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(54) **MONITORING OF MOVING HANDRAILS FOR PASSENGER CONVEYORS**

(57) A moving handrail monitoring system (60) for a passenger conveyor (10) comprises at least one magnetic sensor (62) provided adjacent to a moving handrail (22) of the passenger conveyor (10), wherein the or each magnetic sensor (62) is configured to detect a change in magnetic flux resulting from motion of the moving handrail (22) and provide an output signal. A controller (64) is coupled to the or each magnetic sensor (62). The controller (64) is configured to: receive the output signal from the magnetic sensor (62), determine a change in a distance (X) between a surface (25) of the handrail (22) and the magnetic sensor (62) based on the variation in the output signal from the magnetic sensor (62); and calculate a handrail tension based on the change in distance (X).

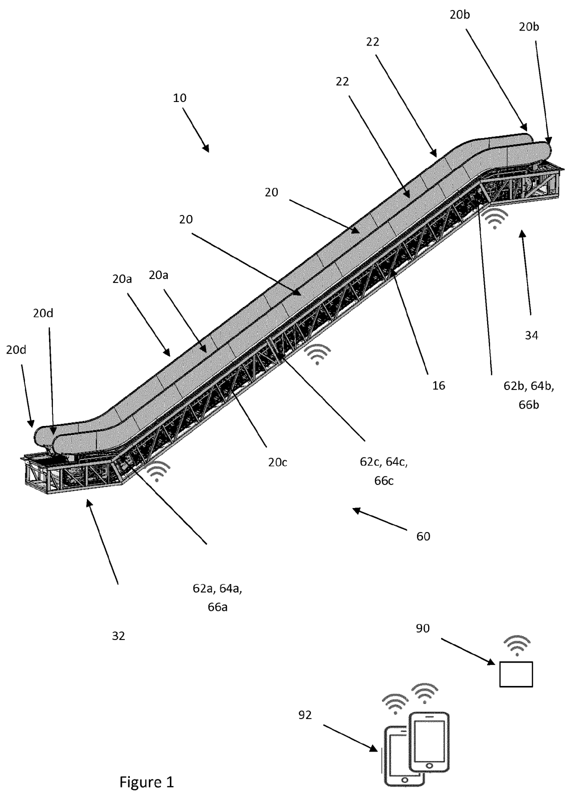

Figure 1

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Description

Technical field

[0001] This disclosure relates to systems and methods for monitoring moving handrails for passenger conveyors, such as escalators or moving walkways.

Background

[0002] Conventional passenger conveyors, such as escalators and moving walkways, generally comprise a transportation band, on which passengers stand, which is propelled by a drive system to convey the passengers from one place to another place, for example between floors of a building or along extended distances.

[0003] Escalators and moving walkways are provided with moving handrails which move in synchronisation with the transport band. Moving handrails are generally provided on both sides of the passenger conveyor for the passengers to hold. The handrail generally comprises a strap formed as an endless loop routed around each end of a passenger conveyor balustrade. The moving handrail generally slides along a handrail guide on the upper surface of the balustrade following a conveyance path, and returns along a handrail guide provided inside the balustrade or associated support structure following a return path. A drive mechanism for the moving handrail is generally provided along the return path.

[0004] The moving handrails must not be over-tensioned as this results in problems such as overheating of the handrail, accelerated wear and reduced service life. The moving handrail should also not be under-tensioned since this results in problems such as the moving handrail running at a different speed to the conveyance band, which can cause a risk to passengers' safety.

[0005] The tension of the moving handrails has to be set during installation of the passenger conveyor and this is achieved by manual adjustment of drive components and/or support structure components. The operating conditions, such as temperature, humidity and operational hours, must be taken into account during the adjustment of the moving handrail tension. The installation process is heavy reliant on the experience and expertise of the installation engineer. The installation can generally only be achieved through a trial and error process. This means that installation of the moving handrails is extremely time consuming and unreliable.

[0006] Often a problem with handrail tension only becomes apparent after the installation engineer has left, which means that a return visit is required. Problems with the tension of the moving handrail are the major reason for post-installation maintenance or repair of passenger conveyors. When a problem with a passenger conveyor is reported, an engineer must return to the site to evaluate the situation and carry out further adjustment and/or repair work.

[0007] Therefore, there is a need to improve the installation and monitoring of moving handrails for passenger conveyors.

Summary

[0008] According to a first aspect of this disclosure, there is provided a moving handrail monitoring system for a passenger conveyor comprising: at least one magnetic sensor provided adjacent to a moving handrail of the passenger conveyor, wherein the or each magnetic sensor is configured to detect a change in magnetic flux resulting from motion of the moving handrail and provide an output signal; a controller coupled to the or each magnetic sensor. The controller is configured to: receive the output signal from the magnetic sensor, determine a change in a distance between a surface of the handrail and the magnetic sensor based on the variation in the output signal from the magnetic sensor; and calculate a handrail tension based on the change in distance.

[0009] The controller may comprise multiple controllers, wherein each controller is coupled to a magnetic sensor. The system may comprise a single controller coupled to a plurality of magnetic sensors.

[0010] The controller(s) may be electrically coupled to the or each magnetic sensor. The controller(s) may be wirelessly coupled to the or each magnetic sensor. The controller(s) may have a wired connection to the or each magnetic sensor.

[0011] The output signal may be a voltage signal. The output signal may be a current signal.

[0012] The moving handrail monitoring system may further comprise a control station and/or a user device. The user device may be a smart phone, tablet, laptop or computer. The controller may be configured to send a wireless signal to a user device. The control station may be configured to communicate with one or more user devices, such as a smart phone, tablet, laptop or computer. The control station may be remotely located from the moving handrail monitoring system. The controller may be configured to send a wireless signal to a control station remotely located from the monitoring system. The controller may be configured to send a wireless signal to a control station, either directly or via a cloud computing system. The control station may receive information from the moving handrail monitoring system, collate the information and analyse in order to, for example, establish trends, predict failure and/or calculate remaining operational life of the moving handrail.

[0013] The control station may be configured to use the data from the moving handrail monitoring system as an input to a predictive maintenance system, such as Condition Based Maintenance (CBM). The information from the moving handrail monitoring system may be used with other sensor data from the passenger conveyor in a predictive maintenance system. The information from the moving handrail monitoring system may be used with other sensor data from the passenger conveyor for Condition Based Maintenance.

[0014] The moving handrail monitoring system may be configured to operate in a commissioning mode. The controller may be further configured to transmit the calculated handrail tension to the control station and/or the user device.

[0015] In the commissioning mode, the controller may be configured to compare the calculated handrail tension to a predefined operating value. The controller may be configured to transmit the comparison data to the control station and/or the user device.

[0016] The controller may further be configured to determine whether the moving handrail is over tense or over loose. Alternatively, the control station and and/or the user device may be configured to determine whether the moving handrail is over tense or over loose.

[0017] The controller may be configured to compare the calculated handrail tension to a predefined operating range. The controller may be configured to transmit an alert signal to the control station and/or the user device. The controller may be configured to transmit an alert signal when the calculated handrail tension is outside the predefined operating range.

[0018] The moving handrail monitoring system may be configured to operate in an operational mode. In the operational mode, the controller may be configured to compare the calculated handrail tension to a predefined operating range. In the operational mode, the controller may be configured to transmit an alert signal to the control station and/or the user device. In the operational mode, the controller may be configured to transmit an alert signal when the calculated handrail tension is outside the predefined operating range.

[0019] The predefined operating range may comprise a minimum handrail tension and a maximum handrail tension. Alternatively, the controller may be configured to compare the calculated handrail tension to a predefined operating value. The controller may be configured to transmit an alert signal to a control station and/or a user device when the calculated handrail tension is outside the predefined operating range. The comparison of calculated handrail tension to the predefined operating range may be done over a specific time period

[0020] The controller may further be configured to determine whether the moving handrail is over tense or over loose. Alternatively, the control station and and/or the user device may be configured to determine whether the moving handrail is over tense or over loose.

[0021] The moving handrail monitoring system may comprise a first magnetic sensor coupled to a first controller and a second magnetic sensor coupled to a second controller.

[0022] The moving handrail monitoring system may comprise a power supply coupled to the or each magnetic sensor.

[0023] According to a further aspect of this disclosure, there is provided a passenger conveyor comprising two moving handrails and the moving handrail monitoring system as described above is provided on each moving handrail. At least one magnetic sensor is fixedly mounted to the passenger conveyor, adjacent to each moving handrail. In other words, each moving handrail is provided with at least one magnetic sensor fixedly mounted to the passenger conveyor.

[0024] The passenger conveyor may be an escalator. The escalator may have two handrails. The passenger conveyor may be a moving walkway. The moving walkway may have two handrails. In passenger conveyors, moving handrails include a body and at least one metallic component embedded in and extending longitudinally within the body.

[0025] It will be appreciated that for certain applications, a passenger conveyor may be provided with only one moving handrail extending along one side of the passenger conveyor. Such a passenger conveyor may comprise the moving handrail monitoring system as described above provided on the one moving handrail, wherein the at least one magnetic sensor is fixedly mounted to the passenger conveyor, adjacent to the moving handrail.

[0026] A plurality of magnetic sensors may be provided. A plurality of magnetic sensors may be provided at a plurality of distinct locations along the or each handrail.

[0027] The at least one magnetic sensor may be provided along a return line of the or each moving handrail.

[0028] A plurality of magnetic sensors may be provided in the return line of the or each moving handrail. The or each magnetic sensor may be fixedly mounted to a truss of the passenger conveyor. At least one magnetic sensor may be fixedly mounted at or near one end of the passenger conveyor. At least one magnetic sensor may be fixedly mounted at or near both ends of the passenger conveyor.

[0029] The passenger conveyor may comprise a first landing region at one end, and a second landing region at an opposite end. At least one magnetic sensor may be fixedly mounted at or near the first landing region. At least one magnetic sensor may be fixedly mounted at or near the first second region.

[0030] The passenger conveyor may comprise a truss extending from a first end of the passenger conveyor to a second end of the passenger conveyor. The or each magnetic sensor may be mounted on the truss. The or each magnetic sensor may be mounted adjacent to an outer surface of the moving handrail.

[0031] A first magnetic sensor may be mounted at the first end of the passenger conveyor. A second magnetic sensor may be mounted at the second end of the passenger conveyor. A third magnetic sensor may be mounted at a mid-point of the passenger conveyor. A first magnetic sensor may be provided for the or each moving handrail, mounted at the first end of the passenger conveyor. A second magnetic sensor may be provided for the or each moving handrail, mounted at the second end of the passenger conveyor. A third magnetic sensor may be provided for the or each moving handrail, mounted at a mid-point of the passenger conveyor.

[0032] A first magnetic sensor may be provided for the or each moving handrail, mounted on the truss at the first end of the passenger conveyor. A second magnetic sensor may be provided for the or each moving handrail, mounted on the truss at the second end of the passenger conveyor. The passenger conveyor may comprise a third magnetic sensor mounted on the truss at a mid-point of the passenger conveyor adjacent to the or each moving handrail.

[0033] A first magnetic sensor may be mounted on the truss at or near an end point of a handrail guide. A first magnetic sensor may be mounted on the truss at or near a lower end point of a handrail guide. A second magnetic sensor may be mounted on the truss at or near an opposite end of the handrail guide.

[0034] According to a second aspect of this disclosure, there is provided a method for monitoring a moving handrail of a passenger conveyor, the method comprising detecting a magnetic flux change of at least one magnetic sensor provided adjacent to the moving handrail; generating an output signal indicative of the magnetic flux change; determining a change in distance between a surface of the handrail and the magnetic sensor based on the variation in the output signal from the magnetic sensor; and calculating a handrail tension based on the change in distance.

[0035] There may be a plurality of magnetic sensors, wherein each controller is coupled to a magnetic sensor which receives an output signal and determines a magnetic flux change at the respective magnetic sensor. Alternatively, the system may comprise a single controller which uses the method steps above to calculate a handrail tension at each magnetic sensor location.

[0036] The output signal may be a voltage signal. The output signal may be a current signal.

[0037] The output signal may be transmitted from the magnetic sensor via an electrical coupling. The output signal may be transmitted from the magnetic sensor wirelessly.

[0038] The method may further comprise operating in a commissioning mode. The method may further comprise transmitting the calculated handrail tension to a control station and/or a user device.

[0039] The controller may be configured to compare the calculated handrail tension to a predefined operating value and transmit the comparison data to the control station and/or the user device. The controller may be configured to compare the calculated handrail tension to a predefined operating range and transmit the comparison data to the control station and/or the user device.

[0040] Alternatively, a control station and/or a user device may receive the calculated handrail tension data, compare them to a predefined operating range and determine whether the calculated tension is outside of the required operational range. Alternatively or additionally, a control station and/or a user device may receive the calculated handrail tension data, compare them to a predefined operating value and determine whether the calculated tension is above or below the predefined operating value.

[0041] The method may further comprise an operational mode. The method may further comprise comparing the calculated handrail tension to a predefined operating range. The method may further comprise determining whether the calculated handrail tension is outside the predefined operating range. The method may comprise transmitting an alert signal to a control station and/or a user device. The method may comprise transmitting an alert signal when the calculated handrail tension is outside the predefined operating range. The predefined operating range may comprise a minimum handrail tension and a maximum handrail tension.

[0042] Alternatively or additionally, the method may comprise comparing the calculated handrail tension to a predefined operating value, and determining whether the calculated handrail tension is above or below the predefined operating value. The method may comprise transmitting an alert signal to a control station and/or a user device. The method may comprise transmitting an alert signal when the calculated handrail tension is above or below the predefined operating value.

[0043] Alternatively, a control station and/or a user device may receive the calculated handrail tension data and perform the analysis. The control station and/or the user device may compare the data related to the calculated handrail tension to a predefined operating range and determine whether the calculated handrail tension is outside of the predetermined range and/or whether it is above or below the predefined operating value.

[0044] The method may further comprise determining whether the moving handrail is over tense or over loose.

[0045] The step of determining the change in distance may comprise processing the variation in the output signal in the time or frequency domain to determine the distance.

[0046] The step of calculating the handrail tension may comprise calculating an instantaneous speed of the moving handrail.

[0047] The method may comprise using the data relating to the handrail tension as an input to a predictive maintenance system, such as Condition Based Maintenance (CBM). The method may comprise combining the data relating to the handrail tension with data from other sensors provided on the passenger conveyor in a predictive maintenance system.

[0048] Features described in relation to the first aspect of the present disclosure may of course also be applied to this second aspect. In general, features of any example described herein may be applied wherever appropriate to any other example described herein. Where reference is made to different examples or sets of examples, it should be understood that these are not necessarily distinct but may overlap.

[0049] The monitoring system and method described provide reliable data related to handrail tension to engineers on site during commissioning which results in fast and more effective installation and set-up of the moving handrails. Data transmitted in the operational mode allows accurate monitoring of the handrail tension, which means that problems with handrail tension (over tense or over loose handrails) can be identified promptly. Proactive repair or maintenance plans can be implemented, which reduce damage to the handrail or associated passenger conveyor components. The correction of problems before serious damage occurs improves the availability of the passenger conveyors, since the problem does not lead to a fault resulting in the need to shut down the conveyor. Overall the service related costs are reduced.

[0050] Since the components of the monitoring system are not in contact with the moving handrail, it is it not prone to wear or degradation during operation.

[0051] Further, the monitoring system and method provide a low cost and high accuracy solution which can be integrated into new passenger conveyors or retrofitted into existing passenger conveyors.

Detailed description

[0052] Certain examples of this disclosure will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 shows a passenger conveyor according to an example of the present disclosure;

Figure 2 shows a cross-sectional view of the passenger conveyor according to an example of the present disclosure;

Figure 3 shows a lower portion of an escalator handrail according to an example of the present disclosure;

Figure 4 shows a schematic representation of a monitoring system according to an example of the present disclosure; and

Figure 5 shows a schematic representation of an exemplary method of the present disclosure.

[0053] Figure 1 shows a passenger conveyor 10, represented in this figure as an escalator, on which passengers are transported between a lower landing region 32 and an upper landing region 34. A truss 16 extends between the lower landing region 32 (also referred to as a first end) and the upper landing region 34 (also referred to as a second end). Two balustrades 20 which support moving handrails 22 extend along each side of the passenger conveyor 10.

[0054] Each moving handrail 22 is formed of an endless strap mounted such that it is routed along an operational path which extends along a top 20a of each balustrade 20, around one end 20b of the balustrade 20, along a return line 20c within the truss 16, and around a second, opposite end 20d of the balustrade 20. During operation of the passenger conveyor 10, the moving handrails 22 move along the operational path in a clockwise or anticlockwise direction dependent on the direction in which passengers are to be conveyed.

[0055] A moving handrail monitoring system 60 is provided for monitoring a moving handrail 22. The moving handrail monitoring system 60 includes a first magnetic sensor 62a provided at the lower landing region 32 of the escalator 10, a second magnetic sensor 62b provided at the upper landing region 34 of the escalator 10, and a third magnetic sensor 62c provided at a mid-point of the escalator 10. Each magnetic sensor 62a, 62b, 62c has an associated controller 64a, 64b, 64c and associated power source 66a, 66b, 66c.

[0056] A control station 90 is provided at a remote location to the passenger conveyor 10. The controllers 64a, 64b, 64c are configured to communicate wirelessly with the control station 90. The control station 90 is configured to communicate with one or more user devices 92. Alternatively or additionally, the controllers 64a, 64b, 64c are configured to communicate wirelessly with one or more user devices 92.

[0057] Although an escalator system is illustrated and described above, this invention is equally applicable to other passenger conveyor systems such as moving walkways. It will be appreciated that moving walkways may transport passengers along a substantially horizontal distance, between a first landing region and a second landing region. Moving walkways can also transport passengers over a vertical distance between a lower (first) landing region and an upper (second) landing region.

[0058] Figure 1 shows an arrangement for monitoring one of the moving handrails 22 of the passenger conveyor 10. It will be appreciated that the same arrangement is provided on the other moving handrail 22.

[0059] It will be appreciated that whilst the example of figure 1 shows three magnetic sensors 62, any number of magnetic sensors 62 can be provided for monitoring the or each moving handrail 22. In another example, not shown in the figures, a moving handrail monitoring system 60 comprises a single magnetic sensor 62 provided adjacent to the or each moving handrail 22 at or near the lower landing region 32, preferably mounted to the truss 16. In a further example, not shown in the figures, a moving handrail monitoring system 60 comprises a first magnetic sensor 62a provided adjacent to the or each moving handrail 22 at or near the lower landing region 32 and a second magnetic sensor 62a provided adjacent to the or each moving handrail 22 at or near the upper landing region 34.

[0060] Figure 2 shows a close-up, cross section view at one end of one moving handrail 22 on a passenger conveyor 10, such as an escalator or a moving walkway. The moving handrail 22 extends along a guide rail 28 which extends along the return line 20c from an upper end point to a lower end point 28a (Figure 3). A magnetic sensor 62 is fixedly mounted on a portion of the truss 16. The magnetic sensor 62 is positioned underneath the moving handrail 22. The controller 64 is mounted on the truss 16 adjacent to the magnetic sensor 62, and is electrically coupled to the magnetic sensor 62.

[0061] Figure 3 shows a side view of one end of a passenger conveyor 10, for example the lower landing region 32 of an escalator or the first landing region of a moving walkway. Figure 3 shows a magnetic sensor 62 provided advantageously at a location close to the lower end point 28a of the handrail guide 28. A controller 64 is also mounted on the truss 16, adjacent to the magnetic sensor 62.

[0062] Figure 4 is a schematic view through one magnetic sensor 62 and the adjacent section of the moving handrail 22. The moving handrail 22 includes a body 23 and a plurality of elongate metallic components 24 which are embedded in and extend along the length of the handrail body 23. The moving handrail 22 has an outer surface 25, which is the surface which is held by a passenger. The magnetic sensor 62 comprises a permanent magnet 70 surrounded by a coil 72. A controller 64 is coupled to the magnetic sensor 62, and a power supply 66 is provided. The magnetic sensor 62 is fixedly mounted to the truss 16 (which is not shown in Figure 4) a short distance X from the outer surface 25 of the moving handrail 22. The distance X is optimised so as to minimise an air gap between the magnetic sensor 62 and the outer surface 25 in order to maximise sensitivity of the sensor, whilst maintaining a sufficient separation from any moving components so as to reduce the risk of damage during operation.

[0063] The distance X between the outer surface 25 of the moving handrail 22 varies as the handrail tension varies. An optimum operating tension can be determined and from this an optimum value or range for the distance X for each magnetic sensor 62 can be defined.

[0064] The optimum operating tension can be approximated using the following equation:

$$F_{opt} = \frac{v^2 * m}{L},$$

where v = optimum Handrail speed, L = handrail length, m = modified mass of handrail.

[0065] The estimated optimum operating tension can be used to provide an optimum operating range, i.e. by using a suitable tolerance to determine upper and lower range points above and below the estimated value.

[0066] If the handrail 22 is over tensioned, the distance X will be lower than an optimum operating value or below an optimum operating range. If the moving handrail 22 is under tensioned, the distance X will be greater than the optimum operating value or above the optimum operating range.

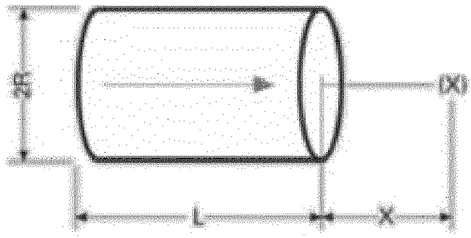
[0067] During operation of the passenger conveyor 10, the moving handrail 22 travels along the operational path and moves over the magnetic sensor 62. Movement of the metallic components 24 within the moving handrail 22 relative to the magnetic sensor 62 causes a change in the magnetic flux of the magnetic sensor 62, resulting in a change in voltage across the coil 72. The changing output signal is sent to the controller 64.

[0068] A method of monitoring a moving handrail is schematically represented in Figure 5.

[0069] The magnetic flux change is caused by the movement of the handrail 22 (step 210). This generates an output signal, for example a voltage signal or a current signal, from the magnetic sensor 62 which is transmitted to the controller 64 in step 220.

[0070] The variation in the output signal is used by the controller 64 to determine a change in distance X between the magnetic sensor 62 and the outer surface 25 of the handrail 22 in step 230. The controller 64 processes the output signal in the time or frequency domain to determine the distance X.

[0071] By knowing the Radius R, Length L, and Remanence (Residual magnetic flux density) Br and the measured magnetic flux Bx(X), the distance X can be determined as a root of the following equation:



$$Bx(X) = \frac{Br}{2}\left[\frac{L+X}{\sqrt{R^2+(L+X)^2}} - \frac{X}{\sqrt{R^2+X^2}}\right]$$

[0072] The controller 64 uses the determined distance X to calculate a handrail tension in step 240. The controller 64 calculates an instantaneous speed of the moving handrail for use in the calculation of the handrail tension.

[0073] Using the frequency of the change of the air gap between handrail and magnet, the tension can be determined as follows:

$$F = 4 * f^2 * m * L = 4 * \left(\frac{dt}{dD}\right)^2 * m * L,$$

where F = tension force, f = frequency, m = modified mass, L = handrail length, and dt/dD = frequency of air gap

[0074] The controller 64 uses the calculated handrail tension to evaluate the handrail tension (step 250). This can involve comparison of the calculated tension to a predefined range or value.

[0075] The method may further comprise a step of determining whether the moving handrail 22 is over tense or over loose. The method may also involve providing an indication if the moving handrail 22 is over tensed or over loose, based on the comparison.

[0076] After the installation and set-up of the passenger conveyor 10, the moving handrail monitoring system 60 is operated in a commissioning mode. The engineer uses the commissioning mode to check and then adjust the tension of the moving handrail 22. In the commissioning mode, the moving handrail monitoring system 60 provides the engineer with reliable data relating to the handrail tension on a hand held device 92. The engineer can then adjust the tension accordingly in order to achieve the optimum handrail tension.

[0077] Once the handrail tension has been set using the commissioning mode, the moving handrail monitoring system 60 is then operated in an operational mode. The moving handrail monitoring system 60 compares the calculated handrail tension to a predefined operating range, and then determines whether the calculated handrail tension is outside the predefined operating range. The moving handrail monitoring system 60 compares the calculated handrail tension to predefined operating parameters over a specified time period to provide trend data which can be analysed. The moving handrail monitoring system 60 can send an indication, such as an alert signal, when the instantaneously calculated handrail tension or the handrail tension as evaluated over the specified time data is outside the desired operating parameters. When alert signal(s) are received, corrective action can be taken. For example, it may be determined that the issue requires immediate repair, or corrective action could be incorporated into scheduled maintenance.

[0078] While the disclosure has been described in detail in connection with only a limited number of examples, it should be readily understood that the disclosure is not limited to such disclosed examples. Rather, the disclosure can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the scope of the disclosure. Additionally, while various examples of the disclosure have been described, it is to be understood that aspects of the disclosure may include only some of the described examples. Accordingly, the disclosure is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A moving handrail monitoring system (60) for a passenger conveyor (10) comprising:

at least one magnetic sensor (62) provided adjacent to a moving handrail (22) of the passenger conveyor (10),

the or each magnetic sensor (62) being configured to detect a change in magnetic flux resulting from motion of the moving handrail (22) and provide an output signal;
a controller (64) coupled to the or each magnetic sensor (62),

wherein the controller (64) is configured to:

receive the output signal from the magnetic sensor (62),
determine a change in a distance (X) between a surface (25) of the handrail (22) and the magnetic sensor (62) based on the variation in the output signal from the magnetic sensor (62); and
calculate a handrail tension based on the change in distance (X).

2. The moving handrail monitoring system (60) according to claim 1, further comprising a control station (90) and/or a user device (92).

3. The moving handrail monitoring system (60) according to claim 2, wherein the controller (62) is further configured to transmit the calculated handrail tension to the control station (90) and/or the user device (92).

4. The moving handrail monitoring system (60) according to claim 2 or 3, wherein which the controller (62) is configured to:

compare the calculated handrail tension to a predefined operating range;
transmit an alert signal to the control station (90) and/or the user device (92) when the calculated handrail tension is outside the predefined operating range.

5. The moving handrail monitoring system (60) according to any of the preceding claims, comprising a first magnetic sensor (62a) coupled to a first controller (64a) and a second magnetic sensor (62b) coupled to a second controller (64b).

6. A passenger conveyor (10) comprising two moving handrails (22) and the moving handrail monitoring system (60) of any of claims 1 to 5 provided on each moving handrail (22), wherein at least one magnetic sensor (62) is fixedly mounted to the passenger conveyor (10), adjacent to each moving handrail (22).

7. The passenger conveyor (10) according to claim 6, wherein the at least one magnetic sensor (62) is provided along a return line (20c) of each moving handrail (22).

8. The passenger conveyor (10) according to claim 6 or 7, wherein the passenger conveyor (10) comprises a truss (16) extending from a first end (32) of the passenger conveyor (10) to a second end of the passenger conveyor (10); wherein the at least one magnetic sensor (62) is mounted on the truss (16) adjacent to an outer surface (25) of each moving handrail (22).

9. The passenger conveyor (10) according to claim 8, wherein for each moving handrail: a first sensor (62a) is mounted on the truss (16) at the first end of the passenger conveyor (10), and a second sensor (62b) is mounted on the truss (16) at the second end of the passenger conveyor (10).

10. A method for monitoring a moving handrail (22) of a passenger conveyor (10), the method comprising:

detecting a magnetic flux change of at least one magnetic sensor (62) provided adjacent to the moving handrail (22) ;
generating an output signal indicative of the magnetic flux change;
determining a change in distance (X) between a surface (25) of the handrail (22) and the magnetic sensor (62) based on the variation in the output signal from the magnetic sensor (62); and
calculating a handrail tension based on the change in distance (X).

11. The method according to claim 10, further comprising:
transmitting the calculated handrail tension to a control station (90) and/or a user device (92).

12. The method according to claim 10 or 11, further comprising:

comparing the calculated handrail tension to a predefined operating range;
determining whether the calculated handrail tension is outside the predefined operating range.

13. The method according to any of claims 10 to 12, further comprising transmitting an alert signal to a control station (90) and/or a user device (92).

14. The method according to any of claims 10 to 13, wherein the step of determining the change in distance (X) comprises: processing the variation in the output signal in the time or frequency domain to determine the distance (X).

15. The method according to any of claims 10 to 14, wherein the step of calculating the handrail tension further comprises: calculating an instantaneous speed of the moving handrail.

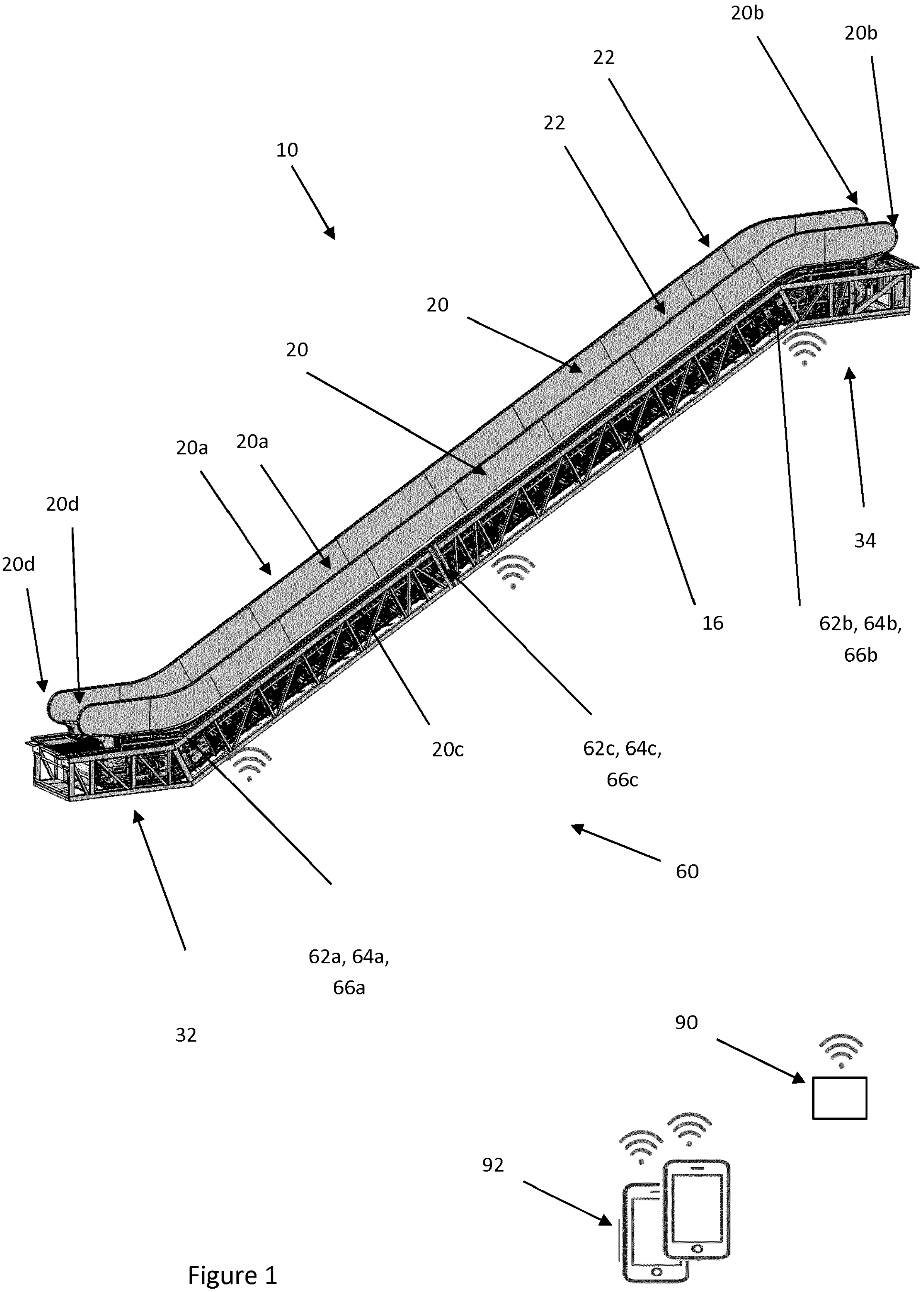

10
20b
20b
22
22
20
20
20a
20a
20d
20d
16
34
20c
62b, 64b, 66b
62c, 64c, 66c
60
62a, 64a, 66a
32
90
92

Figure 1

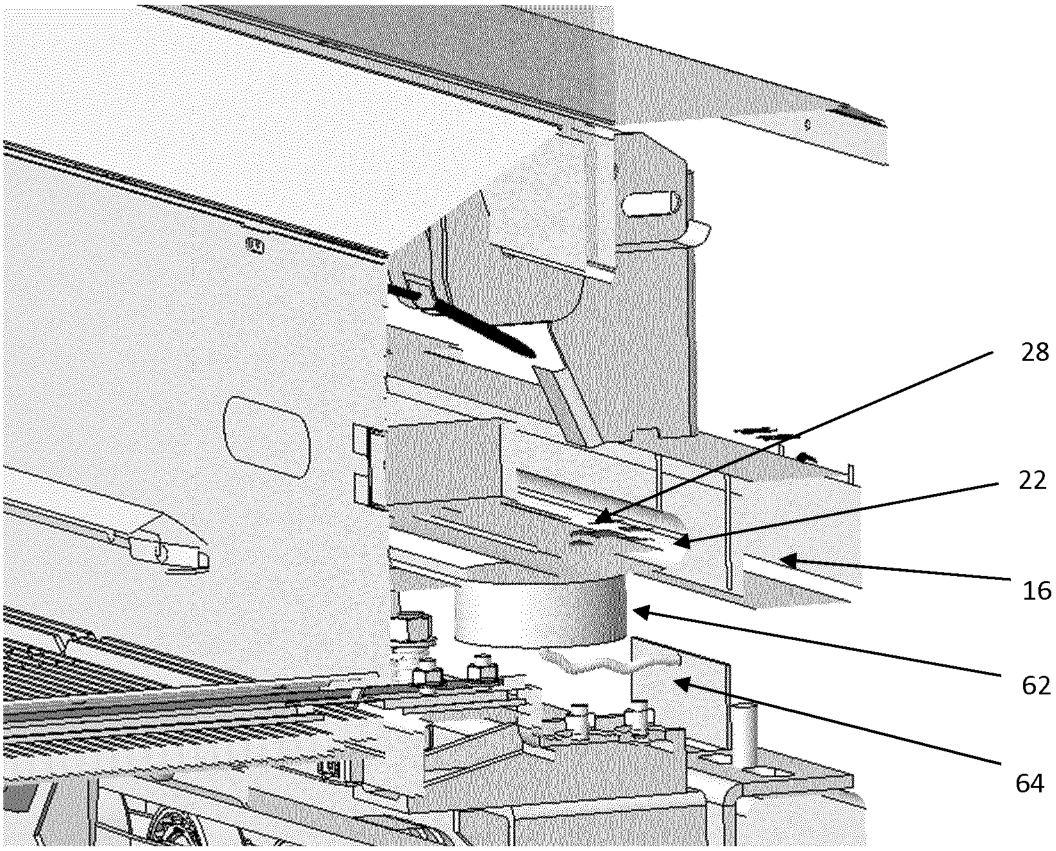


Figure 2

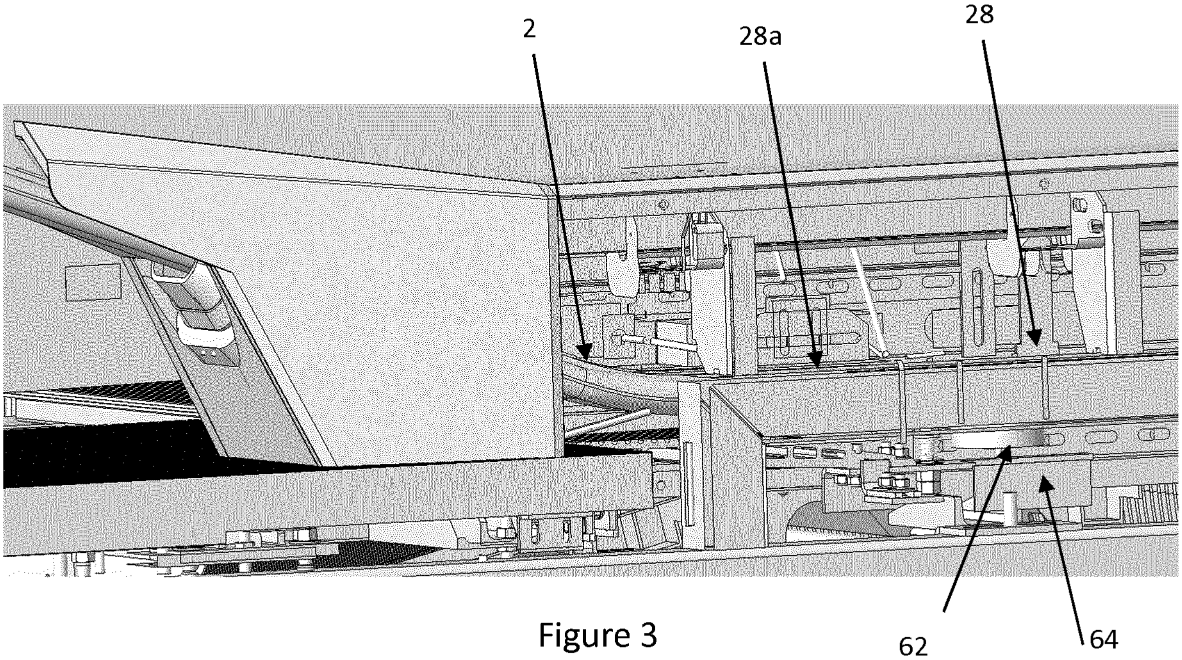


Figure 3

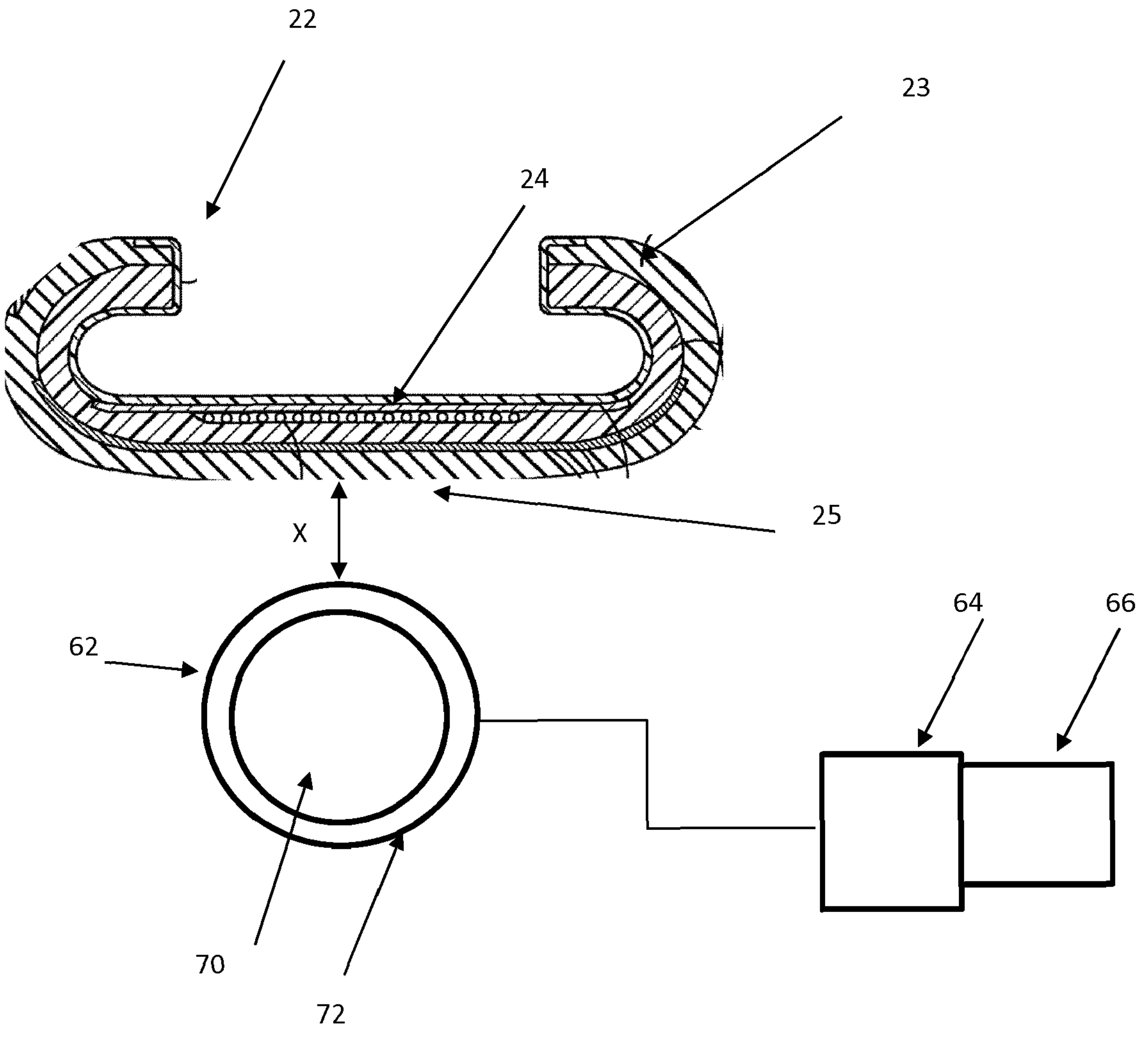


Figure 4

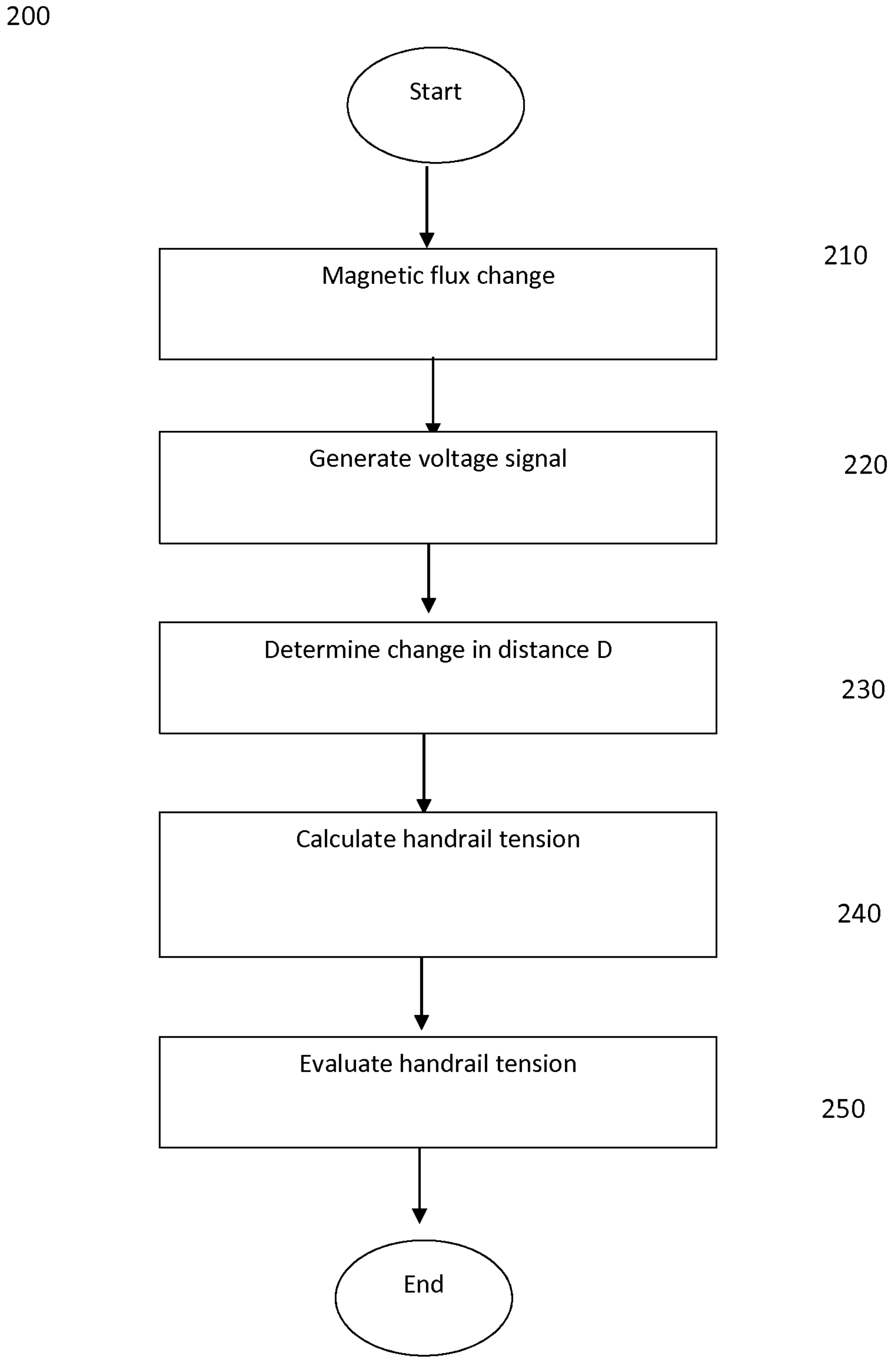

200
Start
Magnetic flux change
210
Generate voltage signal
220
Determine change in distance D
230
Calculate handrail tension
240
Evaluate handrail tension
250
End

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 19 21 1344

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	JP 2015 160724 A (MITSUBISHI ELECTRIC CORP) 7 September 2015 (2015-09-07) * abstract; figures 1-7 * -----	1-15	
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TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 June 2020	Szován, Levente

CATEGORY OF CITED DOCUMENTS

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02-06-2020

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