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(71) Applicant: ASSA ABLOY ENTRANCE SYSTEMS AB  
[SE/SE]; Box 131, 261 22 LANDSKRONA (SE).

(72) Inventors: ZIMMERMANN, Robert; Achheimerstrasse  
8, 79206 Breisach (DE). SCHMIDT, Christoph; Mühleck-  
le 26, 77797 Ohlsbach (DE).

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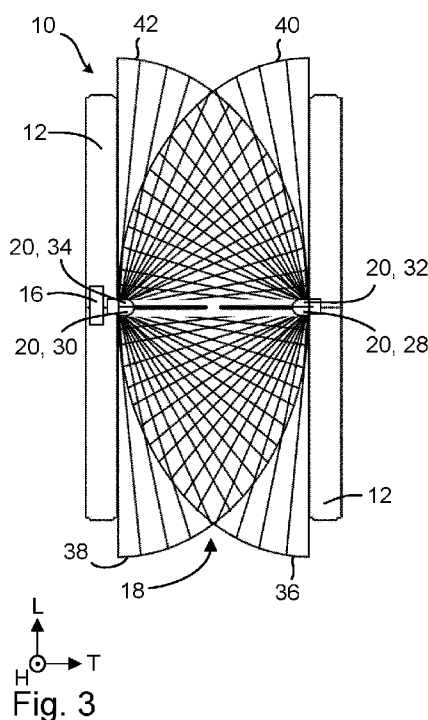
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(54) Title: DETECTION SYSTEM AS WELL AS METHOD FOR OPERATING A DETECTION SYSTEM



(57) Abstract: A detection system (10) has an automatic door (14), a control unit (16) for operating the automatic door (14), a controlled passageway (18) in front of the automatic door (14), at least two barriers (12), and at least one time-of-flight camera (20). The barriers (12) are located on opposite lateral sides of the controlled passageway (18) confining the controlled passageway (18) in between. The time-of-flight camera (20) is located at one of the lateral sides of the controlled passageway (18), the field of view (36, 38, 40, 42) of the time-of-flight camera (20) spanning between a transverse border and a longitudinal border, wherein the transverse border extends substantially in the transverse direction (T) across the controlled passageway (18) and the longitudinal border extends substantially in the longitudinal direction (L) along the lateral side of the controlled passageway (18). Further, a method for operating a detection system (10) is provided.



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Detection system as well as method for operating a detection system

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The invention relates to a detection system as well as a method for operating a detection system.

Detection systems are well known in the art and are used, for example in conjunction with access control systems in the form of speedgates, to control  
10 access to a secure area so that only persons presenting a valid authorization may pass into the secure area.

Detection systems may be used in airport environments and at the entrance of office buildings but also to control access to public transportation. In this case, the authorization equates to a valid ticket.

15 Various schemes for gaining unauthorized access are known and need to be prevented by the detection system. For example, two persons could be walking very close one behind the other attempting to both gain access even though only one person has presented a valid authorization to the access control system. This scheme is known as tailgating.

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Further, a different form of tailgating, called side-by-side tailgating is known. In this case, two persons are walking side-by-side very close together so that they appear to the detection system also as a single, large person. Side-by-side tailgating attempts are very difficult to detect. Even though it is known to detect  
5 side-by-side tailgating using cameras and image recognition techniques, these solutions are very complex and cannot always be implemented in the given environments.

Thus, it is the object of the invention to provide a detection system as well as a method for operating a detection system that is capable of detecting side-by-  
10 side tailgating in a simple and reliable way.

For this purpose, a detection system is provided comprising an automatic door, a control unit for operating the automatic door, a controlled passageway in front of the automatic door, at least two barriers, and at least one time-of-flight camera. The barriers are located on opposite lateral sides of the controlled  
15 passageway confining the controlled passageway in between. The time-of-flight camera is located at one of the lateral sides of the controlled passageway, the field of view of the time-of-flight camera spanning between a first border and a second border, wherein the first border extends substantially in the transverse direction across the controlled passageway and the second border extends  
20 substantially in the longitudinal direction along the lateral side of the controlled passageway.

By using a time-of-flight camera, more information about the objects in the controlled passageway can be generated, which allow a reliable detection of side-by-side tailgating without the need for image recognition of video image  
25 of the scene at the detection system.

As such, if desired, the solution can be fully integrated into the barriers and/or doors of a detection system so that the solution does not need any external detection devices.

In particular, the longitudinal border extends along same lateral side of controlled passageway as the respective time-of-flight camera.

The detection system may be a speedgate, a turnstile or a one-way passage system.

- 5 The detection system may comprise an access control system with a reader.

The detection system, in particular the control unit, may be configured to carry out a method as described below.

The at least two barriers may comprise a cabinet and/or a railing, providing a clear confinement for the controlled passageway.

- 10 In an embodiment, the time-of-flight camera is a laser scanner type sensor, for example a FlatScan sensor by BEA Sensors, and/or wherein the field of view has an angle of view of at least  $60^\circ$ , in particular at least  $85^\circ$ , more particularly at least  $90^\circ$ , allowing to cover a large area with a single camera.

- 15 The angle of view is, in particular, the angle of the field of view in the horizontal plane, i.e. the plane spanned by the transverse and longitudinal direction.

In order to simplify the interpretation of the measurements of the camera, the field of view may be confined in the height direction to a detection plane, in particular the detection plane being horizontal.

- 20 The plane may be less than 10 mm, in particular less than 5 mm in height. In an aspect, the time-of-flight camera is located in the longitudinal direction at the level of the automatic door, maximizing the area of the controlled passageway covered by the field of view.

In order to increase reliability, the first camera and/or the second camera may be located above the ground at leg height and/or at waist height.

- 25 For example, "leg height" describes the range of 15 cm to 70 cm above the ground, i.e. above the bottom of the detection system, and/or "waist height"

describes the range of 70 cm and 100 cm above ground, i.e. above the bottom of the detection system.

The cameras may be mounted at different heights so that their detection planes do not overlap in the height direction to avoid interference between the cameras.

- 5 The time-of-flight cameras may all be located at leg height or at waist height. It is also conceivable that one of the time-of-flight cameras is located at leg height, whereas another one of the time-of-flight cameras is located at waist height.

In an embodiment, the automatic door has at least one door leaf mounted movably with respect to the barrier and an actuator, in particular the automatic  
10 door having two door leaves mounted to opposite ones of the barrier and two actuators, allowing a quick actuation of the door.

In particular, the actuators are controlled by the control unit.

For example, the automatic door comprises at least one door leaf support column supporting the door leaf, wherein the door leaf is movably, in  
15 particularly rotatably mounted to the support column.

In order to integrate the time-of-flight camera inconspicuously, the at least one time-of-flight camera may be mounted to the barrier, to the support column and/or on top of the support column.

In an embodiment, the detection system comprises at least two time-of-flight  
20 cameras, wherein the first camera of the at least two time-of-flight cameras is located at a first side of the lateral sides of the controlled passageway, and the second camera of the at least two time-of-flight cameras is located at the second side, wherein the fields of view of the first camera and the second camera overlap. Using a second time-of-flight camera with an overlapping field of view  
25 drastically increases the detection efficiency and accuracy.

For example, the fields of view may overlap with at least 90%, in particular 100% of their area seen in top view.

The transverse borders of the fields of view of the first camera and of the second camera may be parallel to each other or cross each other. Alternatively or in  
5 addition, the longitudinal borders of the fields of view of the first camera and of the second camera may be parallel to each other.

In an embodiment, the barriers and the controlled passageway extend also at the back of the automatic door, wherein the detection system comprises at least four time-of-flight cameras, wherein a third camera and a fourth camera of the at  
10 least four time-of-flight cameras are arranged at the back of the door. Further, a second reader of the access control system may be provided at the back of the automatic door. By also providing time-of-flight cameras and optionally a reader at the back of the automatic door, the detection system may be used in both directions. The detection system may thus provide a bi-directional flow of  
15 people.

In particular, the third camera and the fourth camera are arranged at the back of the door in the same manner as the first camera and the second camera in front of the automatic door.

For centrally detecting side-by-side tailgating the control unit may be  
20 configured to receive results of distance measurements, in particular a distance profile of an object in the controlled passageway, from the at least one time-of-flight camera, in particular from each of the first camera and the second camera and/or from each of the third camera and the fourth camera, and to determine whether or not two persons are present side-by-side in the controlled  
25 passageway based on the received results.

Within this disclosure, "side-by-side" meaning next to one another in the transverse direction.

The distance profile may a horizontal one-dimensional distance profile.

For example, the control unit controls the automatic door to close or to keep closed when two persons walking side-by-side are detected.

In a further embodiment, the control unit is configured to receive results of  
5 distance measurements, in particular a distance profile of an object in the controlled passageway, from the at least one time-of-flight camera, in particular from each of the first camera and the second camera and/or from each of the third camera and the fourth camera, and to determine, based on the received results, whether or not a predetermined security distance in the longitudinal  
10 direction between two persons in the controlled passageway is kept, and/or whether or not the automatic door can be operated, particularly closed, safely. This way, other schemes of tailgating may be detected and/or safety is increased.

For above mentioned purpose, further there is provided a method for operating  
15 a detection system having a controlled passageway, in particular a detection system as described above. The method comprises the following steps:

- measuring at least one distance profile of an object in the controlled passageway from a first side of a lateral side of the controlled passageway, and
- 20 – determining, based on the measured distance profile, if the object is two persons walking side-by-side in the controlled passageway.

The features and advantages described with respect to the detection system also apply to the method and vice versa. The components of the detection system carrying out a certain task are configured to do so.

25 For increasing the accuracy, the method may comprise the following further steps:

- measuring at least one distance profile of an object in the controlled passageway from a second side of a lateral side of the controlled passageway, the second side being opposite to the first side, and
- determining, based on the at least two measured distance profiles, if the  
5 object is two persons walking side-by-side in the controlled passageway.

In an aspect, the method comprises the step of closing the automatic door of the detection system or keeping the automatic door closed, if it has been determined that two persons are walking side-by-side in the controlled passageway. By closing the door, persons attempting to trespass are prevented from doing so.

- 10 For increasing the security and/or safety further, the method may comprise the following further steps:

- determining, based on the at least one measured distance profile, whether or not a predetermined security distance in the longitudinal direction between two persons in the controlled passageway is kept, and/or
- 15 – determining whether or not the automatic door can be operated, particularly closed, safely.

For example, the automatic door is closed if the distance in the longitudinal direction is smaller than the threshold of the predetermined security distance. The threshold may depend on the speed of the persons passing through the  
20 controlled passageway.

In order to anticipate usage of the detection system, the method may comprise the step of determining, based on the at least measured distance profile, whether a person outside the controlled passageway is approaching the detection system and intends to pass through the detection system, wherein the field of view of  
25 the at least one time-of-flight camera extends further than the controlled passageway.

Further features and advantages will be apparent from the following description as well as the accompanying drawings, to which reference is made. In the drawings

- Fig. 1: shows a detection system according to an embodiment of the invention in a perspective view,
- Fig. 2: shows the detection system of Figure 1 in a top view,
- Fig. 3: shows the same view as Figure 2, wherein the fields of view of the time-of-flight cameras are indicated,
- Fig. 4: shows the detection system of a first embodiment of the invention in a perspective view,
- Figs. 5, 6: show distance profiles measured by the time-of-flight cameras in the situations shown in Figure 4,
- Fig. 7: shows a flowchart of a method for operating the detection system according to an embodiment of the invention,
- Fig. 8: shows a detection system according to a second embodiment of the invention in a perspective view,
- Figs. 9, 10: show distance profiles measured by the time-of-flight cameras in the situation shown in Figure 8, and
- Figs. 11, 12: show further embodiments of a detection system based on the first and second embodiment, respectively.

Figure 1 and 2 show a detection system 10 of an embodiment of the invention in a perspective view and a top view, respectively.

In the shown embodiment, the detection system 10 is a speedgate for example for use at airports, in public transportation or office buildings.

The detection system 10 may as well be a turnstile or a one-way passage system, as, for example, used at airports to allow passage from the flight side to the public side.

In the shown embodiment, the detection system 10 comprises two barriers 12,  
5 an automatic door 14, a control unit 16, a controlled passageway 18, and at least one time-of-flight camera 20.

Further, an access control system with a reader 21 is present. For example, the detection system 10 comprising the access control system and/or the reader 21. The reader 21 may be attached, in particular integrated into one of the barriers  
10 12.

The reader 21 may be a card reader, an RFID reader, an NFC reader, a fingerprint sensor and/or a face recognition device.

The barriers 12 may comprise a cabinet and/or a railing and extend parallel to each other while being spaced apart by a distance.

15 In the shown embodiment, the barriers 12 are between waist and chest high but they may as well be much higher, i.e. higher than a person. It is also conceivable, that the barriers 12 form a closed housing of the detection system 10 through which persons may pass.

Between the barriers 12, the controlled passageway 18 is located. The  
20 controlled passageway 18 is laterally confined by the barriers 12 which extend at opposite lateral sides of the controlled passageway 18.

The controlled passageway 18 has a transverse direction T perpendicular to the barriers 12 and a longitudinal direction L parallel to the barriers 12.

The controlled passageway 18 may be entered and left by a person at the  
25 longitudinal ends, as the lateral sides of the passageway 18 are blocked by the barriers 12.

The automatic door 14 is located between the barriers 12 and is configured to block the controlled passageway 18 or allow passage through the controlled passageway 18.

For example, the automatic door 14 is located in the middle of the controlled  
5 passageway 18 with respect to the longitudinal direction L.

The controlled passageway 18 thus extents in front of the automatic door 14 and, in the shown embodiment, also further behind at the back of the automatic door 14.

The automatic door 14 comprises at least one door leaf 22, a door leaf support  
10 column 24 for each of the door leaves 22 and an actuator 26 for each of the door leaves 22.

In the shown embodiment, the automatic door 14 comprises two door leaves 22 and thus two door leaf support columns 24 as well as two actuators 26.

The door leaf support columns 24 are arranged at the inside of the barriers 12  
15 and adjacent to the respective barrier 12 or even mounted to the respective barrier 12.

The door leaves 22 are mounted to the door leaf support column 24 such that they are rotatable with respect to the barrier 12.

The door leaves 22 and the respective door leaf support columns 24 are arranged  
20 at opposite ones of the barriers 12 at the same level with respect to the longitudinal direction of the controlled passageway 18.

The door leaves 22 can assume at least two different positions, namely a closed position and an open position.

In the open position, the door leaves 22 are perpendicular to the longitudinal  
25 direction L of the controlled passageway 18 and block the passage through the

controlled passageway 18. In particular, in the closed position the two door leaves 22 are in the same plane.

In the open position, in the door leaves 22 extend substantially parallel to the longitudinal direction L and are adjacent to the respective barrier 12, thus  
5 allowing passage through the controlled passageway 18.

The door leaves 22 are actuated by the actuators 26 between the at least two positions. To this end, the actuator 26 is connected to the control unit 16. The automatic door 14 is thus a swing door.

It is also conceivable that the door leaves 22 are mounted movably with respect  
10 to the barriers 12 in a way that the axis of rotation of the door leaves 22 is parallel to the longitudinal direction L. In this case the door leaves 22 may move from the closed position to the open position by rotating the door leaves 22 into the respective barrier 12.

The control unit 16 is, for example, arranged in one of the barriers 12 and  
15 connected to the actuator 26 as well as to the time-of-flight cameras 20.

In the shown embodiment, the detection system 10 comprises two pairs of time-of-flight cameras 20. The first camera 28 and the second camera 30 of the time-of-flight cameras 20 form the first pair, and the third camera 32 and the fourth camera 34 of the time-of-flight cameras 20 form the second pair.

20 Each of the cameras 28, 30, 32, 34 has a field of view, namely a first field of view 36, a second field-of-view 38, a third field-of-view 40, and a fourth field-of-view 42, respectively. The fields of view 36, 38, 40, 42 are depicted in Figure 3.

One of the pairs of time-of-flight cameras 20 monitors the controlled  
25 passageway 18 in front of the automatic door 14, the other pair of time-of-flight cameras monitors the controlled passageway behind the automatic door 14.

The time-of-flight cameras 20 may be laser scanner type cameras, meaning that a laser beam is moved between the transverse border and the longitudinal border in quick repetition to cover the whole field of view. In other words, the field-of-view is not captured at once but by scanning with the laser beam.

- 5 Each of the time-of-flight cameras 20 has a field of view having an angle of view of at least  $60^\circ$ , in particular at least  $85^\circ$ , more particularly at least  $90^\circ$ , as shown in Figure 3. For example, the angle of view is determined in a top view projecting the field of view in a horizontal plane, e.g. the plane spanned by the transverse direction T and the longitudinal direction L of the controlled  
10 passageway 18.

In the height direction, i.e. perpendicular to the transverse direction T and the longitudinal direction L, the field of view 36, 38, 40, 42 of each of the cameras 20 is confined to a detection plane 44 (Figs 4, 7). The detection plane 44 may have a height of less than 10 cm, in particular less than 5 cm.

- 15 The cameras 20 may be mounted at different heights so that their detection planes 44 do not overlap in the height direction H to avoid interference between the cameras 20.

- Horizontally, the fields of view 36, 38, 40, 42 of each of the time-of-flight cameras 20 is bordered by a transverse border and a longitudinal border. The  
20 transverse border of each of the field of view 36, 38, 40, 42 extends substantially in the transverse direction of the controlled passageway 18, i.e. fully across the controlled passageway 18.

- The longitudinal borders of each of the field of views 36, 38, 40, 42 extend substantially in the longitudinal direction L of the controlled passageway 18 at  
25 the lateral side at which the respective camera 28, 30, 32, 34 is located.

Within this disclosure, substantially in the transverse direction T or substantially in the longitudinal direction L means that the respective object

extends exactly in the respective direction or with a deviation of plus/minus  $10^\circ$  of the respective direction.

The longitudinal border extends away from the door 14 and optionally even further than the end of the barrier 12 and thus further than the end of the controlled passageway 18 in the longitudinal direction L.

In particular, the longitudinal border and/or the transverse border do not cross the automatic door 14.

For each pair, the time-of-flight cameras 20 are located on opposite sides of the controlled passageway 18, in particular at the lateral sides of the controlled passageway 18.

In the longitudinal direction L, the time-of-flight cameras 20 are located at the level of the automatic door 14. For example, the distance between the time-of-flight cameras 20 in the longitudinal direction L and/or the transverse border of the respective fields of view 36, 38, 40, 42 to the plane of the automatic door 14 is less than 20 cm, in particular less than 10 cm. In particular, the transverse border may be in the plane of the door leaves 22 in the closed position.

As shown in Figures 2 and 3, the time-of-flight cameras 20 may be mounted to the door leaf support column 24 of the respective side of the controlled passageway 18, in particular mounted on top of the respective door leaf support column 24.

It is also conceivable, that the time-of-flight cameras 20 are mounted to the barriers 12.

In the height direction H, the time-of-flight cameras of the same pair, in particular all time-of-flight cameras 20 located at the same height. Thus, the fields of view 36, 38 of the first and second camera 28, 30 overlap, and the fields of view 40, 42 of the third and fourth camera 32, 34 overlap.

For example, seen in a top view, the fields of view 36, 38 and 40, 42 of the same pair overlap with at least 90% of their area, in particular with at least 100% of their area.

In particular, the transverse borders of the fields of view 36, 38 and 40, 42 are  
5 parallel to each other or cross each other.

The longitudinal borders of the fields of view 36, 38 of the first camera 28, and second camera 30 do not intersect and are in particular parallel to each other. The same holds true for the transverse borders and longitudinal borders of the fields of view 40, 42 of the third and fourth camera 32, 34.

10 Figure 4 shows a first embodiment of the detection system 10 in a perspective view. The detection plane 44 of the first and second camera 28, 30 is indicated as well as two persons approaching the controlled passageway 18.

In this embodiment, the first and second camera 28, 30 and thus the detection plane 44 are located at leg height, i.e. between 15 cm to 70 cm above the ground,  
15 e.g. above the bottom of the detection system 10. As such, the time-of-flight cameras 20 measure the distance to the legs of the persons in the controlled passageway 18.

During operation, each of the time-of-flight cameras 20 performs distance measurements while creating a distance profile of objects within the respective  
20 field of view 36, 38, 40, 42. The distance profile may be a horizontal one-dimensional distance profile.

For the ease of description, only the functionality of the first pair of cameras, i.e. the first camera 28 and the second camera 30, is explained in the following. Of course, the functionality of the second pair of cameras, i.e. the third camera  
25 32 and the fourth camera 34 is the same when persons are intending to pass the detection system 10 from the other side.

Figure 5 shows schematically the distance profile measured by the first camera 28 in the situation of Figure 4. The distance to the camera 20 is indicated with circular sectors and the legs of the persons are shown as footsteps, both for illustration purposes only.

- 5     The line 46 indicates the distance profile actually measured by the first camera 28.

In this distance profile, four legs can clearly be distinguished from one another. But it is worth noticing that the legs shield the areas behind them from the view of the camera 20 so that shaded or blind areas are present.

- 10   Figure 6 shows an overlay of two measured distance profile, namely the distance profile measured by the first camera 28 as shown in Figure 5 and the distance profile measured by the second camera 30. Line 48 depicts the distance profile measured by the second camera 30.

- As can be seen, the bottom left-hand leg is very close to the second camera 30, shielding a wide range of the field of view 38 of the second camera 30. In particular, the other three legs are completely shielded from view.
- 15

For operating the detection system 10, a method according to an embodiment of the invention as shown as a flowchart in Figure 7 is carried out.

- The first camera 28 and the second camera 30 perform the distance measurement and create distance profiles as shown in Figures 5 and 6. Thus, the distance to an object O (in the shown case four legs) in the controlled passageway is measured from a first lateral side by the first camera 28 (step S1) and from the second lateral side by the second camera third the (step S2). The measurements from both sides can be performed simultaneously or in an arbitrary order.
- 20
- 25

In particular, the measurements are performed regularly, e.g. with at least 50 Hz.

The measured distances or distance profile is then transmitted to the control unit 16 which receives the results of the distance measurements from the time-of-flight cameras 20 (step S3).

The control unit 16 then determines, based on the distance profiles, whether or not the object O amounts to two persons being present in the controlled passageway 18 that walk side-by-side. Side-by-side meaning that the persons are walking next to each other in the transverse direction T.

For example, the control unit 16 receives the distances profiles as the results of the distance measurement from the cameras 28, 30 and determines in step S4 the size of the object O in the transverse direction T. This may be done in a simple case by assuming that the object has a size in the transverse direction T being the transverse distance between the point closest to the left-hand barrier 12 and the point closest to the right-hand barrier 12.

The control unit 16 may then, in step S5, determine whether or not the object O is two persons walking side-by-side in the controlled passageway 18 by comparing the determined size of the object O in the transverse direction T with a predefined threshold.

If the size of the object O as determined by the control unit 16 is smaller than the predetermined threshold, the control unit 16 decides that no side-by-side tailgating is attempted (Step S6). Thus, in this regard no reasons for closing the automatic door 14 or keeping the door 14 closed are present.

In the next step S7, other requirements for opening the door 14 may be checked by the control unit 16. This may be done previously, simultaneously or after checking for side-by-side tailgating.

For example, the control unit 16 determines, based on a single or a plurality of distance profiles taken at a single point in time or over a certain period of time, the distance between two objects O in the longitudinal direction L of the controlled passageway 18. The distance may be a spatial or a timewise distance.

- 5 If this distance is smaller than a predetermined security distance, in this regard no reasons for closing the automatic door 14 or keeping the door 14 closed are present. The predefined security distance may also depend on the speed of the person passing through the controlled passageway 18.

Further, in step S7, it is also checked, whether or not the automatic door 14 can  
10 be opened safely, for example verifying that no objects are present close to the door leaves 22.

If no side-by-side tailgating is detected, the security distance in the longitudinal direction is kept and the door 14 may be opened safely, the control unit 16 controls the actuators 26 to open the door leaves 22 (step S8). The person can  
15 then freely pass through the detection system 10.

A further requirement for opening the door 14 is also that the person has been authenticated successfully by the access control system, in particular after usage of the reader 21.

In the scenario shown in Figures 4, 5 and 6, however, two persons are  
20 approaching the detection system side-by-side.

Thus, in step S5 it is determined that the size of the object O (being the two persons) is larger than the predetermined threshold. The control unit 16 then determines that there are two persons walking side-by-side in the controlled passageway 18 which is regarded as an attempt of side-by-side tailgating.

25 In response, the control unit 16 and controls the actuators 26 of the automatic door 14 to close the automatic door 14, i.e. the door leaves 22, or to keep the

automatic door 14 (more precisely the door leaves 22) closed (step S9). As a result, the persons attempting to trespass cannot pass the detection system 10.

Further, if the distance between the persons or object in the longitudinal direction L is smaller than the predetermined security distance as determined in  
5 step S7, the control unit 16 also controls the automatic door 14 to close the automatic door 14 or to keep closed the door 14 closed as explained with respect to step S9.

Due to the use of the time-of-flight cameras 20, more information about the object O present in the controlled passageway 18 can be obtained because  
10 distance measurements leading to distance profiles are available. This allows the detection of persons walking side-by-side, i.e. side-by-side tailgating, which could not be determined by the use of light barriers only. Thus, the detection system 10 eliminates a further type of attempt to gain unauthorized access, drastically increasing the security offered by the detection system 10 without  
15 the need for elaborate image recognition.

The same detection may also be carried out using only a single time-of-flight camera instead of a pair of time-of-flight cameras. In this case, however, a time series of distance profiles has to be taken into account to minimize the effects of objects shielding other objects or legs from view, as seen in Figure 6.

20 Figure 8 shows a second embodiment of the detection system 10. The detection system 10 of the second embodiment is substantially identical to the first embodiment, only the height of the cameras 20 and thus of the detection plane 44 differs.

In the second embodiment, the cameras 20 and thus the detection plane 44 is  
25 located at waist height. Waist height may include a range of 70 cm to 100 cm above the ground, i.e. above the bottom of the detection system 10.

It is also conceivable that one of the time-of-flight cameras 20 is located at leg height, whereas another one of the time-of-flight cameras 20 is located at waist height.

Figures 9 and 10 correspond to Figures 5 and 6 of the first embodiment and  
5 show the measured distance profile of the first camera 28 (line 46; Fig. 9) and the distance profiles of the first camera and the second camera 28, 30 (lines 46, 48; Fig. 10). The measured distance profiles differ drastically from the ones of the first embodiment, even though the same situation is depicted. Nevertheless, side-by-side tailgating detection and normal tailgating detection (i.e. measuring  
10 the security distance in the longitudinal direction L) is possible in the same way using the distance profiles shown in Figures 9 and 10.

Figures 11 and 12 a show a third and a fourth embodiment of the detection system 10, wherein the third embodiment of Figure 11 is based on the first  
15 embodiment and the fourth embodiment of Figure 12 is based on the second embodiment.

In the third and fourth embodiment, the fields of view of the respective cameras 20 extent further than the controlled passageway 18 and also cover an area in front of the controlled passageway 18.

Thus, based on the measured distance profiles, it can be determined, whether a  
20 person is approaching the detection system 10, even though the person is outside the controlled passageway 18.

For example, it can be distinguished, whether a person intends to pass through the detection system 10 and is about to enter the controlled passageway 18 or whether this person is cross traffic, i.e. it does not desire to pass through the  
25 detection system 10.

If it has been determined, in particular by the control unit 16, that a person intends to pass through the detection system 10 and is about to enter the controlled passageway 18, one or more actions may be taken by the control unit.

5 The control unit 16 may actuate the automatic door 14 to open so that the person does not have to slow down, allowing a more natural and undisturbed flow of persons. This functionality may be used for allowing persons to leave the secure area into a public area, i.e. exit-situations without the need for checking authorization.

10 Further, if a person has been detected intending to pass through the detection system 10, the control unit 16 may power up identification control systems of the detection system 10 that have been powered down to save energy.

### Claims

1. Detection system comprising an automatic door (14), a control unit (16) for operating the automatic door (14), a controlled passageway (18) in front of the automatic door (14), at least two barriers (12), and at least one time-of-flight camera (20),  
5 wherein the barriers (12) are located on opposite lateral sides of the controlled passageway (18) confining the controlled passageway (18) in between,  
wherein the time-of-flight camera (20) is located at one of the lateral sides of the controlled passageway (18), the field of view (36, 38, 40, 42) of the time-of-flight camera (20) spanning between a transverse border and a longitudinal border, wherein the transverse border extends substantially in the transverse direction (T) across the controlled passageway (18) and the longitudinal border extends substantially in the longitudinal direction (L) along the lateral side of the controlled passageway (18).  
10
- 15 2. Detection system according to claim 1, characterized in that the time-of-flight camera (20) is a laser scanner type camera and/or wherein the field of view (36, 38, 40, 42) has an angle of view of at least 60°, in particular at least 85°, more particularly at least 90°.
- 20 3. Detection system according to claim 1 or 2, characterized in that the field of view (36, 38, 40, 42) is confined in the height direction (H) to a detection plane (44), in particular the detection plane (44) being horizontal.
4. Detection system according to any of the preceding claims, characterized in that the time-of-flight camera (20) is located in the longitudinal direction (L) at the level of the automatic door (14), and/or wherein the time-of-flight camera (20) and/or the field of view (36, 38, 40, 42) are located above the ground at leg height and/or at waist height.  
25
5. Detection system according to any of the preceding claims, characterized in that the automatic door (14) has at least one door leaf (22) mounted movably with respect to the barrier (12) and an actuator (26) for actuating the door leaf

(22), in particular the automatic door (14) having two door leaves (22) mounted to opposite ones of the barrier (12) and two actuators (26).

6. Detection system according to claim 5, characterized in that the automatic door (14) comprises at least one door leaf support column (24) supporting the door leaf (22), wherein the door leaf (22) is movably, in particular rotatably mounted to the support column (24).

7. Detection system according to any of the preceding claims, characterized in that the at least one time-of-flight camera (20) is mounted to the barrier (12), to the support column (24) and/or on top of the support column (24).

8. Detection system according to any of the preceding claims, characterized in that the detection system (10) comprises at least two time-of-flight cameras (20), wherein the first camera (28) of the at least two time-of-flight cameras (20) is located at a first side of the lateral sides of the controlled passageway (18), and the second camera (30) of the at least two time-of-flight cameras (20) is located at the second side, wherein the fields of view (36, 38) of the first camera (28) and the second camera (30) overlap.

9. Detection system according to claim 8, characterized in that the barriers (12) and the controlled passageway (18) extend also at the back of the automatic door (14), wherein the detection system (10) comprises at least four time-of-flight cameras (20), wherein a third camera (32) and a fourth camera (34) of the at least four time-of-flight cameras (20) are arranged at the back of the automatic door (14).

10. Detection system according to any of the preceding claims, characterized in that the control unit (16) is configured to receive results of distance measurements, in particular a distance profile of an object (O) in the controlled passageway (18), from the at least one time-of-flight camera (20), in particular from each of the first camera (28) and the second camera (30) and/or from each of the third camera (32) and the fourth camera (34), and to determine whether

or not two persons are present side-by-side in the controlled passageway (18) based on the received results.

11. Detection system according to any of the preceding claims, characterized in that the control unit (10) is configured to receive results of distance  
5 measurements, in particular a distance profile of an object (O) in the controlled passageway (18), from the at least one time-of-flight camera (20), in particular from each of the first camera (28) and the second camera (30) and/or from each of the third camera (32) and the fourth camera (34), and to determine, based on the received results, whether or not a predetermined security distance in the  
10 longitudinal direction (L) between two persons in the controlled passageway is kept, and/or whether or not the automatic door (14) can be operated, particularly closed, safely.

12. Method for operating an detection system (10) having a controlled passageway (18), in particular an detection system (10) according to any one of  
15 the preceding claims, characterized by the following steps:

- measuring at least one distance profile of an object (O) in the controlled passageway (18) from a first side of a lateral side of the controlled passageway (18), and
- determining, based on the measured distance profile, if the object  
20 (O) is two persons walking side-by-side in the controlled passageway (18).

13. Method according to claim 12 characterized by the following further steps:

- measuring at least one distance profile of an object (O) in the  
25 controlled passageway (18) from a second side of a lateral side of the controlled passageway (18), the second side being opposite to the first side, and

- determining, based on the at least two measured distance profiles, if the object (O) is two persons walking side-by-side in the controlled passageway (18).
14. Method according to claim 12 or 13 characterized by the following further step:
- closing the automatic door (14) of the detection system (10) or keeping the automatic door (14) closed, if it has been determined that two persons are walking side-by-side in the controlled passageway (18).
15. Method according to any of the claims 12 to 14 characterized by the following further steps:
- determining, based on the at least one measured distance profile, whether or not a predetermined security distance in the longitudinal direction (L) between two persons in the controlled passageway (18) is kept, and/or
  - determining whether or not the automatic door (14) can be operated, particularly closed, safely.
16. Method according to any of the claims 12 to 15 characterized by the following further step:
- determining, based on the at least measured distance profile, whether a person outside the controlled passageway (18) is approaching the detection system (10) and intends to pass through the detection system (10),
- wherein the field of view (36, 38, 40, 42) of the at least one time-of-flight camera (20) extends further than the controlled passageway (18).

1 / 5

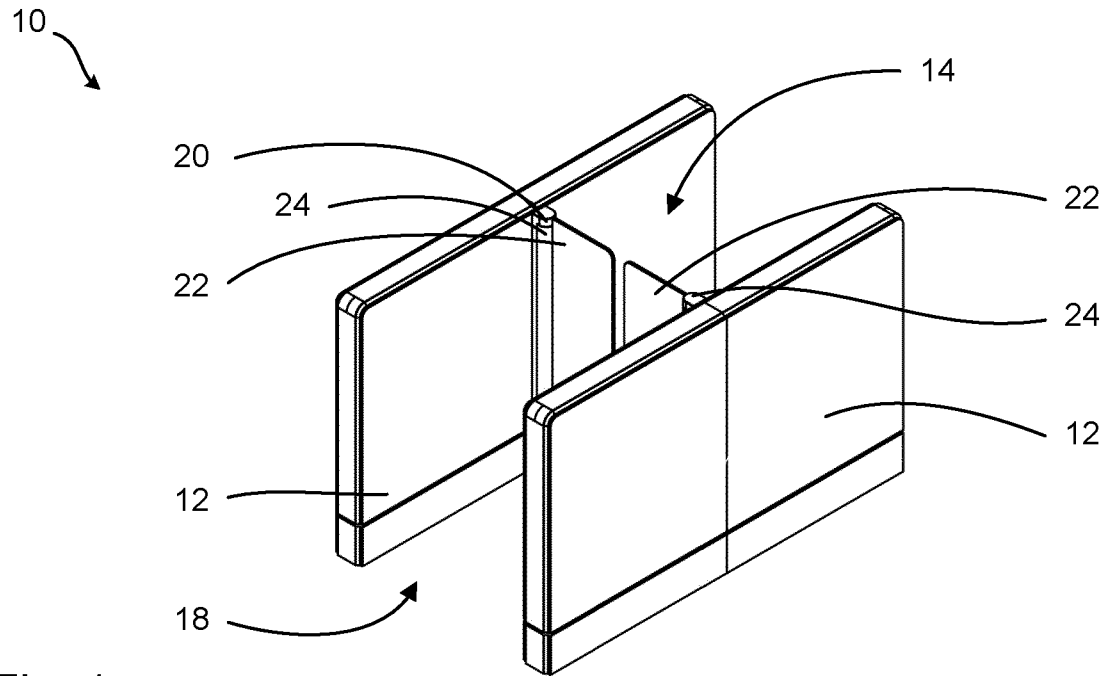


Fig. 1

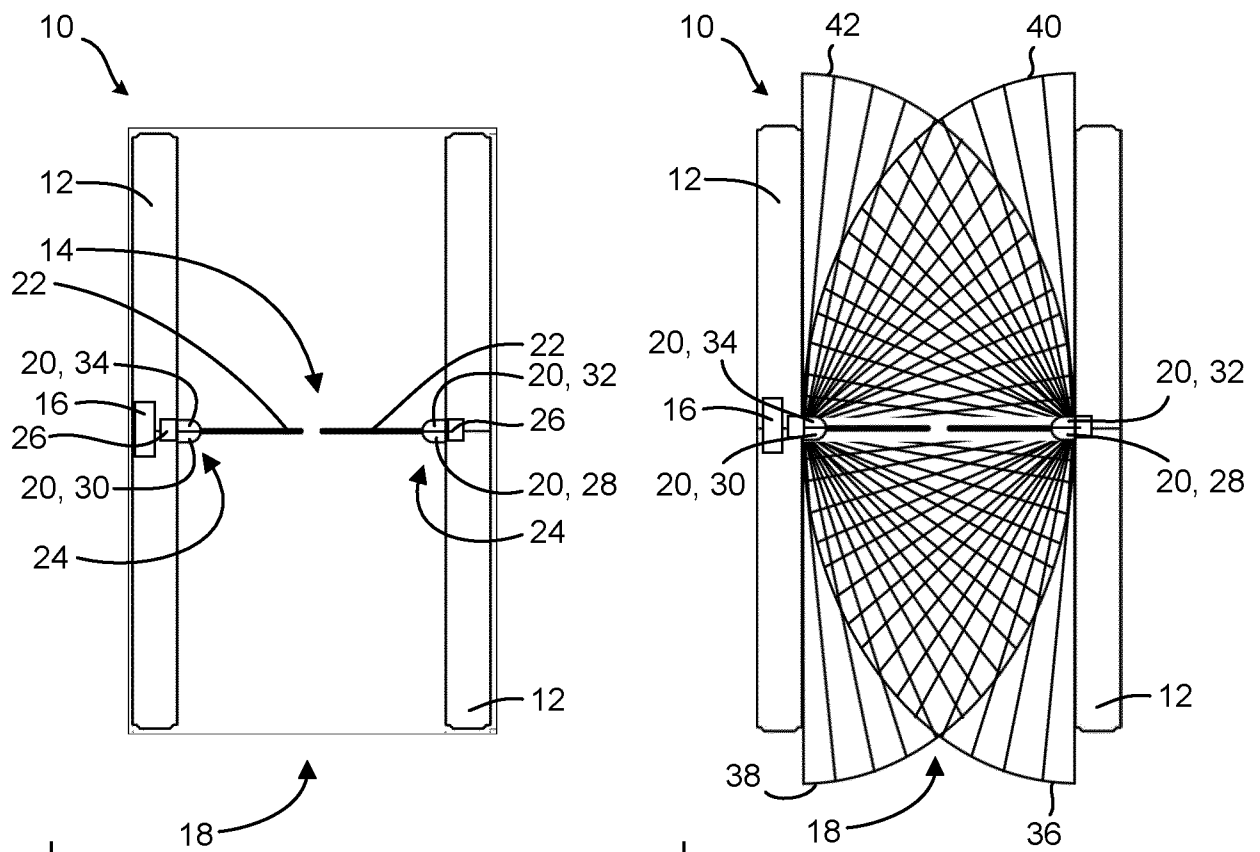


Fig. 2

Fig. 3

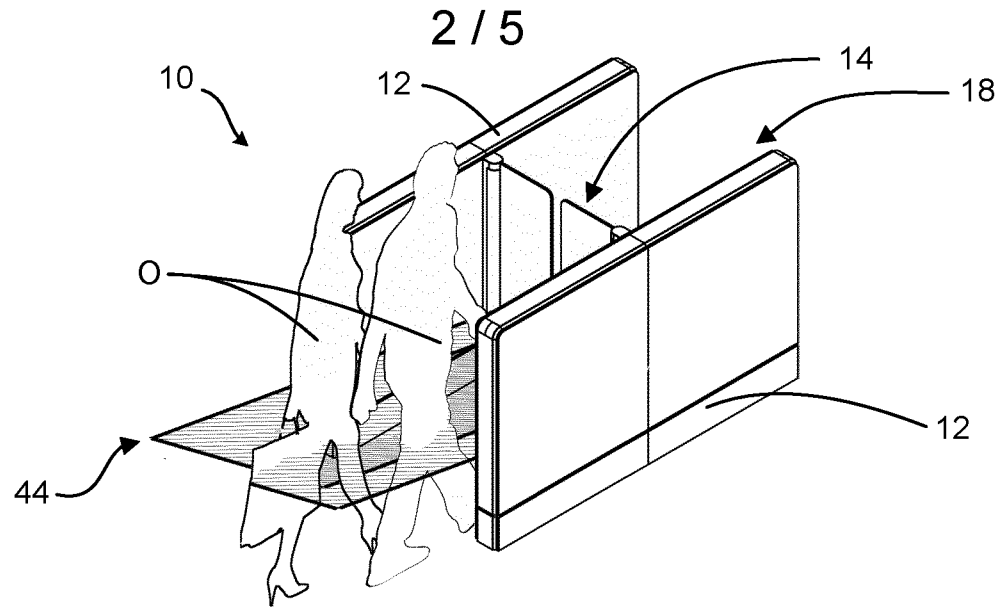


Fig. 4

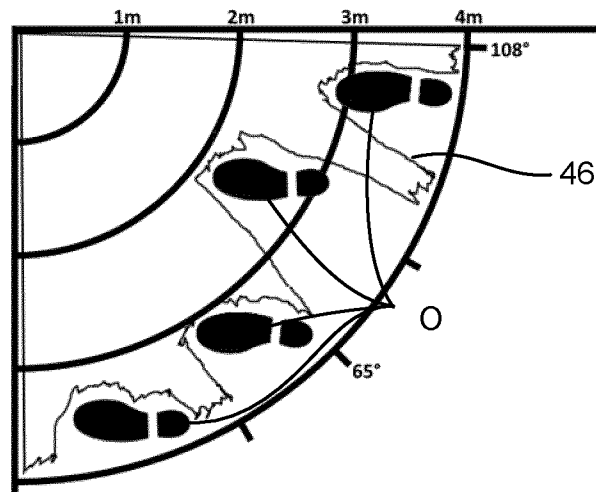


Fig. 5



Fig. 6

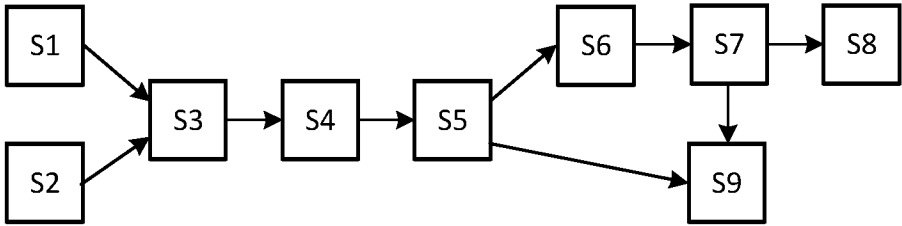


Fig. 7

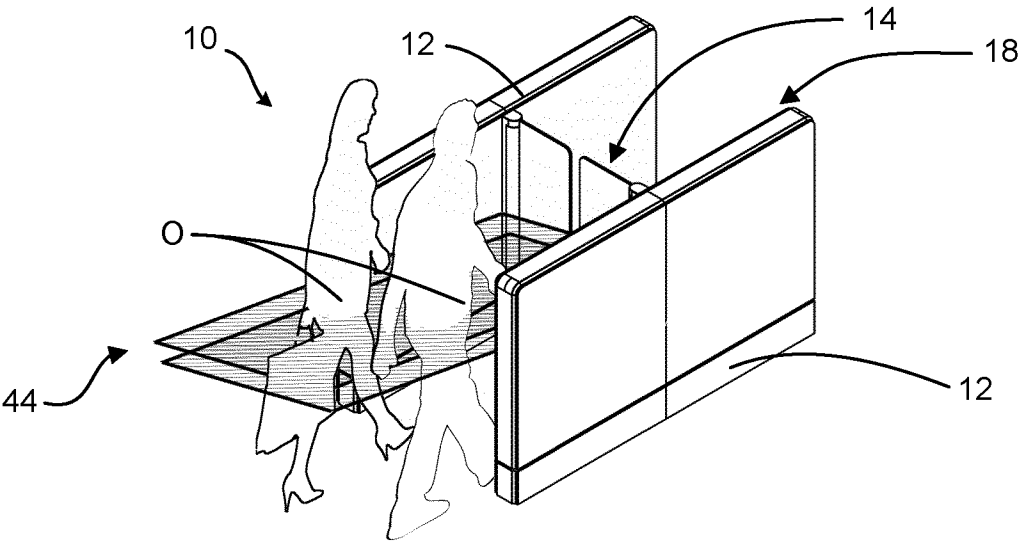
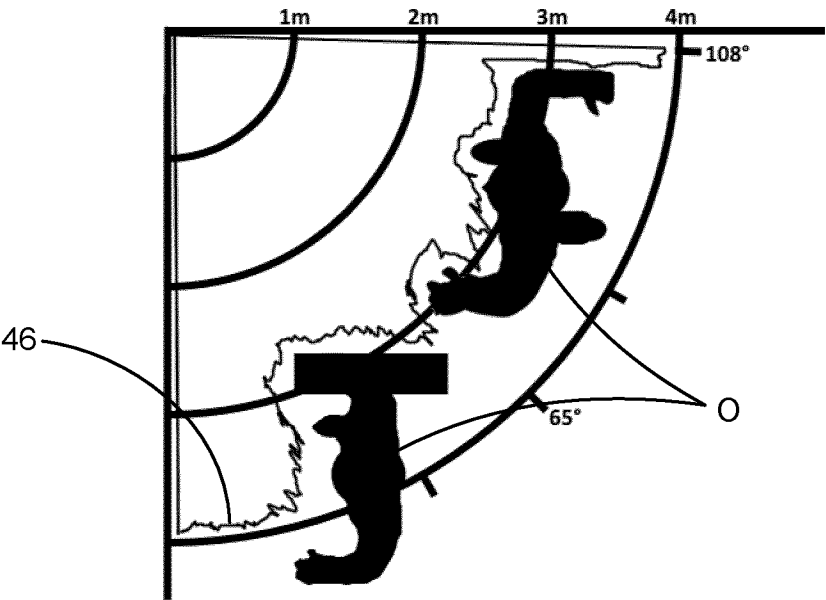


Fig. 8



5 / 5

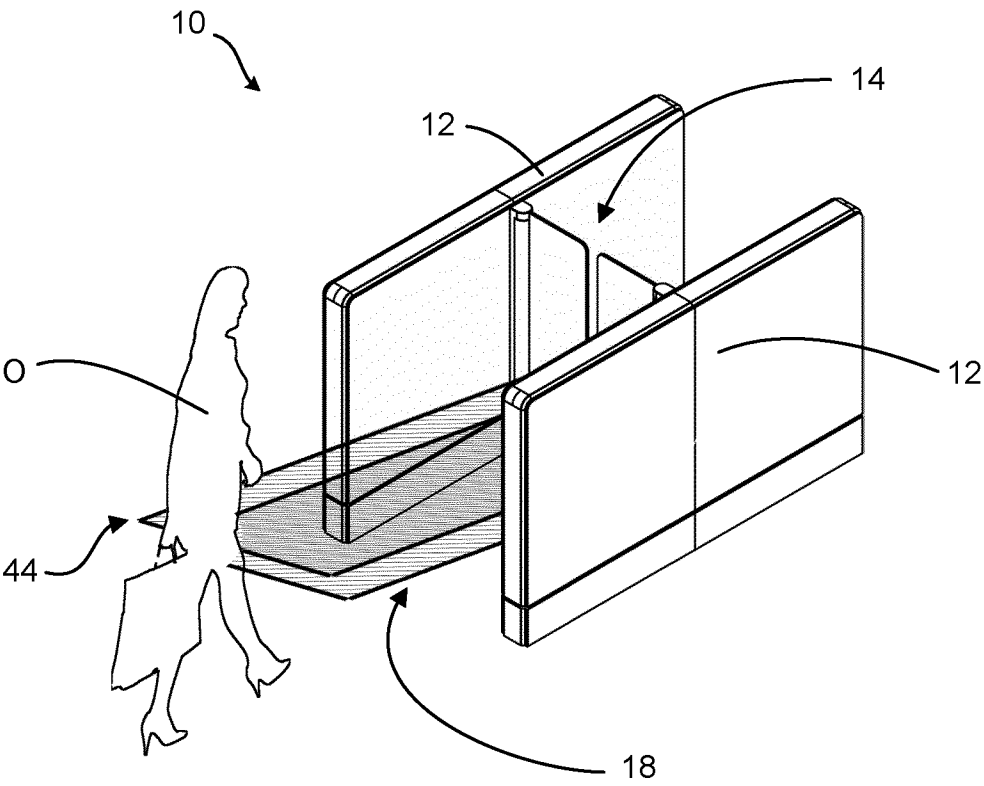


Fig. 11

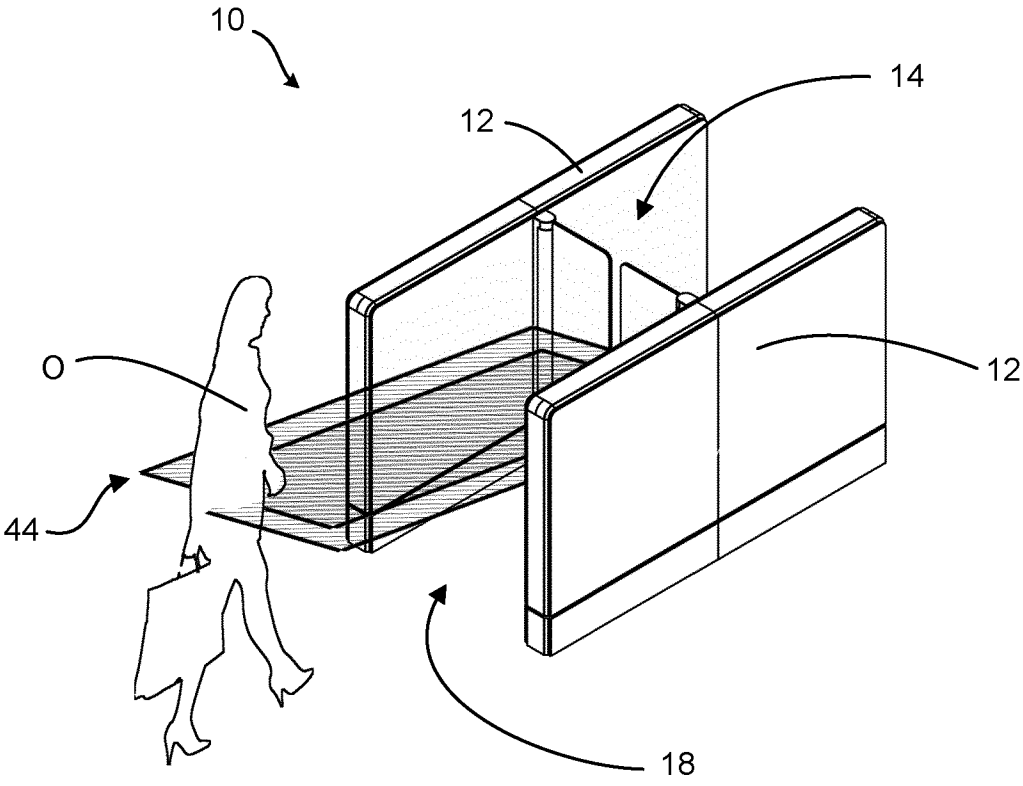


Fig. 12

## INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2023/071704

**A. CLASSIFICATION OF SUBJECT MATTER****INV. G07C9/15****ADD.**

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

**G07C E05F**

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

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

**EPO-Internal****C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                              | Relevant to claim No. |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>X</b>  | <b>US 2022/228419 A1 (TISO MARCO [IT] ET AL)</b><br><b>21 July 2022 (2022-07-21)</b><br><b>abstract; figures 1-6D</b><br><b>paragraph [0004] - paragraph [0071]</b><br>-----                                                    | <b>1-16</b>           |
| <b>X</b>  | <b>US 2020/041688 A1 (HUFF DEREK [GB])</b><br><b>6 February 2020 (2020-02-06)</b><br><b>abstract; figures 1a-5</b><br><b>paragraph [0001]</b><br><b>paragraph [0005]</b><br><b>paragraph [0010] - paragraph [0059]</b><br>----- | <b>1-16</b>           |
| <b>X</b>  | <b>GB 2 549 782 A (INTEGRATED DESIGN LTD</b><br><b>[GB]) 1 November 2017 (2017-11-01)</b><br><b>figures 3-5</b><br><b>page 3, line 27 - page 8, line 2</b><br>-----                                                             | <b>1-9, 11</b>        |
| <b>A</b>  | <b>figures 3-5</b><br><b>page 3, line 27 - page 8, line 2</b><br>-----<br>-/-                                                                                                                                                   | <b>10, 12-16</b>      |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

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Date of the actual completion of the international search

**27 October 2023**

Date of mailing of the international search report

**07/11/2023**

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2

NL - 2280 HV Rijswijk

Tel. (+31-70) 340-2040,

Fax: (+31-70) 340-3016

Authorized officer

**Holzmann, Wolf**

## INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2023/071704

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                            |                       |
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Information on patent family members

International application No

PCT/EP2023/071704

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                                       | Publication<br>date                                                                                          |
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