



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.11.2016 Bulletin 2016/44

(51) Int Cl.:
B66B 29/06 (2006.01)

(21) Application number: **15382207.7**

(22) Date of filing: **27.04.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

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(54) **SAFETY DEVICE AND METHOD FOR PREVENTING ACCIDENTS IN THE COMBPLATE AREA OF ESCALATORS OR MOVING WALKWAYS**

(57) Safety device and method for preventing accidents in the combplate area of escalators or moving walkways. The safety device comprises:
- at least one capacitor (8), each one formed by a first capacitor plate in contact with a combplate (2) or floor plate of an escalator or moving walkway (1) and a second capacitor plate (9) connected to a reference voltage;
- a capacitance measuring module (7) for measuring the capacitance (C) of the at least one capacitor (8), obtaining at least one capacitance signal (20);

- a controller (6) configured for comparing each capacitance signal (20) with at least one predefined value (22) and, based on said comparison, deciding whether a dangerous situation has occurred, and in that case sending the escalator or moving walkway (1) a warning signal or a stop order signal.

This safety device can detect when human skin is close to the combplate area to stop the escalator or moving walkway, and thus avoiding human body injuries.

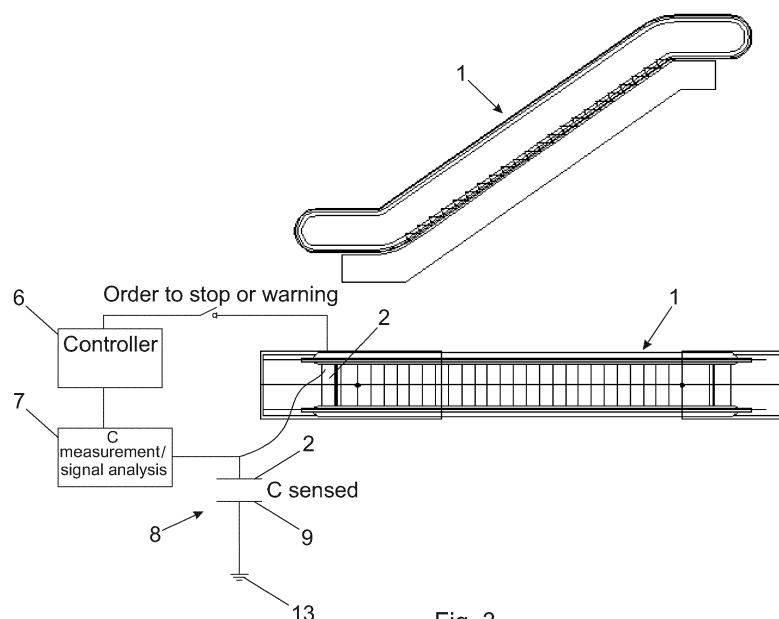


Fig. 3

Description

Field of the Invention

[0001] The present invention is comprised within the field of escalators and moving walkways, and more particularly in the field of safety devices for preventing accidents in the combplate area.

Background of the Invention

[0002] The combplate is a piece at the entrance and exit in an escalator or moving walkway which separates the movable part (pallets or steps) from the fixed part, the floor plate. The edge of the combplate has a series of teeth which mesh with grooves in escalator steps or in moving walkway plates. Due to this, an entrapment risk is always present, especially for fingers and toes. Several accidents in the combplate area are reported every year, where fingers or toes are trapped in the limit between the movable and non-movable parts of the escalator or moving walkway. Other common accidents are caused by fallen people on the floor plate who are unintentionally blocking the exit of the escalator/moving walk, increasing the risk while the escalator/moving walk keep running until somebody stops manually the system.

[0003] It is well known that escalators and moving walkways must be stopped if any problem (mechanical collision, entrapment...) leading to a combplate displacement is detected. In some cases a comb tooth fracture may also cause a displacement in the combplate by the significant force applied on the toothed segment in question, implying a risk to the passengers of the walkway or escalator, so that an automatic stop of the escalator or moving walkway must be initiated.

[0004] Some security devices can monitor the movement of the comb segment and/or the combplate and trigger an alarm signal. Nowadays, when safety devices installed in the escalators or moving walkways detect a displacement of the combplate, the escalator or moving walkway is immediately stopped.

[0005] Document DE29907184-A1 discloses an escalator and a moving walkway wherein the comb segments have a wire attached to the comb teeth. When there is a comb tooth fracture, it can be detected since the wire is interrupted. Document WO14208906-A1 also detects comb teeth fracture by using a detection line.

[0006] It is also known the use of plastic combplates with integral plastic teeth which are provided with a cavity for an electronic detection system that detects a tooth break and shuts off the motor in response. However, these safety devices have several disadvantages: the circuits within the teeth are expensive to manufacture and using a single piece plate-and-teeth assembly makes for an expensive replacement because when a tooth breaks the entire combplate must be replaced. These disadvantages are solved in US2007137979-A1, where the comb teeth with a printed circuit detector which

are electrically connected to a circuit board and a processor that detects an unsafe condition by the breaking of a tooth.

[0007] Document US5718319-A discloses a safety device for use in an escalator or moving walkway for detecting stuck objects, wherein a fine high-strength flexible wire is positioned through all the comb teeth. A stretching of the wire triggers an electrical switch which in turn causes a relay to stop operation of the escalator or moving walkway.

[0008] Document GB1031967-A discloses a safety comb for escalators with comb teeth which are longitudinally movable against respective springs to close a switch in the circuit of the drive motor of the escalator. Thus, an obstruction in the treads of a step of the escalator will engage one or more comb teeth and stop the escalator.

[0009] DE10259149-A1 discloses use of capacitance sensors for monitoring the integrity of the comb teeth on an escalator combplate. To that end, pairs of conductive foil electrodes are located on the comb teeth and nearby on the combplate, and connected to an electronic monitoring unit which indicates the breaking of a single comb tooth when detects a change in capacitance. When this safety device detects the effective breaking of a single comb tooth, it causes a shutdown of the escalator or the moving walkway.

[0010] Document WO14015870-A2 discloses a security device mounted at the junction of the comb teeth with the combplate, extending transversely with respect to the operating direction of the escalator or moving walkway, such that movements of the combplate and/or the comb teeth can be detected. When relative movements that exceed a predetermined amount are detected, a shutdown of the escalator or moving walk is automatically initiated.

[0011] Document JP8073170-A discloses a safety device for preventing an accident of an object being caught in the space between a step and a comb plate of an escalator. A plate is rotatably fitted to the combplate. When a foreign object is caught in the space between the comb and a step, the plate is lifted and a cam is released from a safety switch, interlocked with the motion of the plate, thereby stopping the escalator.

[0012] US5611417-A also discloses an apparatus for stopping escalators and moving walkways which responds to movement of the combplate due to an applied force to actuate a safety switch. Document KR20040016094-A discloses a combplate safety device for a moving walkway comprising a sensor plate causing deformation due to the displacement of the comb, a deformation-sensing member attached to the sensor plate to sense deformation of the sensor plate, and a switch for stopping the operation of the moving walkway if the sensed deformation is larger than a predetermined value.

[0013] Many other safety devices are known which mechanically detect displacement of a combplate or obstruction in the space between the combplate and a step,

normally using a switch to stop operation of the escalator or moving walkway, such as the inventions disclosed in CN101323412-A, US2004134748-A, CN202296792-U and DE102011112528-A1.

[0014] Some safety devices use optical means to detect obstruction or breakage in the combplate area. For instance, document US4800998-A discloses a safety device for use in the comb part of an escalator landing, operable to detect objects which pass into the comb from the escalator treads. The device includes a photodetector positioned beneath the comb and which detects a light beam projected across the comb where the treads pass through the comb. When a foreign object passes under the comb and blocks the light beam, this potential hazard is sensed by the detector. If the light beam remains blocked for a predetermined time period, operation of the escalator motor is stopped. Other documents, such as JP11292451-A and CN203922417U, also make use of photosensors to detect when a comb tooth is broken or there is an obstruction in the combplate area.

[0015] Other safety devices, such as the one disclosed in US2008252724-A, includes optically monitoring of a combplate by taking a picture of the combplate with a camera, comparing the picture with a reference picture, and then determining the safety state of the combplate based on such comparison.

[0016] All these current safety devices decrease the consequence of accidents, but in many cases the amputation of the finger or toe cannot be avoided, since when the obstruction or the displacement of the combplate is detected it may be too late for the user's finger or toe. The present invention solves this problem, preventing accidents before they occur, that is, before the combplate is displaced or obstructed by a user's finger or toe.

Description of the Invention

[0017] This new type of safety device is based on capacitive technology, and it takes into account the different capacitance which can be measured on a metallic surface depending on the contact, or presence near the metal, of human skin or a human body. Using this type of technology, which can use the human body or skin capacitance as an input, the system is able to detect when a human body or human skin is near or in contact to a dangerous area (such as comb teeth) ignoring at the same time the contact with other parts like shoes, umbrellas, rollers, etc. The combplate or floor plate itself works as a component of the capacitive sensor. The invention is used not only for avoiding entrapment of fingers, but for detecting a fallen person in the combplate/floor plate area.

[0018] The capacitance measured in the comb area can be managed by a controller who can adjust the defined level to sense, filter the signal and decide when there is a real dangerous situation even before the finger contacts the detection area.

[0019] With this solution the detection can be done in

the combs edge or in an embedded band near combs and displacement of the combplate is not needed to activate the safety function, thus avoiding human body injuries. With the same solution installed in the floor plate area fallen people can be detected due to the capacity variation caused by the presence of the human body over the floor plate. As in this case the body surface in contact with the metal plate is higher than in the combs solution, a person lying on the floor plate can be detected even when there is no skin contact with the floor plate (i.e. there is only contact with the person's clothes).

[0020] In accordance with a first aspect of the present invention there is provided a safety device for preventing accidents in the combplate/floor plate area of escalators or moving walkways. The safety device comprises:

- at least one capacitor, each one formed by a first capacitor plate in contact with a combplate or floor plate of an escalator or moving walkway and a second capacitor plate connected to a reference voltage (preferably connected to ground);
- a capacitance measuring module for measuring the capacitance of the at least one capacitor, obtaining at least one capacitance signal;
- a controller configured for comparing each capacitance signal with at least one predefined value and, based on said comparison, deciding whether a dangerous situation has occurred, and in that case sending the escalator or moving walkway a warning signal or a stop order signal.

[0021] In a preferred embodiment the safety device comprises only one capacitor, wherein the first capacitor plate may be formed:

- by the whole combplate, or
- by the whole combplate including also the frames between the floor plate and combs, or
- by the whole combplate including also the floor plate, or
- by the whole floor plate.

[0022] In another preferred embodiment the safety device comprises a plurality of capacitors, as many as combplate segments, wherein the first capacitor plate of each capacitor is formed by a different combplate segment.

[0023] The at least one predefined value is established so as to detect the approach/contact of human or animal skin to the combplate area or to detect a fallen body on the floor plate. This predefined value or values may be static (do not change) or dynamic (they dynamically change and adapt to the particular situation).

[0024] The controller is preferably configured to stop itself the escalator or moving walkway when a dangerous situation is detected.

[0025] In accordance with a further aspect of the present invention there is provided a method for prevent-

ing accidents in the combplate area of escalators or moving walkways. The method comprises:

- measuring the capacitance of at least one capacitor, each one formed by a first capacitor plate in contact with a combplate of an escalator or moving walkway and a second capacitor plate connected to a reference voltage (preferably connected to ground), obtaining at least one capacitance signal;
- comparing each capacitance signal with at least one predefined value;
- deciding, based on said comparison, whether a dangerous situation has occurred, and in that case sending the escalator or moving walkway a warning signal or a stop order signal.

[0026] The method preferably also comprises a conditioning and filtering step of the capacitance signal, for instance to filter anomalous data such as sudden peaks in the capacitance signal.

[0027] In a preferred embodiment the method further comprises checking if the acceptable predefined values have changed and in that case defining new predefined values.

[0028] The method may comprise measuring the capacitance of a plurality of capacitors, as many as combplate segments, wherein the first capacitor plate of each capacitor is formed by a different combplate segment.

Brief Description of the Drawings

[0029] A series of drawings which aid in better understanding the invention and which are expressly related with an embodiment of said invention, presented as a non-limiting example thereof, are very briefly described below.

Figure 1 depicts the measurement of capacitance in the combplate area of an escalator or moving walkway according to the present invention.

Figures 2A and 2B show different capacitance measurements according to the distance between a finger and the combplate.

Figure 3 illustrates a schematic diagram of the safety device installed on an escalator.

Figures 4A depicts a combplate formed by several combplate segments. Figure 4B shows an embodiment of the safety device comprising several capacitors, a capacitor for each combplate segment.

Figure 5 shows a flow diagram of the method for preventing accidents in the combplate area according to the present invention.

Figure 6 shows the comparison of the capacitance

signal with a threshold.

Figure 7 shows the measurement of the amplitude and frequency of a periodic capacitance signal.

Figure 8A shows a risk situation with a fallen person on the floor plate, and Figures 8B and 8C shows two different methods for monitoring the capacitance signal and determining if a risk situation has occurred.

Description of a Preferred Embodiment of the Invention

[0030] The invention relates to a new detection system to detect contact or proximity of a human or animal body in the combplate or floor plate area. The system is able to distinguish the human or animal body/skin from other objects.

[0031] This system is based on capacitive technology which allows, measuring the capacitance in the combplate or floor plate area, to distinguish different materials.

[0032] Using the combplate or the floor plate as one of the capacitor plates (positive or negative) and ground or any other part of the escalator/moving walkway as the other capacitor plate there will be a capacitor where the dielectric is composed by the air and the materials between the combplate/floor plate and the other capacitor plate.

[0033] Due to this, the capacitance of this capacitor will be different according to the materials/conditions between these two plates. This means that the presence of a human near the combplate will be translated in a different value of the capacitance in comparison with the presence of other material and/or with the empty area, as it is shown in **Figure 1**. This figure depicts in the upper section a graph of the capacitance

[0034] C measured between two capacitor plates:

- a first capacitor plate: the combplate 2 of an escalator or moving walkway 1; and
- a second capacitor plate: a conductive surface connected to a reference voltage (preferably connected to ground).

[0035] The capacitance C measured corresponds to the different situations illustrated in the lower section of Figure 1. Thus, it can be appreciated that when a hand 3 is close to the combplate area, the capacitance signal 20 substantially increases (see central section 11 of the graph), and in a normal situation, when no human or animal skin is close to the combs area (see left 10 and right 12 sections of the graph), capacitance C remains substantially steady.

[0036] Figures 2A and 2B shows in more detail the approach of a finger 5 of a user's hand 3 to the teeth 4 of the combplate 2. Capacitance is an electrical property that exists between two conductive surfaces within a reasonable proximity. A change in the distance between both conductive surfaces or their electrical charge (+q,

-q) implies a capacitance variation. In Figure 2A when a user's finger 5 is located at a distance x of the comb teeth 4, the capacitance measured is C_1 . In Figure 2B, when the finger 5 is contacting a comb tooth 4, the capacitance measured is C_1 , wherein $C_1 \neq C_2$.

[0037] Figure 3 depicts a basic electrical diagram of the safety device installed on an escalator 1 (depicted in a side view and a top view). The safety device comprises a controller 6 (for instance, a microcontroller or a PLC), a capacitance measuring module 7 and a capacitor 8, which is formed by a first capacitor plate (the combplate 2) and a second capacitor plate 9 connected to ground 13.

[0038] The capacitance measuring module 7 measures the capacitance C of the capacitor 8. The controller 6 receives the capacitance information measured by the capacitance measuring module 7 and decides, based on said information, whether it is a normal situation or a dangerous situation. In the latter case, the controller 6 can stop the escalator 1 or emit a warning signal. Hence, by measuring the capacitance and processing the capacitance value the system is able to detect variations in the environment and decide if a person has touched the combplate or not after analyzing the received information. The controller 6 and the capacitance measuring module 7 can be implemented in the same or in different equipment.

[0039] A combplate 2 is normally formed by several combplate segments 14, as illustrated in Figure 4A (although Figure 4A only shows two combplate segments, the combplate is normally formed more than two). Depending on the sensibility required, the capacitance can be measured in several different ways:

- A capacitance measure (C , C' , C'') for each combplate segment 14 independently, as depicted in Figure 4B, showing a capacitor 8' for each combplate segment 14 (in this embodiment, the combplate is formed by three combplate segments 14, but there are usually more combplate segments).
- Just one capacitance measure C for all the combplate segments 14, as depicted in Figure 3.
- The capacitance measure for the complete combplate area including the frames between the floor plate (the fixed part) and combs.
- The capacitance measure for the combplate area including also the floor plate.

[0040] Figure 5 shows a flow diagram of the process performed by the safety device according to a preferred embodiment. In step 100 capacitance measurement is started. In step 102 the capacitance measuring module 7 receives a signal from the capacitor 8 in the combplate area. The signal received is analyzed after a conditioning and filtering step 104 in order to measure the capacitance value. This step 104 may be performed in the capacitance measuring module 7 or in the controller 6. The controller 6 of the safety device compares 106 the measured signal

with a predefined value or values (for instance, a higher and a lower threshold), which can be dynamic or static. In step 108 the result of the comparison is determined acceptable or not, depending on the variation of the measured signal with respect to the threshold/s. For instance, Figure 6 shows the measured capacitance signal 20 and only one static threshold 22. When the capacitance signal 20 exceeds the threshold 22, the safety device considers that a dangerous situation has occurred (a person or animal is touching the sensed area), and sends a warning signal or a stop order signal to the escalator controller, as shown in step 110. The controller 6 of the safety device can also be part of the escalator controller and in that case it can immediately stop the escalator or moving walk 1.

[0041] Optionally, the determined threshold can be dynamically obtained. In step 112 the safety device can check if the acceptable limits have changed and in that case define 114 new limits/thresholds for establishing the comparison. For instance, if the measured capacitance value exceeds the limit value during 1 second, a detection can be assumed. But since the capacitance is also depending on the environment condition (humidity, escalator model, steps/pallets speed, etc.), a new limit value may be fixed depending on different factors, such as the last N previous values or the mean value during the last X minutes, or another similar factor. This would be similar to an autotuning of the safety device.

[0042] There are several ways to measure the capacitance. Figure 7 shows another way, based on measuring the amplitude and frequency of a periodic capacitance signal 20. Depending on the value of the capacitance C and due to the resonance phenomenon, the amplitude of the periodic capacitance signal 20 will change in a different frequency range depending on the action performed (one finger 5, one complete hand 3, etc.). The upper graph of Figure 7 shows a periodic capacitance signal with no changes in amplitude. When a finger 5 (middle graph) or hand 3 (lower graph) is placed near the combplate area, there are some changes in amplitude that can be detected by the safety device.

[0043] In a first embodiment, shown in previous figures, the safety device is used to detect contact of human skin in the combplate area for avoiding entrapment of fingers. In this first embodiment one of the capacitor plates is formed, at least partially, by the combplate.

[0044] In a second embodiment, shown in Figures 8A to 8C, the safety device is used to detect a fallen person on the floor plate. In this second embodiment one of the capacitor plates is formed by the floor plate. As in this case the body surface in contact with the metal plate is much higher than in the first embodiment, in this second embodiment a fallen person on the floor plate can be detected due to the capacity variation caused by the presence of the human body over the floor plate, even when there is no skin contact with the floor plate (i.e. there is only contact with the person's clothes).

[0045] Upper image of Figure 8A shows a top view of

an escalator/moving walkway where the floor plate is free. Lower image of Figure 8A shows a risk situation with a fallen person 15 on the floor plate 16.

[0046] Figures 8B and 8C depicts two different methods for monitoring the capacitance signal and determining if a risk situation has occurred. In the method of **Figure 8B**, equivalent to that described in Figure 6, the capacitance signal is compared with an upper threshold. The upper graph corresponds to the capacitance measured for the upper situation in Figure 8A (the floor plate is free), a normal situation where the capacitance signal 20 is lower than the threshold 22. The lower graph of Figure 8A corresponds to the capacitance measured for the lower situation of Figure 8A (a fallen person on the floor plate). In this case the capacitance signal 20 exceeds the threshold 22, and a risk situation is therefore detected.

[0047] In the method of **Figure 8C**, equivalent to that described in Figure 7, the amplitude and frequency of a periodic capacitance signal 20 is monitored. The upper graph of Figure 8C corresponds to the upper situation of Figure 8A (normal situation), showing a periodic capacitance signal with no changes in amplitude. The lower graph of Figure 8C corresponds to the lower situation of Figure 8A (fallen person on the floor plate), showing some changes in amplitude that can be detected by the safety device.

[0048] The detection principle of this second embodiment (a fallen person on the floor plate) is the same as in the first embodiment (human skin -e.g. a finger/hand- getting close or in contact with the combplate), checking in this second embodiment the influence in the capacitance when a human body 15 is in contact with the metal plate of the floor plate 16. In this second embodiment the complete body with clothes produces a significant variation in the capacitance, similar to the variation of capacitance in the comb area when a finger/hand is close to the combplate. The thresholds in both embodiments will however be different.

Claims

1. Safety device for preventing accidents in the combplate area of escalators or moving walkways, **characterized in that** it comprises:

- at least one capacitor (8), each one formed by a first capacitor plate in contact with a combplate (2) or floor plate (16) of an escalator or moving walkway (1) and a second capacitor plate (9) connected to a reference voltage;
- a capacitance measuring module (7) for measuring the capacitance (C) of the at least one capacitor (8), obtaining at least one capacitance signal (20);
- a controller (6) configured for comparing each capacitance signal (20) with at least one prede-

fined value (22) and, based on said comparison, deciding whether a dangerous situation has occurred, and **in that** case sending the escalator or moving walkway (1) a warning signal or a stop order signal.

2. Safety device according to claim 1, comprising only one capacitor (8) wherein the first capacitor plate is formed by the whole combplate (2).
3. Safety device according to claim 1, comprising only one capacitor (8) wherein the first capacitor plate is formed by the whole combplate (2) including also the frames between the floor plate and combs.
4. Safety device according to claim 1, comprising only one capacitor (8) wherein the first capacitor plate is formed by the whole combplate (2) including also the floor plate.
5. Safety device according to claim 1, comprising only one capacitor (8) wherein the first capacitor plate is formed by the whole floor plate (16).
6. Safety device according to claim 1, comprising a plurality of capacitors (8), as many as combplate segments (14), wherein the first capacitor plate of each capacitor (8) is formed by a different combplate segment (14).
7. Safety device according to any of previous claims, wherein the second capacitor plate (9) of each capacitor (8) is connected to ground (13).
8. Safety device according to any of previous claims, wherein the at least one predefined value (22) is established to detect the approach of human or animal skin to the combplate area.
9. Safety device according to of claims 1 to 7, wherein the at least one predefined value (22) is established to detect a fallen body on the floor plate.
10. Safety device according to any of previous claims, wherein the at least one predefined value (22) is dynamic.
11. Safety device according to any of previous claims, wherein the controller (6) is configured to stop the escalator or moving walkway (1) when a dangerous situation is detected.
12. Method for preventing accidents in the combplate area of escalators or moving walkways, **characterized in that** it comprises:
 - measuring (102) the capacitance (C) of at least one capacitor (8), each one formed by a first

capacitor plate in contact with a combplate (2) or floor plate (16) of an escalator or moving walkway (1) and a second capacitor plate (9) connected to a reference voltage, obtaining at least one capacitance signal (20);

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- comparing (106) each capacitance signal (20) with at least one predefined value (22);

- deciding (108), based on said comparison, whether a dangerous situation has occurred, and **in that** case sending (110) the escalator or moving walkway (1) a warning signal or a stop order signal.

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- 13.** Method according to claim 12, further comprising checking (112) if the acceptable predefined values (22) have changed and in that case defining (114) new predefined values (22).

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- 14.** Method according to any of claims 12 to 13, comprising measuring (102) the capacitance (C) of a plurality of capacitors (8), as many as combplate segments (14), wherein the first capacitor plate of each capacitor (8) is formed by a different combplate segment (14).

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- 15.** Method according to any of claims 12 to 14, wherein the second capacitor plate (9) of each capacitor (8) is connected to ground (13).

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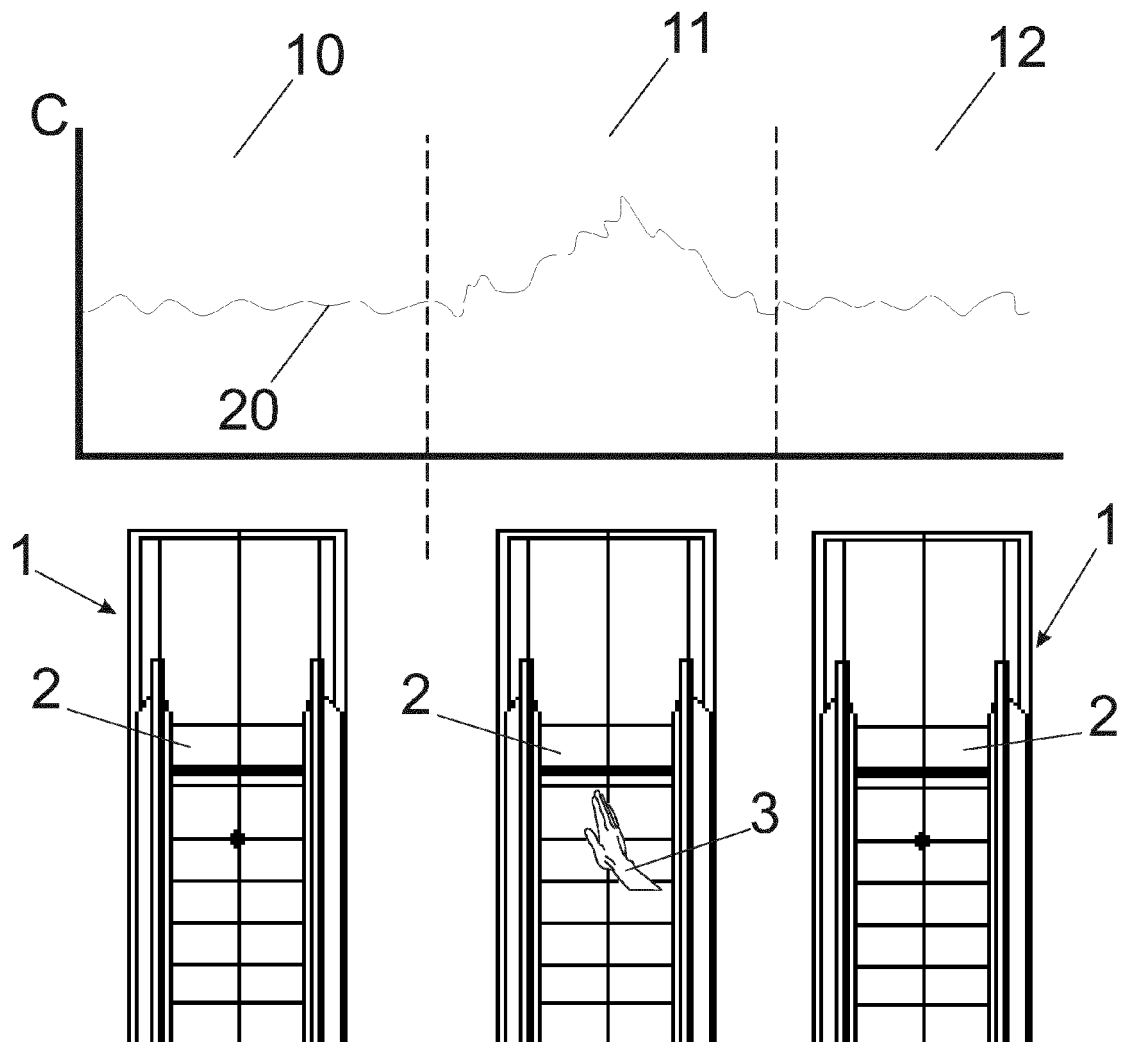
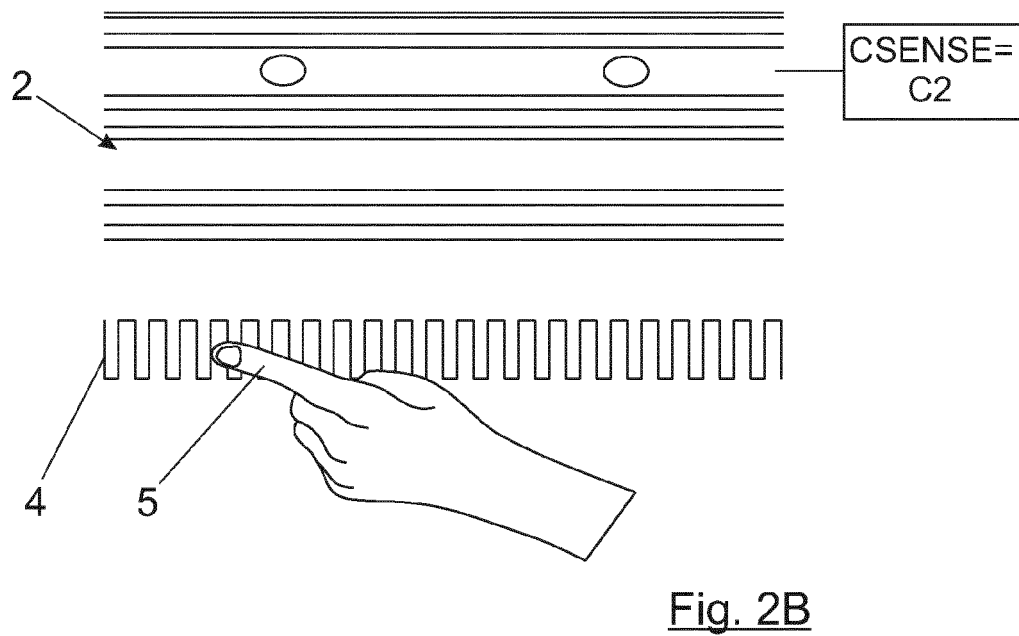
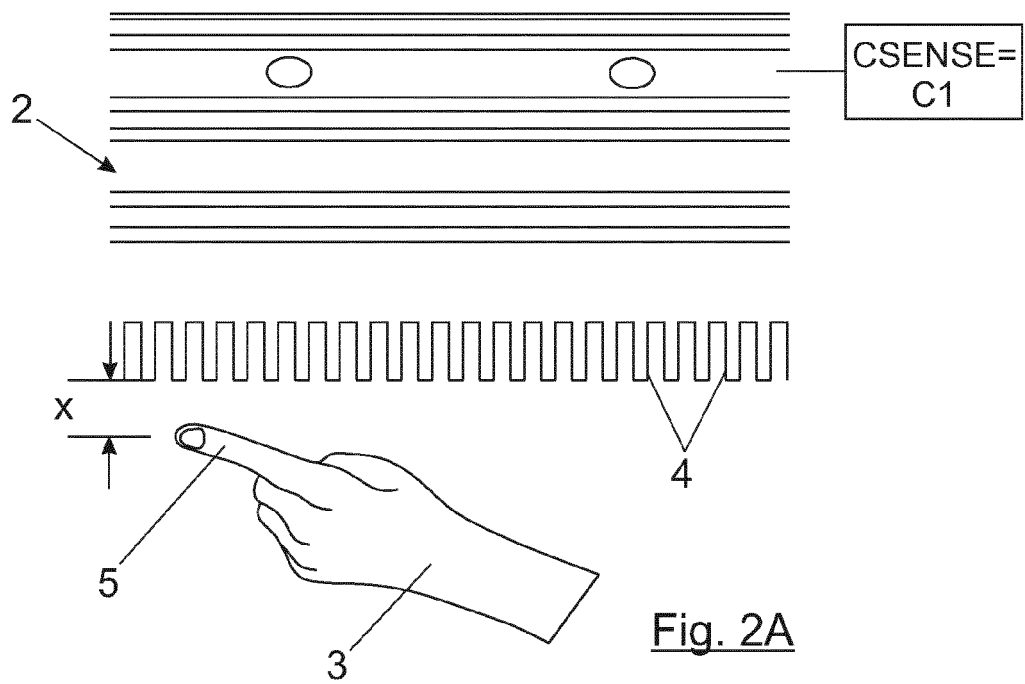


Fig. 1



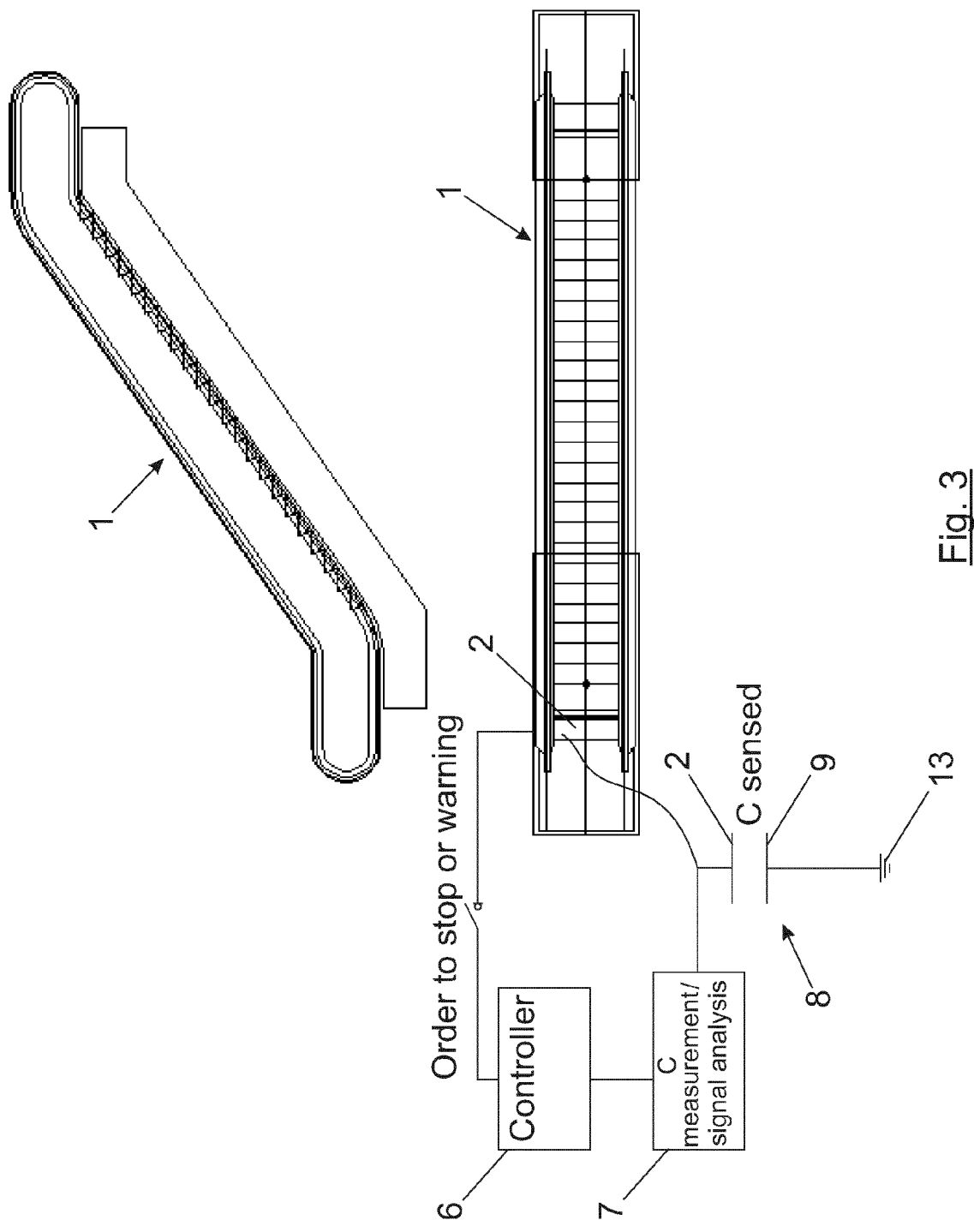


Fig. 3

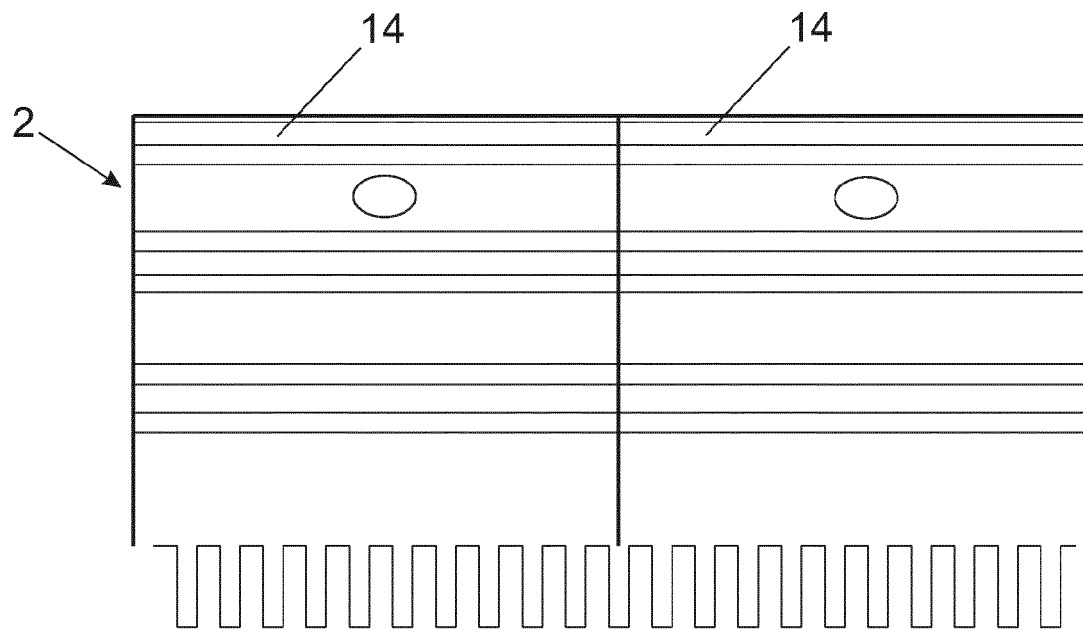


Fig. 4A

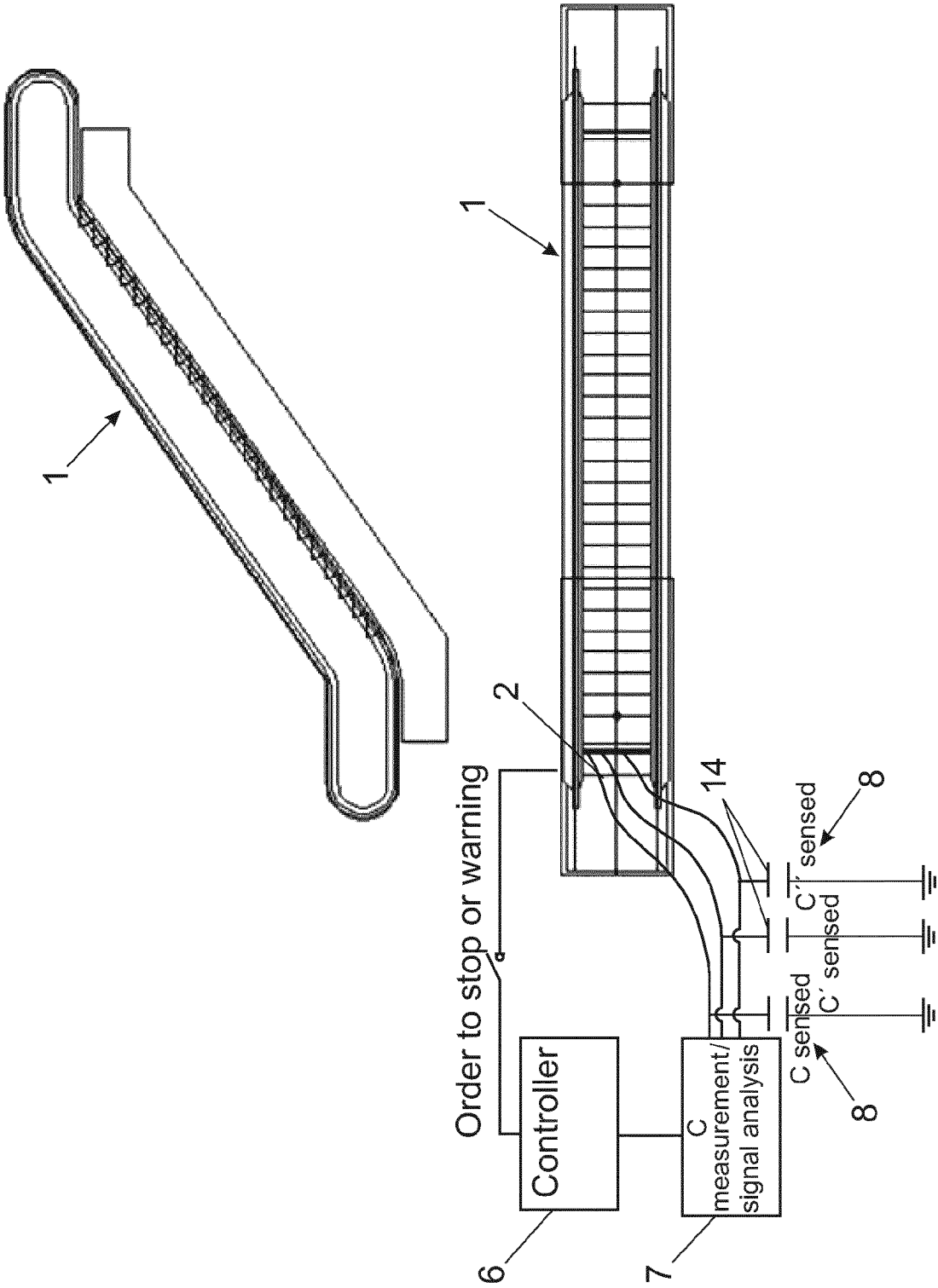
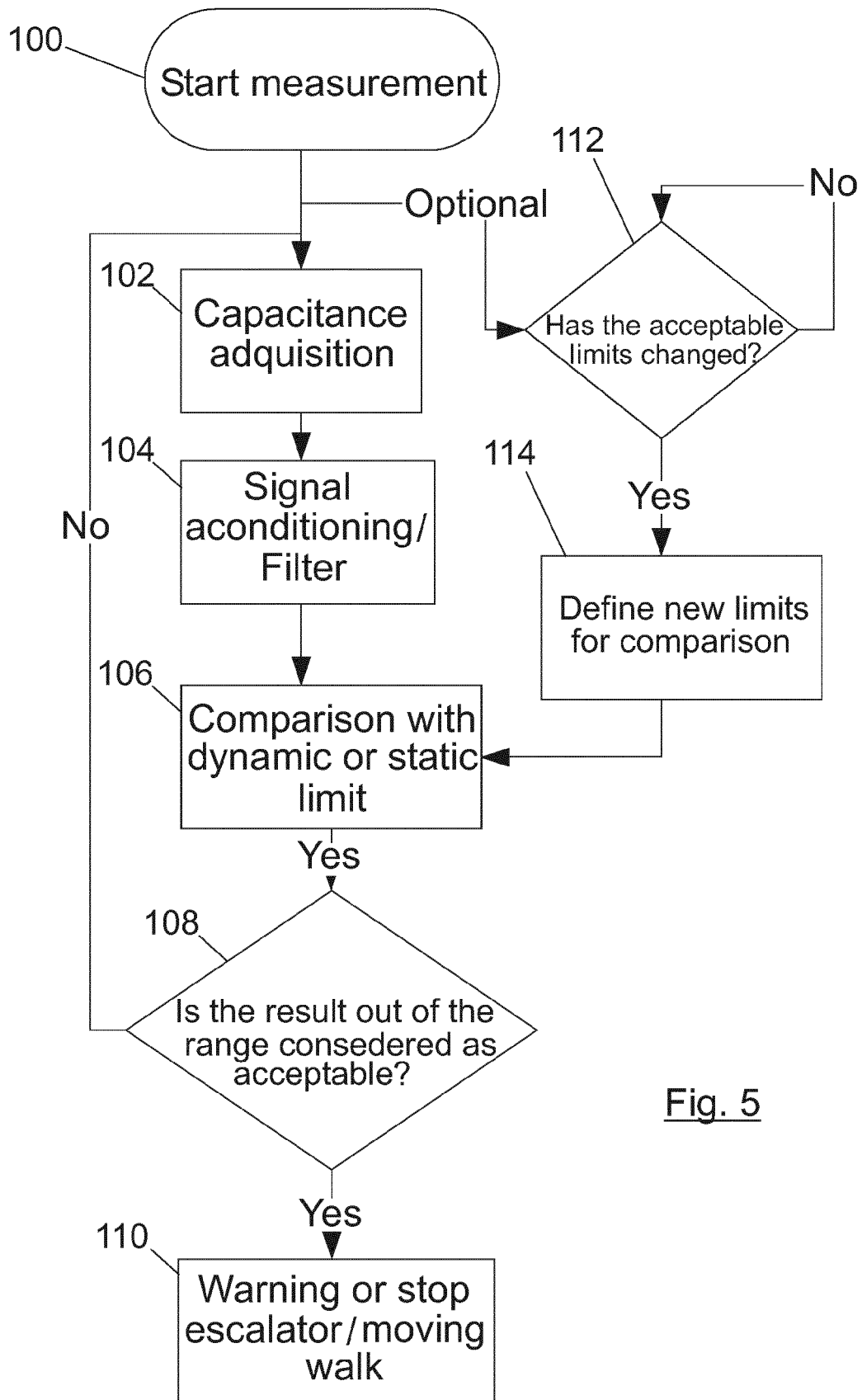


Fig. 4B

Fig. 5

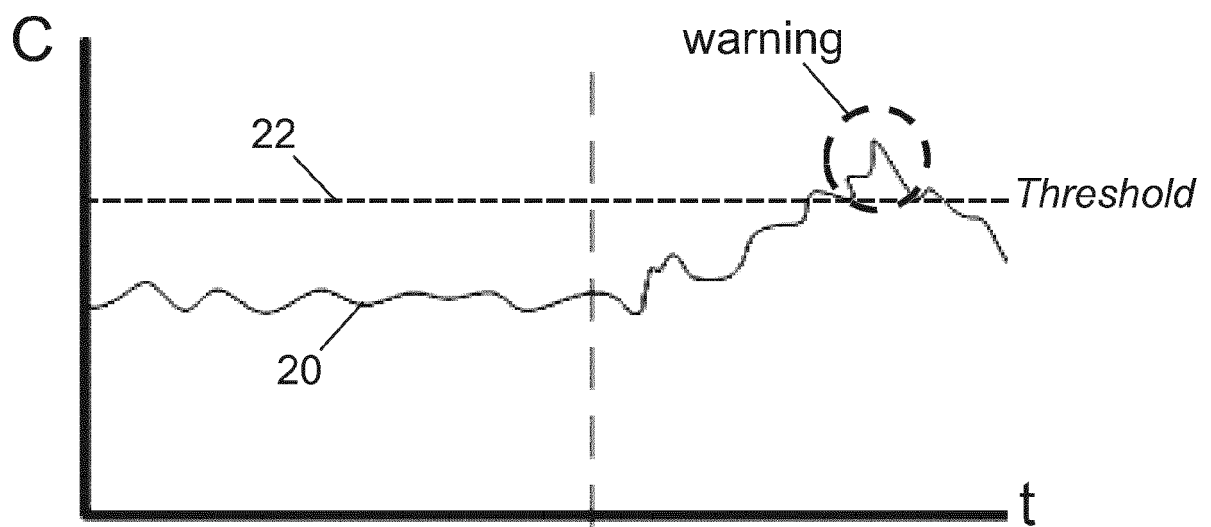


Fig. 6

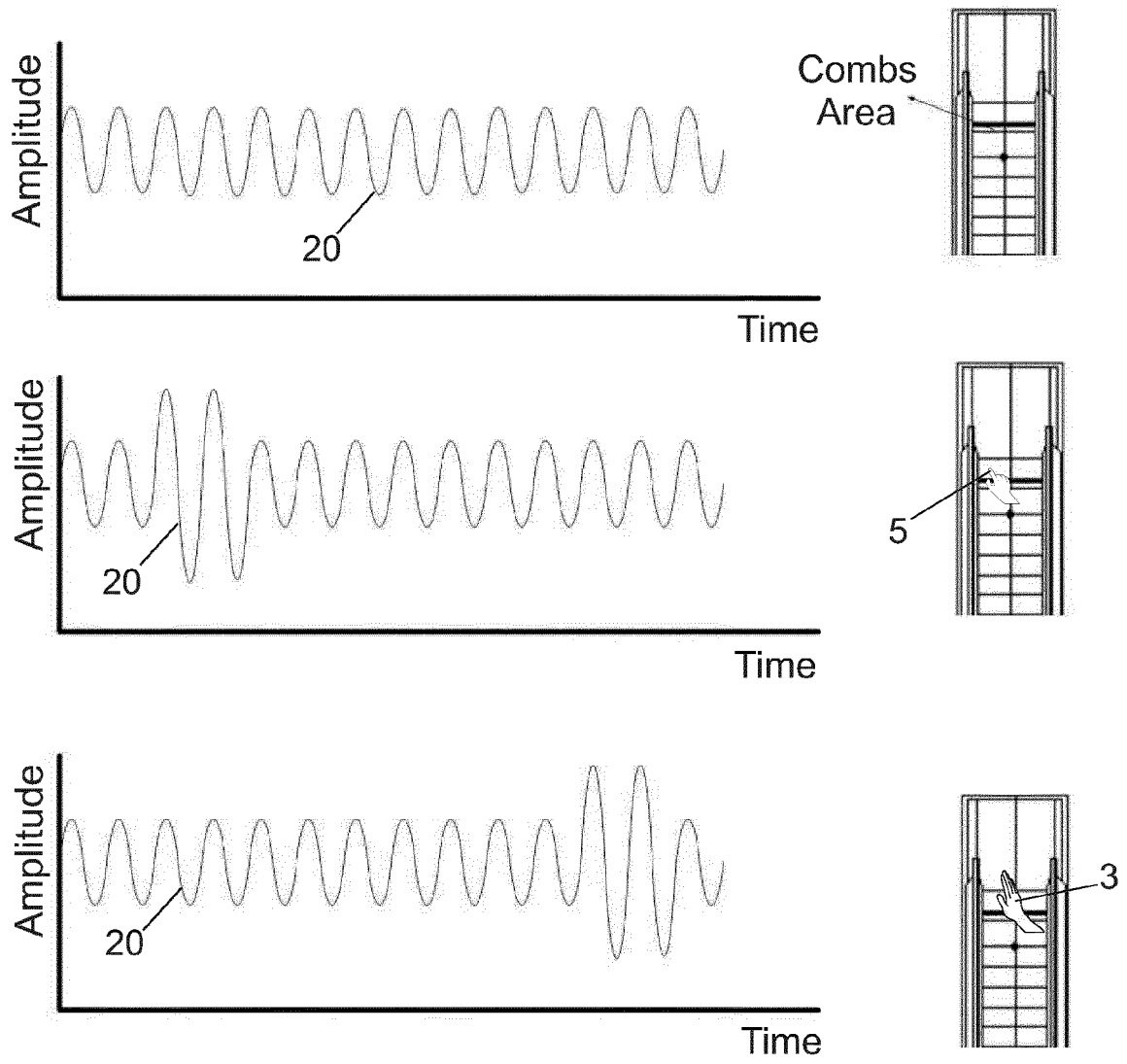


Fig. 7

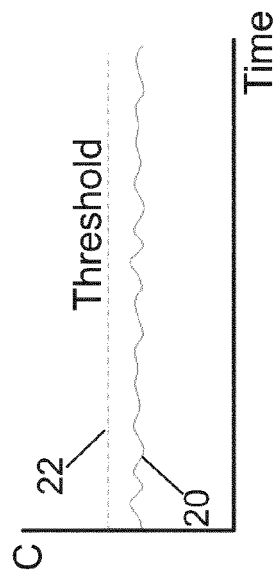


Fig. 8A

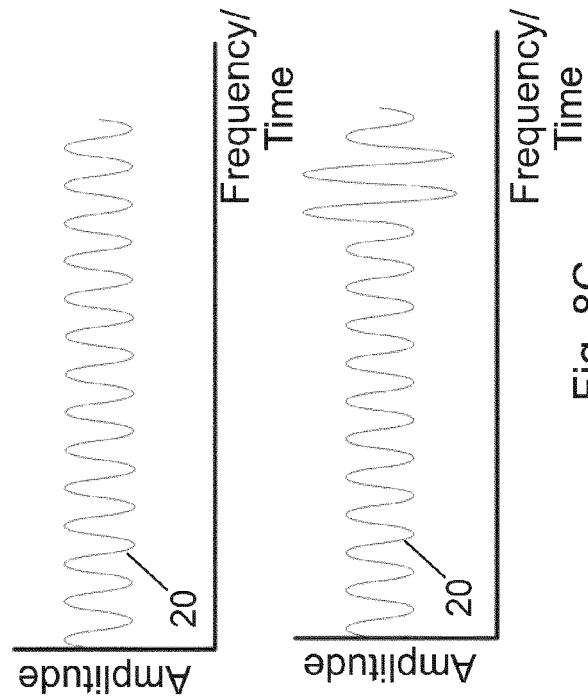


Fig. 8B

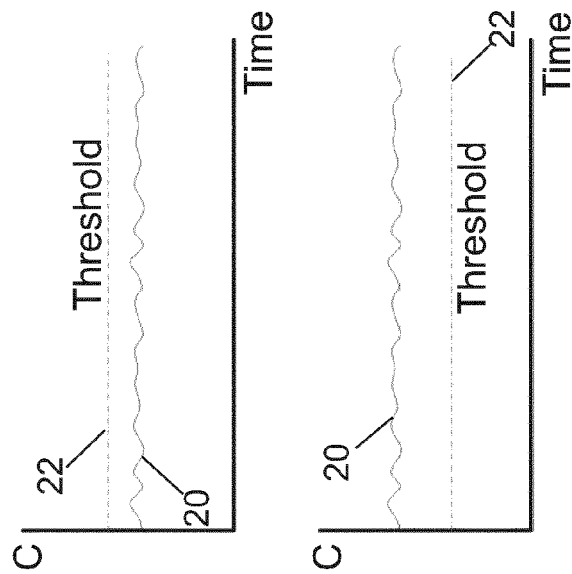


Fig. 8C



EUROPEAN SEARCH REPORT

Application Number
EP 15 38 2207

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	WO 2014/015870 A2 (THYSSENKRUPP FAHRTREPPEN GMBH [DE]) 30 January 2014 (2014-01-30) * page 2, paragraph 2 * * page 7, paragraph 3 * * page 13 - page 14 * * figures 4-6,8 * * claims 1,9 *	1,2,6-15 3-5	INV. B66B29/06
X	DE 727 487 C1 (STAHL R FA) 4 November 1942 (1942-11-04) * page 2, line 29 - line 44; figure 1 *	1,7-9, 11-13,15	
X,D	DE 102 59 149 A1 (KONE CORP [FI]) 15 July 2004 (2004-07-15) * figures 1,2 *	1,12	
X	US 6 520 310 B1 (LAUCH RICHARD [US] ET AL) 18 February 2003 (2003-02-18) * the whole document *	1,12	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 September 2015	Examiner Fiorani, Giuseppe
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			

EPO FORM 1503 03/82 (P04C01)

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

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