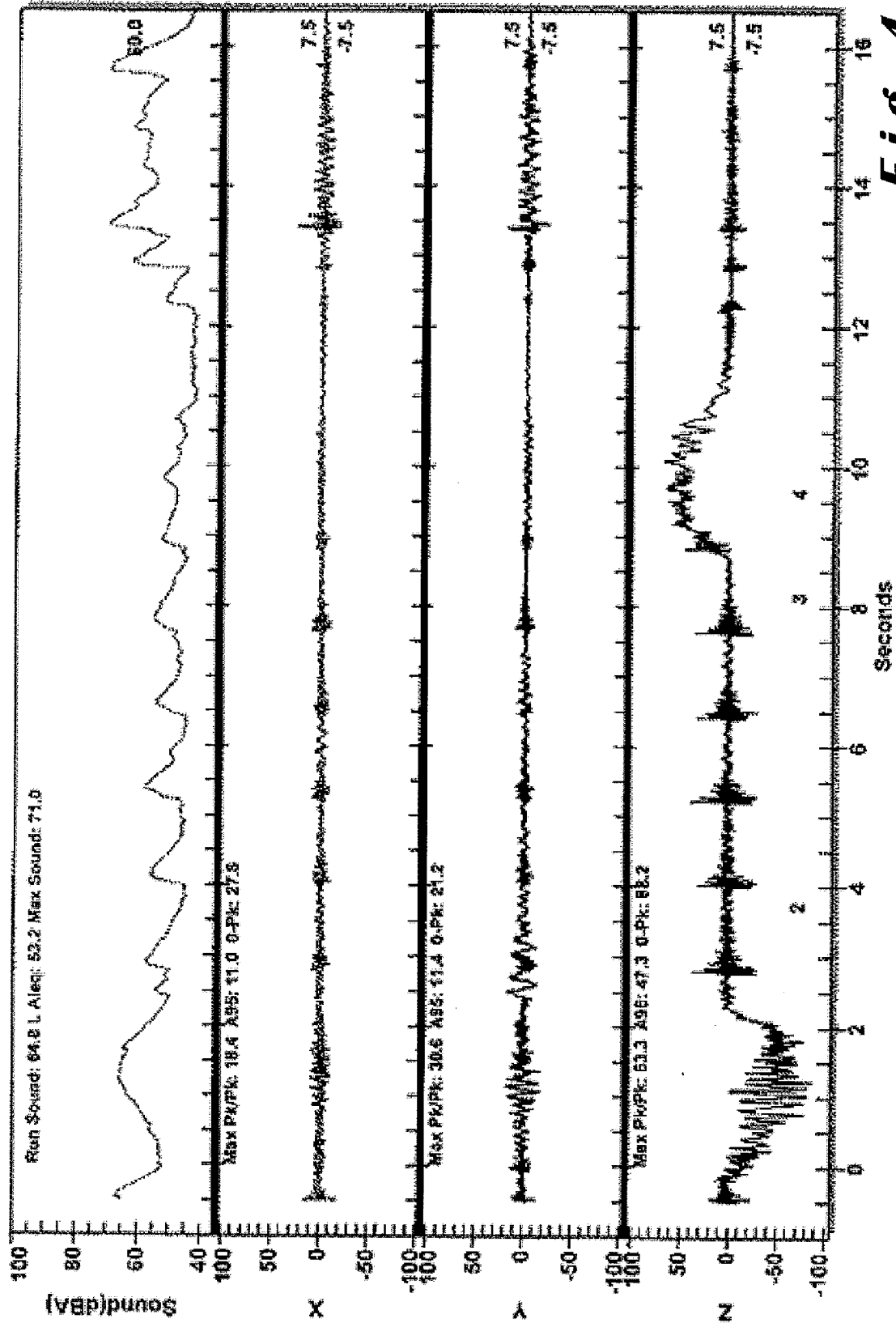


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4916

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 July 2011	Examiner Iuliano, Emanuela
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 15 4916

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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