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(54) **SYSTEM FOR DETECTING THE PRESENCE AND DIRECTION OF A PEDESTRIAN OR CYCLIST MOVEMENT**

(57) The present disclosure relates to a system for detecting movement of a pedestrian or cyclist comprising: a bendable plate for arranging on a pavement; two pressure sensors for detecting bending of the bendable plate under pedestrian or cyclist weight, each said sensor being placed under a distinct region of the bendable plate; a control unit comprising an electronic data processor

configured to detect a pedestrian or cyclist approaching a crosswalk by: receiving pressure signals from said sensors; identifying the direction of the movement of the pedestrian or cyclist by determining which sensor detects bending first. The disclosure also relates to a method for operating a system for detecting movement of a pedestrian or cyclist.

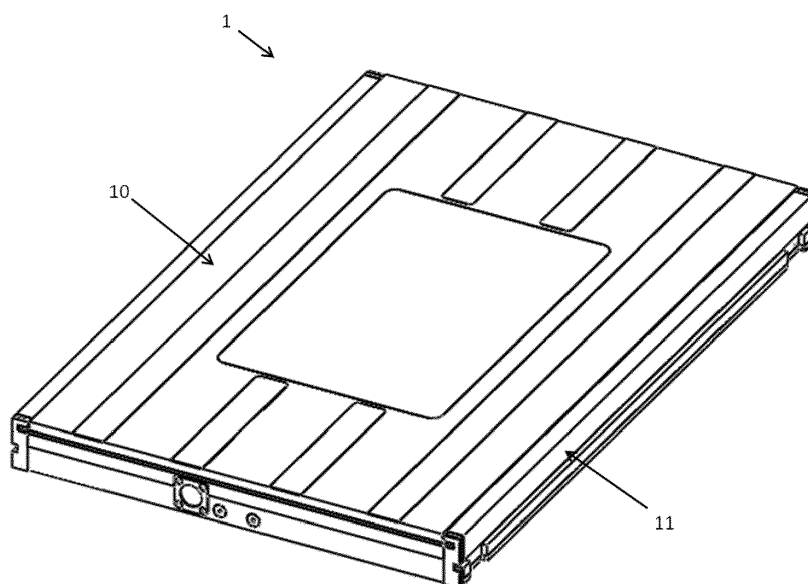


Fig. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to a pedestrian or cyclist crossing warning system. Particularly, it relates to a system to be applied near the pedestrian crossings for the detection of the presence and direction of movement of pedestrians, comprising an integrated control system for light signalling to be used next to the crosswalk, in order to promote road safety. The present disclosure can be applied in the area of road safety, in the management and control of road traffic, and also in the area of equipment, systems and methods for intelligent road signalling and signalling control.

BACKGROUND

[0002] The introduction of safety measures such as the mandatory use of seat belts in automobiles and of helmets in motorcycles, as well as the implementation of limitations to the speed of circulation on different types of roads and on the level of blood alcohol levels have enabled, in the past, to achieve a significant reduction in the number of road accidents. Improvements in the infrastructures and in the vehicles have followed, which also made it possible to make a positive contribution to reducing the number of these accidents. However, over the past few years, the reduction in the numbers associated to road accidents has stagnated and new solutions are needed in order to be able to significantly reduce these accidents to levels close to zero.

[0003] At the urban level, a great part of road accidents directly affects the vulnerable road users, namely pedestrians and cyclists, and the vast majority of these accidents occur on crosswalks, the place defined for these users to cross the road safely.

[0004] The main measures implemented to protect the vulnerable road users on crosswalks are the implementation of speed bumps before the crosswalks, or even the elevation of the crosswalks, so that drivers reduce their vehicles' speed to avoid suffering a considerable impact when crossing these obstacles. However, these measures do not transmit any information to drivers about the presence of pedestrians on the site, or their intention to cross the road, they are simply implemented on the pavement so that the driver reduces the vehicle' speed. Thus, despite having a significant effectiveness in reducing the number of accidents, by reducing the speed of circulation of the place, they do not solve the problem in its entirety, having other associated negative factors, such as the generation of noise pollution, due to the noise generated by the vehicle's interaction with the obstacle, and can also cause injury to the vehicle occupants if they travel at speeds above the permitted, as well as it causes damage to vehicles. Other problems associated with speed bumps are the increased danger of aquaplaning, as they hinder water runoff at the site;

the increase in the atmospheric pollution of the place, as they lead to sudden braking and acceleration, which increases vehicle emissions; and also delays and damages to emergency vehicles, such as ambulances and fire-fighters. For these reasons, these solutions have a low social acceptance and infrastructure managers do not implement them massively.

[0005] Another solution implemented globally is traffic light signs, which allow to manage both car and pedestrian traffic in an orderly manner, defining priorities and controlling who should drive and who should wait, through a set of lights with different colours that allow drivers and pedestrians know what action to take, the colours of the lights being properly regulated by an international road code. This measure is significantly effective, but it does not prevent human error, both from pedestrians / cyclists or from car drivers, and even at road intersections with traffic light signs, road accidents continue to occur, some of them with very negative consequences. The fact that this equipment has high associated costs is also a barrier to its massive application, making it mostly applied in places with a large number of vehicles, and not so much in places of considerable danger for vulnerable users to cross the road.

[0006] Recently, with the aim of signalling places such as crosswalks, the concept of road markers was developed, initially with a backlight system to reflect the light coming from vehicles and thus become visible, especially at night, thus creating a warning for vehicle drivers; and more recently, these road markers have started to incorporate their own lights, mostly using LED technology, allowing them to increase their effectiveness as a measure of horizontal signalling of different locations, including crosswalks.

[0007] It were also developed some solutions to control the lighting of these road markers, based on the detection of pedestrians by cameras, laser sensors, infrared sensors, or sensors for determining distance by sound, or even activation by pressing a manual button, such as disclosed in patent documents EP1775692, EP2141676, US6384742 and US2020/0199832. However, the systems presented in these patent documents typically lack the full detection of movement of pedestrians, not detecting if they are actually entering the crosswalk, which means that road markers are continuously switched on, whenever a pedestrian is detected on the spot, leading to a lack of trust from the drivers when they see the road markers turned on, lowering the efficiency of the solution, and also leading to a high energy inefficiency, spending more electricity than is actually needed to promote pedestrian safety. These solutions also lack control of road markers, alerting the drivers of vehicles that are approaching the crosswalk about the movement of the pedestrian, which would allow to increase the level of driver alertness and to maximize pedestrian safety.

[0008] From the analysis of existing solutions, it appears that none of it performs a full detection of movement of pedestrians, in order to detect when a pedestrian

is or intends to enter the crosswalk, in order to control road signalling devices depending on the movement of the pedestrian, and none of it detects the type of movement of the pedestrian - if it is walking slowly, normally, fast, or even stopped near the crosswalk entrance.

[0009] It is concluded from this analysis that there are gaps in the area of road safety on crosswalks, namely in the correct identification of the pedestrian patterns near crosswalks, which would allow to signal the presence of pedestrians when they intend or are crossing the crosswalk, and also in solutions that can implement light effects on road signalling devices in order to communicate effective messages through such visual effects to vehicle drivers.

[0010] These facts are disclosed in order to illustrate the technical problem addressed by the present disclosure.

GENERAL DESCRIPTION

[0011] The present disclosure allows to detect both the presence of pedestrians or cyclists and their movement direction, as well as the type of movement (if it is walking slowly, normally, fast, or even momentarily stopped near the crosswalk entrance), which allows to effectively control the activation of road safety solutions, with a control that maximizes road safety, through greater efficiency in signalling pedestrians and improving the interaction with vehicle drivers, as well as optimizing the energy consumption of the place, by adjusting the lighting time to the type of movement of the pedestrian.

[0012] Road accidents are a major cause of death worldwide and vulnerable road users, such as pedestrians and cyclists, are among the most affected groups. One of the places where there is a large number of accidents involving these road users is pedestrian crossings and one of the main causes of these accidents is the poor visibility of these users or, sometimes, their complete lack of visibility by the drivers.

[0013] One of the objectives of the present disclosure is to create a system to be applied next to pedestrian crossings, more specifically on the sidewalk, with the objective of detecting the presence and direction of movement of pedestrians, in order to identify when a pedestrian is moving in the direction of the pedestrian crossing adjacent to the system, as well as the type of movement of the pedestrian: if it is a slow, normal, fast, or if it is stopped. Depending on the detection carried out, the system can be integrated with road safety equipment such as road light signalling devices, vertical signalling, traffic lights or crosswalk lighting, creating light alerts in order to alert the drivers of vehicles that approach the crosswalk about the presence of pedestrians, who may be entering or even moving on the crosswalk, increasing road safety in these places.

[0014] The present disclosure is useful to promote the safety of pedestrians on crosswalks, as well as of other vulnerable road users such as cyclists, working integrat-

ed with other safety equipment existing on the place, such as traffic light signs or road markers, with the main advantage of reducing the number of pedestrians being run over by vehicles in these areas, which translates into a reduction in road accident rates, a reduction in the number of deaths and serious injuries and, ultimately, a reduction in the social and economic impact that these accidents have on society.

[0015] One of the applications of this solution is on pedestrian pavements or sidewalks, next to pedestrian crossings, in order to detect the presence of pedestrians moving towards the entrance of the crosswalk through specific sensors, and, based on this information, to control light signalling devices applied next to the crosswalk, both on the road and vertically, with a duration equivalent to the estimated time that the pedestrian takes to cross the crosswalk, based on the pedestrian movement, giving them a greater visibility and protection.

[0016] Another application of this disclosure relates to its integration with smart city solutions, performing the count of pedestrians on the place, not only in relation to the number of pedestrians passing by, but also on the type of movement of pedestrians, allowing to increase the knowledge of pedestrian circulation patterns of the place and, as a result, adjust the safety conditions of the place.

[0017] The present invention relates to a system for detecting the presence and direction of movement of pedestrians to be applied on sidewalks along pedestrian crossings, and a control unit to operate light signalling systems, in order to promote pedestrian safety in these places, as well as other road users, such as cyclists.

[0018] In an embodiment, the system for detecting the presence and movement of pedestrians comprises a device applied at the level of the sidewalk, near the entrance or the beginning of the crosswalk, which comprises a bendable surface, preferably a bendable plate, which undergoes a small displacement when pressed by a person, a bicycle, or another similar load, or higher, that acts on it, and that has a set of pressure sensors on its bottom, which are pressed against a base composed of a resilient material, so as not to be damaged by excessive loads, but with the ability to exercise a sufficient load on the sensors to press them. These pressure sensors are arranged in a matrix, at different points on the bendable plate, in order to be activated at different times, depending on the profile of the load acting on the surface. The pressure sensors are connected to control unit comprising an electronic board with a microcontroller embedded, placed inside the support structure, and depending on the sequence of signals from the pressure sensors, the microcontroller identifies the direction of movement of the load acting on the surface. Whenever the direction of movement is towards the crossing entrance, the microcontroller sends a digital message to a central control unit, in order to signal the presence of a pedestrian towards the crossing entrance; if it detects that the pedestrian is moving in a direction other than the crossing en-

trance, it does not send any message to the central control unit, or sends a message indicating that the movement of the pedestrian is in a different direction from the crossing entrance. Besides detecting the direction of movement of the pedestrian, by reading the signals from the pressure sensors, the microcontroller can also measure the type of movement of the pedestrian, classifying it as "slow", "normal", "fast" or "stopped", by the difference between the activation time of the different sensors.

[0019] This device also comprises a set of springs inside, used to restore the bendable plate to its initial position after the end of the application of a load on it. These devices can be applied directly on the sidewalk, or applied in any structure selected from a metallic, polymeric or concrete structure, preferably a metallic structure, which is embedded and fixed in the sidewalk. Each pedestrian detection system has two electrical connections, one at each end, which allows the connection between different systems by direct connection, transmitting data and power to each other, thus allowing only one plug to connect to the pedestrian detection system that it is at one end of a sequence of multiple systems.

[0020] In an embodiment, the central control unit is an electronic board with a microcontroller embedded, which receives messages from multiple pedestrian detection systems, on one or both sides of the crosswalk, and it is prepared to send messages to light signals, which can be applied on the road or in vertical signalling equipment. These messages allow the creation of luminous effects, which in turn transmit visual alert messages to the drivers of vehicles that approach the crossing, and can indicate in which side of the crossing the pedestrian (or more) is entering (or has already entered) and for which side he is moving, these effects having a duration equivalent to the time it takes the pedestrian to cross each road lane, being thus variable (and programmable) depending on the number of lanes. If pedestrians are detected entering both sides of the crosswalk, the control of the luminous effect can be adjusted so that the effect transmits this information to the drivers of the vehicles. The central control unit also has a light sensor connection, in order to adjust the light intensity of the light signals, and the connection to a noise emitter, in order to alert pedestrians. It also comprises connections to external equipment by radiofrequency in order to receive information from external sensors, and by long-range wireless communication protocols, to be able to communicate with other equipment or even to send data to an external database. The control unit can be applied either on the sidewalk, next to the pedestrian sensors, or near the crosswalk selected from a vertical signal near the crosswalk, or in an electrical cabinet near the crosswalk.

[0021] The present disclosure relates to a system for detecting movement of a pedestrian or cyclist comprising:

- a bendable plate for arranging on a pavement;
- two pressure sensors for detecting bending of the

bendable plate under pedestrian or cyclist weight, each said sensor being placed under a distinct region of the bendable plate;

a control unit comprising an electronic data processor configured to detect a pedestrian or cyclist approaching a crosswalk by:

- receiving pressure signals from said sensors;
- identifying the direction of the movement of the pedestrian or cyclist by determining which sensor detects bending first.

[0022] In an embodiment, the system further comprises a support bar for limiting the bending of the bendable plate, which is arranged between the two sensors to separate said distinct regions of the bendable plate.

[0023] In an embodiment, the system comprises at least one spring fixed on the support bar, for restoring an unbent state of the bendable plate.

[0024] In an embodiment, the system comprises a display connected to the control unit, wherein the control unit is configured to display a warning signal in said display for vehicle drivers indicating the direction of the movement of the pedestrian or cyclist.

[0025] In an embodiment, the electronic data processor is further configured to:

if, after determining that a first sensor of the two pressure sensors has firstly detected bending, and that a second sensor of the two pressure sensors does not detect bending within a predetermined period of time, then determining the direction of the movement as uncertain.

[0026] In an embodiment, the electronic data processor is further configured to:

if, after determining that a first sensor of the two pressure sensors has firstly detected bending, and that a second sensor of the two pressure sensors has secondly detected the bending, then determining the direction of the movement as entering a crosswalk; otherwise, if the second sensor has firstly detected bending and that the first sensor has secondly detected bending, then determining the direction of the movement as exiting the crosswalk.

[0027] In an embodiment, the system comprises protuberant stoppers for supporting the pressure sensor when the bendable plate is bent onto the pressure sensor by the pedestrian or cyclist.

[0028] In an embodiment, the number of protuberant stoppers is the same as the number of pressure sensors.

[0029] In an embodiment, the protuberant stoppers are coated with a flexible material, preferably selected from rubber, cork or foam.

[0030] In an embodiment, the bendable plate comprises four pressure sensors arranged in a matrix and equidistant from the support bar, for perpendicular movement detection of the pedestrian or cyclist.

[0031] In an embodiment, the system comprises a sup-

port structure comprising a base and two parallel side-walls each with a recess for receiving the bendable plate, wherein edges of the bendable plate are inserted in the recesses.

[0032] In an embodiment, the bendable plate is made of polymer or metal or combination thereof.

[0033] In an embodiment, the display means are light signals, preferably horizontal signs, vertical signs or traffic lights.

[0034] Another aspect of the invention relates to a method for operating a system for detecting movement of a pedestrian or cyclist, said system comprising:

a bendable plate for arranging on a pavement;
two pressure sensors for detecting bending of the bendable plate under pedestrian or cyclist weight, each said sensor being placed under a distinct region of the bendable plate;
a control unit comprising an electronic data processor;

said method comprising using said electronic data processor for detecting a pedestrian or cyclist approaching a crosswalk by:

receiving pressure signals from said sensors;
identifying the direction of the movement of the pedestrian or cyclist by determining which sensor detects bending first.

[0035] In an embodiment, the method for identifying the direction of the movement of the pedestrian or cyclist by the electronic data processor carrying out the following steps:

if, after determining that a first sensor of the two pressure sensors has firstly detected bending, that a second sensor of the two pressure sensors does not detect bending within a predetermined period of time, then determining the direction of the movement as uncertain;

otherwise if, after determining that the first sensor has firstly detected bending, the second sensor has secondly detected bending, then determining the direction of the movement as entering a crosswalk;

otherwise, if the second sensor has firstly detected bending and the first sensor has secondly detected bending, then determining the direction of the movement as exiting the crosswalk.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The following figures provide preferred embodiments for illustrating the disclosure and should not be seen as limiting the scope of invention.

Figure 1: Schematic representation of an embodiment of the warning system for detecting the presence and pedestrian direction movement **1**, trimetric view in which **10** represents a plate or cover of the assembly, which comprises a bendable surface that deforms when actuated by a load; and **11** represents the support structure of the plate **10**, in which it is embedded, this structure being applied embedded in the pedestrian pavement.

Figure 2A: Schematic representation of an embodiment of the structure having two protuberant stoppers **19** for two pressure sensors, where the cover support structure **11** of the system for detecting the presence and direction of movement of pedestrians **1**, trimetric view in which **13** represents the side wall of the cover support structure **11** of the pedestrian detection system **1**, having two elements **13**, each on an opposite side of the structure, and in which the bendable plate **10** is recessed in to avoid side movements; **14** represents the lateral top of the structure **11**, with two elements of these in one structure **11**, one on each opposite side, and on which the cover **10** is resting so that there is no movement on its sides; **15** represents an electrical plug for data and power transmission, preferably of the female type; **16** represents the base of the structure **11**; **17** represents a bar applied on the base, which serves as a limit for the movement of the cover plate **10**; **18** represents a spring to restore the position of the bendable plate **10** after the load has left the surface; **19** represents a column applied on the base plate **16**, which serves as a stop to the pressure sensors applied under the bendable plate **10**; **20** represents a male plug for data and power transmission; **21** represents a rubber applied on the top of the part **14**, on which the bendable plate **10** rests, in order to guarantee the isolation of the interior of the system **1**; and **22** represents the electronic board with a microcontroller embedded, to which the pressure sensors applied under the bendable plate **10** are connected.

Figure 2B: Schematic representation of an embodiment of the structure having four protuberant stoppers **19** for four pressure sensors, where the cover support structure **11** of the system for detecting the presence and direction of movement of pedestrians **1**, trimetric view in which **13** represents the side wall of the cover support structure **11** of the pedestrian detection system **1**, having two elements **13**, each on an opposite side of in the structure, and in which the bendable plate **10** is recessed in to avoid side movements; **14** represents the lateral top of the structure **11**, with two elements of these in one structure **11**, one on each opposite side, and on which the cover **10** is resting so that there is no movement on its sides; **15** represents an electrical plug for data

and power transmission, preferably of the female type; **16** represents the base of the structure **11**; **17** represents a bar applied on the base, which serves as a limit for the movement of the bendable plate **10**; **18** represents a spring to restore the position of the cover plate **10** after the load has left the surface; **19** represents a column applied on the base plate **16**, which serves as a stop to the pressure sensors applied under the bendable plate **10**; **20** represents a male plug for data and power transmission; **21** represents a rubber applied on the top of the part **14**, on which the bendable plate **10** rests, in order to guarantee the isolation of the interior of the system **1**; and **22** represents the electronic board with a microcontroller embedded, to which the pressure sensors applied under the bendable plate **10** are connected.

Figure 3: Schematic representation of an embodiment of the cover **10** of the system for detecting the presence and direction of movement of pedestrians **1**, trimetric view from the top on which **110** represents the main bendable plate **10** of the system **1**; **111** represents a plurality of strips of non-slip material, in order to prevent the foot of a pedestrian (or a bicycle wheel) from slipping in case the bendable plate **10** has water; and **112** represents a secondary plate or a display to transmit a message to pedestrians or cyclists, in order to properly sign/identify the device **1**.

Figure 4A and Figure 4B: Schematic representation of an embodiment of the cover **10** of the system for detecting the presence and direction of movement of pedestrians **1**, trimetric view from the bottom in which **24** represents a stopper for the spring **18**, so as not to damage the lower part of the cover **110**; **101** to **106** represent pressure sensors, applied on the bottom of the bendable plate **10**. In Figure 4A an embodiment with two pressure sensors is presented, with a first sensor **101** applied on the side opposite the crosswalk and second sensor **102** applied on the side of the crosswalk. In Figure 4B a version with four pressure sensors is shown, with a first **103** and second **105** sensors applied on the opposite side to the crosswalk and the third **104** and fourth sensors **106** applied on the side of the crosswalk.

Figure 5: Schematic representation of an embodiment of the bendable plate **10** of the system for detecting the presence and direction of movement of pedestrians **1**, with an integrated solar cell system, in which **113** represents a solar cell, arranged along the main cover plate **110**.

Figure 6: Schematic representation of an embodiment comprising a set of systems for detecting the presence and direction of movement of pedestrians

1 applied next to a crosswalk on a two-way road, in which **1** represents a system for detecting the presence and movement of pedestrians; **2** represents a crosswalk; **3** represents the sidewalk, on one side of the road; **4** represents the sidewalk, on the opposite side of the road from **3**; **5** represents a road lane, in the direction of circulation A; **6** represents a road lane, in the direction of circulation B, opposite **5**.

Figure 7: Schematic representation of a section side view of an embodiment where a pedestrian's foot pass over the system **1**, bending the cover (**10**) in which **99** represents the pedestrians' foot passing over the system **1**, **10** represents the bendable plate and **11** represents the plate support structure.

Figure 8: Graphic representation of the digital output of the sensors through time, with the output signal of the pressure sensors **101** and **102** embedded in the bendable plate **10** of the system **1**, when a pedestrian passes by in which **91** represents the output of sensor **101** when a pedestrian passes over the cover **10** of the system **1**, and **92** represents the output of sensor **102** when a pedestrian passes over the bendable plate **10** of the system **1**. The X axis represents time, in seconds / 100, and the Y axis represents the digital output of the sensors.

Figure 9: Graphic representation with the output of the pressure sensors **101** and **102** embedded in the bendable plate **10** of the system **1**, when a pedestrian passes by, for different types of movement in which **91** and **92** have the same meaning as in Figure 8. Figure 9A shows the output of a first pressure sensor **101** and a second pressure sensor **102** for a type of pedestrian movement considered "normal"; Figure 9B shows the output of a first pressure sensor **101** and a second pressure sensor **102** for a type of pedestrian movement considered "fast"; Figure 9C shows the output of first pressure sensor **101** and a second pressure sensor **102** for a type of pedestrian movement considered "slow"; and Figure 9D shows the output of a first pressure sensor **101** and a second pressure sensor **102** for a type of movement of a pedestrian considered "slow" followed by a stop over the bendable plate **10** of the system **1**.

Figure 10: Schematic representation of an embodiment of the control unit **400** of the system **1** comprising a plurality of plugs on which **401** represents an electronic board; **402** represents a microcontroller; **403** represents a plug on the electronic board for connection to a set of systems for detection of pedestrians movement **1** to be applied on the sidewalk **3**; **404** represents a plug on the electronic board for connection to a set of systems for detection of pedestrians movement **1** to be applied on the sidewalk **4**; **405** represents a plug on the electronic board for

connection to light signals; **406** represents a plug on the electronic board for connection to a brightness sensor; **407** represents a plug on the electronic board for connection to a noise emitter; **408** represents a radio frequency communication module; **409** represents a long distance wireless communication module, which can be materialized by a LoRa, Zig-Bee, NB-IOT, 3G / 4G / 5G, or other similar module.

Figure 11: Schematic representation of an embodiment of a set of systems for detecting the presence and direction of movement of pedestrians **1** applied next to a crosswalk on a two-way road, connected to a set of illuminated road signalling devices in which **500** represents a light signal device for application on the road pavement.

Figure 12: Schematic representation of an embodiment of a set of systems for detecting the presence and direction of movement of pedestrians **1** applied next to a crosswalk on a two-way road, connected to a set of vertical signs in which **501** represents vertical sign.

Figure 13: Schematic representation of an embodiment of a set of systems for detecting the presence and direction of movement of pedestrians **1** applied next to a crosswalk of a two-way road, connected to a traffic light on which **502** represents a traffic light.

Figure 14: Schematic representation of an embodiment of the system integrated with a crosswalk signalling solution in a two-lane road, in which **200** represents a set of systems for detecting the presence and pedestrian direction movement **1**, applied in the left side of the crosswalk **2**; **201-204** represents an individual unit of a system **1** for detecting the presence and pedestrian direction movement, specific to the left side of the crosswalk **2**; **210** represents a set of systems **1** for detecting the presence and pedestrian direction movement applied to the right side of the crosswalk **2**; **211-214** represents an individual unit of a system **1** for detecting the presence of a pedestrian and the direction movement, specific to the right side of the crosswalk **2**; **220** represents an electric connection between the first system for detecting the presence and pedestrian direction movement **204** on the left side of the crosswalk **2** and the control unit **400**; **221** represents the electric connection between the first system for detecting the presence and pedestrian direction movement **214** on the right side of the crosswalk **2** and the control unit **400**; **300** represents a set of road signalling devices applied at one end of the crosswalk **2** in a two-lane road; **301-306** represents a specific road signalling device at one end of the crosswalk **2** that fill the width of the first road lane; **311-316** representing a specific road signalling device at one end of the crosswalk **2**

that fill the width of the second road lane; and **222** represents the electric connection between the first road signalling device **301** at one end of the crosswalk **2** and the control unit **400**.

DETAILED DESCRIPTION

[0037] The present invention relates to a system **1** for detecting the presence and direction of movement of pedestrians near pedestrian crossings and for the control of light signalling, whenever it is detected that a pedestrian is moving in the direction of the pedestrian crossing. This system consists of a bendable plate (**10**) that bends with the passage of a pedestrian, applied at the pavement level, built into a support structure **11** and with multiple built-in pressure sensors, whose actuation sequence allows to accurately detect the direction of movement of a pedestrian moving on this surface. The present invention is useful to promote road safety, namely to control pedestrian signalling solutions when they are moving into or crossing a pedestrian crossing, alerting vehicle drivers to the presence of pedestrians and their movement direction.

[0038] The warning system consists of a bendable surface, preferably a bendable plate, applied at the level of the pavement (sidewalk), which is embedded in a support structure that is integrated with the pedestrian pavement. This bendable plate comprises a plurality of pressure sensors embedded in the structure, whose sequence of action allows detecting the direction of movement of the pedestrian moving over it.

[0039] It is disclosed a warning system **1** for detecting the presence and direction of movement of pedestrians near crosswalks **2**, to be applied in one sidewalk, **3** or **4**, or on both sidewalks **3** and **4**. This warning system **1** comprises of a bendable plate **10** deformable by the passage of a pedestrian, preferable from a bendable material, applied at the level of the pavement, embedded in a support structure **11** and with a plurality of built-in pressure sensors, whose sequence of actuation allows to detect with precision the direction of movement of a pedestrian moving on its surface and the type of movement (slow, normal, fast or stopped).

[0040] The bendable plate **10** is applied at the pavement level and undergoes a bending when activated by a person's foot (or by a load greater than 7 kg) - the maximum deformation of the plate is 3 mm, in the central zone, which is achieved with a load equal to or greater than 20 kg. This deformation has a low value, so as not to induce discomfort to pedestrians or cyclists, when passing over it.

[0041] In an embodiment, the system is activated with a load greater than 7 kg which allows that the system does not activate when there are some vibrations nearby, hail falling or some animals are passing.

[0042] The bendable plate **10** is recessed on two sides of the support structure **11**, in order to guarantee that the maximum deformation occurs in the central area of the

plate **10**, regardless of the point where the load is applied. At the two tops **14** of the support structure **11**, adjacent to its sides **13**, the bendable plate **10** is resting. The bendable plate **10** is joined on the sides **13** of the structure, which allow the bending of the plate.

[0043] Below the bendable plate **10** of the system **1**, at least one spring **18** is applied, preferable three, embedded in a support bar **17** applied in the central area of the plate, which allow: i) to stabilize the surface in a flat position; ii) prevent surface vibrations such as wind, rain, pavement vibrations (with the passing of cars or even small earthquakes), among other phenomena; iii) regulate the displacement of the surface depending on the applied load (with loads up to 7 kg only allows the displacement of the cover by 1mm, with loads up to 14 kg only allows the displacement of the cover up to 2mm, and with loads up to 20 kg only allows the cover displacement up to 3mm); iv) and return the surface of the bendable plate **10** to the initial position, after the load has been applied.

[0044] Below the bendable plate **10** of the system **1** a bar **17** of solid material is applied, covered by a film of a flexible material, which allows limiting the displacement of the bendable plate **10**. This bar **17** is applied in order to have its surface with the highest level at a distance of 3 mm from the bottom level of the plate **10**, which allows limiting the maximum displacement of the cover, depending on this distance. On top of the solid material, a film of resilient material, preferably of low thickness, preferably 3 mm, such as rubber, cork, sponge, or similar, is applied, which minimizes the impact of the surface against the bar, as well as eliminating the noise of this impact, minimizing pollution noise of the equipment and the feeling of discomfort when passing over it.

[0045] In an embodiment, on the bottom side of bendable plate **10**, at least two pressure sensors **101**, **102** are used, applied at opposite points of the plate, in the direction of the plate deformation. Preferably the number of sensors is four **103**, **104**, **105** and **106** arranged in a matrix, equidistant from the centre of the plate. Under each pressure sensor, and at a distance of 2 mm, a protuberance **19**, preferably a column, is placed, made of a solid material, covered with a film of a resilient material of low thickness, such as rubber, cork, foam, or similar. When the bendable plate **10** is actuated by loads lower than 14 kg, the plate only moves 2 mm, and the pressure sensors **23** do not come into contact with the column **19** or, at the limit, are leaning against the column **19** without being under pressure, which means that the sensors do not detect the pressure exerted on them. When the load is higher than 14kg, the surface **10** has a displacement above 2mm and the pressure sensors are pressed against the protuberant stoppers **19** - more specifically, against the flexible part, applied purposely so as not to crush the sensor, allowing the respective sensor to detect a load on plate **10**. Preferably, the protuberant stoppers are columns.

[0046] The two **101**, **102** or four **103**, **104**, **105**, **106**

pressure sensors are connected to a microcontroller implemented in an electronic board **22**, and from the measurements made by these sensors, a method is used to detect whether the pedestrian is moving in the direction of the crosswalk or not, as presented following.

[0047] In an embodiment, when two pressure sensors **101**, **102** are applied:

- If the first pressure sensor **101** is activated first and, if within a short period of time defined in the method the second pressure sensor **102** is activated, it is determined that the pedestrian is moving in the direction the crosswalk; if the second pressure sensor **102** is not activated within the prescribed time, the status "uncertain" is determined because the movement is uncertain;
- If the second pressure sensor **102** is activated first and, if within a short period of time defined in the method, first pressure sensor **101** is activated, it is determined that the pedestrian is moving in the exit direction of the crosswalk; if first pressure sensor **101** is not activated within the prescribed time, the status "uncertain" is determined.

[0048] In an embodiment, when four pressure sensors **103**, **104**, **105** and **106** are applied:

- If the first pressure sensor **103** is activated first and if within a short time defined in the method, the next sensor to be activated is pressure sensor **104** or pressure sensor **106**, it is determined that the pedestrian is moving in the direction of the crosswalk; however if the next sensor to be activated is the pressure sensor **105**, it is determined that the pedestrian is not moving in the direction of the crosswalk **2**; if there is no other pressure sensor to be activated within this time, the status "uncertain" is determined;
- If the pressure sensor **105** is activated first and, within a short time defined in the method, which is less than 1 second, the next sensor to be activated is pressure sensor **104** or pressure sensor **106**, it is determined that the pedestrian is moving in the direction of the crosswalk; if the next sensor to be activated is pressure sensor **103**, it is determined that the pedestrian is not moving in the direction of the crosswalk **2**; if there is no other pressure sensor to be activated within this time, the status "uncertain" is determined;
- If the pressure sensor **104** is activated first and, within a short time defined by the control unit in the method, the next sensor to be activated is pressure sensor **103**, **105** or **106**, it is determined that the pedestrian is not moving in the direction of the crosswalk **2**; if there is no other pressure sensor to be activated within this time, the status "uncertain" is determined;

- If the pressure sensor **106** is activated first and, in a short time defined by the control unit in the method, the next sensor to be activated is pressure sensor **103**, **104** or **105**, it is determined that the pedestrian is not moving in the direction of the crosswalk **2**; if there is no other pressure sensor to be activated within this time, the status "uncertain" is determined.
- When the status "uncertain" is determined, and in order to give priority to the pedestrian, it can be defined in the control unit method by an electronic board comprising a microcontroller **22** that the pedestrian intends to enter the crosswalk **2**.

[0049] The term "uncertain" means that it is not possible to determine the direction of the movement of the pedestrian or the cyclist. It is considered an inconclusive movement which is an uncertain direction.

[0050] In an embodiment, this method can be defined based on the pattern of the person's foot movement when said person is walking or running. First the heel is placed on the pavement (the back of the foot), then the palm of the foot, and only at the end of the foot movement is placed the front of the foot. Thus, when a pedestrian moves towards the crosswalk **2**, when stepping on the bendable plate **10** of the detection system **1**, the back part of the bendable plate **10** where pressure sensors **101**, or **103** and **105** are placed, is activated, and only then the front of the plate **10** where pressure sensors **102**, or **104** and **106** are placed is activated. When the movement of the pedestrian is in the opposite direction to the entrance of the crosswalk **2**, that is, when the pedestrians are moving in the exit direction of the crosswalk **2**, the pressure sensor **102** (or the pressure sensors **104** and **106**) is activated first, and only then is pressure sensor **101** (or pressure sensors **103** and **105**) are activated.

[0051] To detect the entrance / exit movement of the crosswalk **2**, two pressure sensors **101** and **102** would be sufficient. However, to also detect perpendicular movements on the crosswalk **2** and prevent the perpendicular movement to trigger the signal of warning about a pedestrian entering the crosswalk **2**, a preferably embodiment comprises four pressure sensors (**103**, **104**, **105**, **106**) integrated into the bendable plate **10** in a matrix way. With these four pressure sensors, it is possible to detect the perpendicular movement in the crosswalk **2**, if the pressure sensor **103** or the pressure sensor **104** is activated first, and the pressure sensor **105** or the pressure sensor **106** is activated next, or even if pressure sensor **105** or pressure sensor **106** is activated first, and pressure sensor **103** or pressure sensor **104** is activated next.

[0052] In an embodiment, the pressure sensors are connected to a microcontroller, embedded on an electronic board **22**, which is part of the pedestrian detection system **1**, and which receives the electronic signals from the multiple pressure sensors, in a binary logic - 0 if the sensor is not detecting pressure or 1 if the sensor is de-

tecting pressure; and the previously presented method is programmed in the microcontroller of the electronic board **22**, so that the decision is made to activate the crosswalk safety system or not.

[0053] In an embodiment, the microcontroller embedded in the electronic board **22** also measures the time between actuations of the different pressure sensors, which allows determining the type of movement of the pedestrian: for a time interval between the actuation of two sensors less than 50 ms, the movement of the pedestrian is determined to be "fast"; for a time interval between 50 and 150 ms, the type of movement is determined to be "normal"; for a time interval between 150 and 300 ms, the type of movement is determined to be "slow". If one or more pressure sensors are at a high level for more than 1000 ms, it is determined that the pedestrian is stopped over the moving surface **10**. The classification of the type of movement is useful to control the activation time of the light signalling, allowing to adjust this time to the estimated time that the pedestrian will take to cross the street, thus improving the safety component of the pedestrian and the energy efficiency component of the lighting solution.

[0054] The entire detection process works equally with bicycles, since these also apply the load to the pavement in a progressive way, in the direction of the travel. Thus, the same method determines the direction of movement of bicycles with the same precision, allowing the same control to be carried out.

[0055] In an embodiment, the bendable plate **10** of system **1** comprises a first plate **110** made of metallic material, polymeric, or combination thereof, in which a plurality of non-slip strips **111** are applied in order to protect pedestrians, preventing the plate from having a slip effect, especially when the plate **10** is wet due to the weather. A secondary plate **112** is applied on top of the first plate **110**, to transmit a message to pedestrians, in order to properly signal the device and the application as a whole.

[0056] In another embodiment, the bendable plate **10** of the pedestrian detection system **1** comprises a plurality of photovoltaic solar cells **113** applied along the main plate **110**, which will have two layers in this configuration, a first layer is metallic or polymeric, and the second layer is on top of the first, is transparent and preferably be made of flexible material, such as acrylic, fibreglass, polycarbonate or their mixtures in order to let solar radiation pass to the solar cells **113** and also protect them mechanically and allow the plate **10** to bend.

[0057] In an embodiment, two connectors **15** and **20** are applied to the tops **14** of the structure **11**, one on each top, which allows the connection between two consecutive pedestrian detection systems **1** by engaging the connectors, since a female connector **15** is applied to the end **14** on one side and a male connector **20** to the end **14** on the opposite side. In this way, several pedestrian detection systems **1** can be applied consecutively, to make up the total width of the crosswalk, in order to detect the presence of pedestrians in any area of the crossing

2 entrance.

[0058] After the system for detecting the presence and direction of movement of pedestrians **1** detects a pedestrian moving in the entrance direction of crosswalk **2**, it sends a digital message to the main control unit **400** which, in turn, takes the decision of the process to be carried out in order to promote road safety on the place.

[0059] In an embodiment, the control unit **400** comprises an electronic board **401**, which has an integrated microcontroller **402**, responsible for the control and operation of the entire system. This is connected to pedestrian movement detection systems **1** through inputs **403** and **404**, with input **403** being connected to the set of pedestrian detection systems **1** applied to the sidewalk **3** on one side of the crosswalk **2**; and the entry **404** to be connected to the set of pedestrian detection systems **1** applied to the sidewalk **4** on the opposite side of the crosswalk **2**. This electronic board also has an output **405** for the connection to light signalling devices, which can be applied on the road pavement **500** or in vertical signalling **501**, with output **405** corresponding to the connection to a communication line through which control messages are sent to the respective light signalling device.

[0060] The electronic board **401** of the control unit **400** also includes the connection to a brightness sensor **406**, so that the microcontroller **402** receives the information of the outside brightness and can thus send it in the control message, both for horizontal **500** or vertical **501** light signalling devices, indicating about the intensity with which the LEDs should be lighted, to maximize the road safety efficiency, as well as the energy efficiency. This electronic board **401** also includes an output for a noise emitter **407**, so that the microcontroller **402** can activate it in case of receiving a message from an approaching vehicle, by an external sensor, and thus alerting pedestrians not only through the light signalling units, but also through this type of device.

[0061] In an embodiment, the electronic board **401** of the control unit **4** includes two wireless data connections, one being a connection **408** for communicating with external radio frequency sensors, ideally for receiving warnings or signals to improve the control performed, such as the approach of a vehicle carried out by an external sensor, which communicates by radio frequency; and another connection **408** to communicate with external applications, with a view to sending control or data to a database, with this connection being able to use different solutions, such as LoRa, zigbee, NB-IOT, 3G/4G or even 5G, which allow medium and long-range communications.

[0062] In an embodiment, Figure 6, it represents the system next to a crosswalk **2**, applied on the sidewalk of one **3** or on both **3** and **4** sides of the crosswalk **2**, to detect the presence and movement of pedestrians moving in the direction of the crosswalk entrance **2**, transmitting a digital message to a control unit **400** whenever this situation is verified, which, in turn, controls one or more types of road signs.

[0063] In an embodiment, Figure 11 shows the system connected to a set of horizontal pavement light signs **500**, in which whenever a pedestrian is moving in the direction of the crosswalk **2** entrance, and this is detected by system **1**, a message is transmitted to the control unit **400** which, in turn, controls the illumination of the horizontal light signs **500**, for a pre-defined time, depending on the type of movement of the pedestrian.

[0064] In an embodiment, Figure 12 shows the system connected to a set of vertical light signals **501**, in which whenever a pedestrian is detected moving in the direction of the crosswalk **2** by system **1**, a message is transmitted to the control unit **400** which, in turn, controls the illumination of the vertical light signals **501**, during a time pre-defined, depending on the type of movement of the pedestrian such as normal, fast, slow, among others.

[0065] In another embodiment Figure 13 represents the combination of the system with traffic light signs **502**, since after a pedestrian is detected by the detection system **1**, it sends the respective digital message to the control unit **400**, which can, apart from controlling the light effect of horizontal **500** or vertical **501** light signals, send digital messages to traffic light signs **502**, indicating the presence of pedestrians near the crosswalk **2**, or even their movement in the crosswalk **2**, which can serve as the switch to indicate the presence of pedestrians in the place.

[0066] In an embodiment, Figure 14 represents the system for detecting movement of a pedestrian or cyclist integrated with a crosswalk signalling solution in a two-lane road. **200** represents a set of systems **1** for detecting the presence and the direction movement of the pedestrian applied in the left side of the crosswalk **2**; **201-204** represents an individual unit of a system **1** positioned on the left side of the crosswalk **2** and **210** represents a set of systems **1** positioned on the right side of the crosswalk **2**; **211-214** represents an individual unit of a system **1** positioned on the right side of the crosswalk **2**; **220** represents an electric connection between the first system **204** for detecting the presence and the direction movement of the pedestrian on the left side of the crosswalk **2** and the control unit **400**; **221** represents the electric connection between the first system for detecting the presence and pedestrian direction movement on the right side of the crosswalk **2**, **214** and the control unit **400**; **300** represents a set of road signalling devices applied at one end of the crosswalk **2** in a two-lane road; **301, 302, 303, 304, 305 and 306** represents a specific road signalling device at one end of the crosswalk **2** that fill the width of the first road lane; **311, 312, 313, 314, 315 and 316** represents a specific road signalling device at one end of the crosswalk **2** that fill the width of the second road lane; **222** represents the electric connection between the first road signalling device **301** at one end of the crosswalk **2** and the control unit **400**.

[0067] In a further embodiment the system **1** may act as a pedestrian counter. For this purpose, the control unit **400** is able to count the number of pedestrians that are

walking by or stopped above the bendable plate **10**, based on the information received by the detection systems **1**, and send that information to a remote database, which can be integrated into the city's data platform, promoting the concept of smart cities.

[0068] In an embodiment, the system comprises a bendable plate **10** for the passage of a pedestrian, applied at the pavement level. The bendable plate **10** is built into a support structure **11** and with a plurality of built-in pressure sensors, whose actuation sequence by the pressure of the pedestrian allows to accurately detect the direction of movement of a pedestrian moving on this surface.

[0069] The system might be constituted by a bendable plate **10**, composed of: a main plate **110**, metallic or polymeric or their combination thereof in which a set of non-slip strips **111** are applied on the top, transversely to the direction of movement of the pedestrians on its surface when they move in the entry direction of a crosswalk; and a secondary plate **112**, mechanically fixed or glued on top of the surface plate **110**.

[0070] The system may comprise a bendable plate **10**, to which a set of pressure sensors are fixed on its bottom part, with a minimum of two **101-102**, with the pressure sensor **101** to be placed between the centre of the plate and the end of the side opposite the crosswalk, and the pressure sensor **102** to be placed between the centre of the plate and the crosswalk side, equidistant.

[0071] The system may comprise a bendable plate **10**, to which a set of pressure sensors are applied at the bottom, with four pressure sensors **103, 104, 105** and **106** to be applied, with sensors **103** and **105** applied between the centre of the plate **10** and the end of the side opposite the crosswalk and sensors **104** and **106** applied between the centre of the plate **10** and the end of the crosswalk side.

[0072] The system may be made up of a support structure **11**, consisting of: a base plate **16**, two side plates **13** and two tops **14**, multiple (one or more) springs **18** to create opposition to the movement of the bendable plate **10** and that allow it to be restored to its initial position, after the load is no longer applied on it; a support bar **17**, applied on the base plate **16** and on which the springs **18** are applied, and which also serves as an end stop for the flexion movement of the upper plate **10**; it also have multiple stops **19**, applied to the base plate **16**, an electronic board **22**, connected to multiple pressure sensors **101, 102, 103, 104, 105** and **106**, which are applied to the lower part of the upper plate **10**; and by two electrical connectors, one male **15** and one female **20**, applied to the tops **14**.

[0073] The system may have a bendable plate **10** that deforms when under load, until it reaches a maximum displacement imposed by the distance between the bottom of the plate **10** and the top of a support bar **17** that works as a stop, and it returns to its initial position through the action of one or more springs **18**, applied inside the bar **17**.

[0074] The system may have a bendable plate **10** that deforms when subjected to a load, and whose pressure sensors **101, 102, 103, 104, 105** and **106** that are connected to its lower part, are pressed against a set of stops **19**, applied in the base **16** of the structure **11**, immediately below the pressure sensors, these sensors being activated only when the area of the bendable plate **10** where they are placed reaches a displacement close to its maximum displacement, reaching the stoppers **19**.

[0075] The system may have a set of pressure sensors **101, 102, 103, 104** and **106** coupled to the bendable plate **10** and connected to an electronic board **22** with a microcontroller embedded, which detects the sequence of actuation of the pressure sensors **101, 102, 103, 104, 105** and **106** for each load applied on the bendable plate **10**, determining the direction of movement depending on the sequence of actuation of such sensors.

[0076] The system may have a set of pressure sensors **101, 102, 103, 104, 105** and **106** coupled to the bendable plate **10** and connected to an electronic board **22** with a microcontroller embedded, which measures the time between the actuation of the different pressure sensors in each load applied on the bendable plate **10**, determining the type of movement as a function of the difference between the activation time of the sensors.

[0077] The system may have an electronic board **22** with a microcontroller embedded, which sends a digital message to a central control unit **400** whenever it detects that a pedestrian is moving towards the entrance of the pedestrian crossing **2**, with the information of the side of the crosswalk the pedestrian will enter and the type of movement of the pedestrian, and it does not send any message to the central control unit **400** if it detects that the pedestrian is moving in a direction other than the direction of entry into the crosswalk **2**, or, in such situation, it sends a message with the indication of the detection of a pedestrian moving in a different direction from the entrance to the crosswalk **2**.

[0078] The system may be able to integrate an electric power generation system by means of photovoltaic solar cells **113**, embedded in the main part **110** of the bendable plate **10** of the system **1**, having the photovoltaic solar cells **113** arranged along the part **110**, and coated with a transparent and flexible material, in order to protect them from mechanical loads, water and dust, allowing the transmission of solar radiation to the photovoltaic solar cells **113**.

[0079] The system may have a main control unit **400**, which is electrically connected and receives digital messages from one or multiple systems to detect the presence and direction of movement of pedestrians **1**, on one or both sides of the crosswalk **2**, and is electrically connected and sends digital messages to one or multiple light signalling systems to promote road safety.

[0080] The system **1** may have a central control unit **400**, which is composed of an electronic board **401**, with an integrated microcontroller **402**, electrical connections for communication with pedestrian detection systems

403, 404 and with light signalling systems **405**, connections with a light sensor **406** and a noise emitter **407**, as well as connections to radio frequency data communication modules **408** and long-range wireless connection protocols **409**, which can be LoRa, ZigBee, NB-IOT, or 3G / 4G / 5G.

[0081] The system 1 may have a central control unit **400** which, depending on the message received by one or more pedestrian detection systems 1, defines a light effect to be carried out by external light signalling devices, and sends individual digital messages to each device for a predefined period of time, proportional to the number of road lanes and the type of pedestrian movement, with the indication of the colour of the light to be emitted, the intensity and duration of the light effect.

[0082] The system 1 may have a central control unit **400** that can communicate with a traffic light system for traffic management, transmitting the information that a pedestrian is on the move towards the crosswalk entrance, allowing a more efficiency of this type of road traffic management solutions.

[0083] The system 1 may be able to count the number of pedestrians entering the crosswalk 2, from the digital messages received by the central control unit **400**, by the pedestrian detection systems 1, being able to communicate this information to a remote database or to an external application.

[0084] The system may be able to send and receive digital messages from the control unit **400**, namely through connections to radio frequency data communication modules **408** and long-range wireless connection protocols **409** (LoRa, ZigBee, NB-IOT, or 3G / 4G / 5G), exchanging these digital messages with external equipment, such as traffic lights, lamps or vertical signalling equipment.

[0085] The term "comprising" whenever used in this document is intended to indicate the presence of stated features, integers, steps, components, but not to preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

[0086] The disclosure should not be seen in any way restricted to the embodiments described and a person with ordinary skill in the art will foresee many possibilities to modifications thereof. The above described embodiments are combinable.

[0087] The following claims further set out particular embodiments of the disclosure.

Claims

1. System for detecting movement of a pedestrian or cyclist comprising:

a bendable plate for arranging on a pavement;
two pressure sensors for detecting bending of the bendable plate under pedestrian or cyclist weight, each said sensor being placed under a

distinct region of the bendable plate;
a control unit comprising an electronic data processor configured to detect a pedestrian or cyclist approaching a crosswalk by:

receiving pressure signals from said sensors;
identifying the direction of the movement of the pedestrian or cyclist by determining which sensor detects bending first.

2. System according to the previous claim wherein comprising a support bar for limiting the bending of the bendable plate, which is arranged between the two sensors to separate said distinct regions of the bendable plate.

3. System according to the previous claim comprising at least one spring fixed on the support bar, for restoring an unbend state of the bendable plate.

4. System according to any of the previous claims comprising a display connected to the control unit, wherein the control unit is configured to display a warning signal in said display for vehicle drivers indicating the direction of the movement of the pedestrian or cyclist.

5. System according to any of the previous claims wherein said electronic data processor is further configured to:
if, after determining that a first sensor of the two pressure sensors has firstly detected bending, and that a second sensor of the two pressure sensors does not detect bending within a predetermined period of time, then determining the direction of the movement as uncertain.

6. System according claims 1-4 wherein said electronic data processor is further configured to:

if, after determining that a first sensor of the two pressure sensors has firstly detected bending, and that a second sensor of the two pressure sensors has secondly detected bending, then determining the direction of the movement as entering a crosswalk;
otherwise, if the second sensor has firstly detected bending and that the first sensor has secondly detected bending, then determining the direction of the movement as exiting the crosswalk.

7. System according to any of the claims 1-6 further comprising protuberant stoppers for supporting the pressure sensor when the bendable plate is bent on to the pressure sensor by the pedestrian or cyclist.

8. System according to the previous claim wherein the number of protuberant stoppers is the same as the number of pressure sensors.
9. System according to claims 7-8 wherein the protuberant stoppers are coated with a flexible material, preferably selected from rubber, cork or foam. 5
10. System according to any of the previous claims wherein the bendable plate comprises four pressure sensors arranged in a matrix and equidistant from the support bar, for perpendicular movement detection of the pedestrian or cyclist. 10
11. System according to any of the previous claims comprising a support structure comprising a base and two parallel sidewalls each with a recess for receiving the bendable plate, wherein edges of the bendable plate are inserted in the recesses. 15
20
12. System according to any of the previous claims wherein the bendable plate is made of polymer or metal, or a combination thereof.
13. System according to any of the previous claims wherein the display means are light signals, preferably horizontal signs, vertical signs or traffic lights. 25
14. Method for operating a system for detecting movement of a pedestrian or cyclist, said system comprising: 30
 - a bendable plate for arranging on a pavement;
 - two pressure sensors for detecting bending of the bendable plate (10) under pedestrian or cyclist weight, each said sensor being placed under a distinct region of the bendable plate; 35
 - a control unit comprising an electronic data processor; 40

said method comprising using said electronic data processor for detecting a pedestrian or cyclist approaching a crosswalk by:

 - receiving pressure signals from said sensors; 45
 - identifying the direction of the movement of the pedestrian or cyclist by determining which sensor detects bending first.- 15. Method according to the previous claim for identifying the direction of the movement of the pedestrian or cyclist by the electronic data processor carrying out the following steps: 50
 - if, after determining that a first sensor of the two pressure sensors has firstly detected bending, that a second sensor of the two pressure sensors does not detect bending within a predeter-

mined period of time, then determining the direction of the movement as uncertain;
 otherwise if, after determining that the first sensor has firstly detected bending, the second sensor has secondly detected bending, then determining the direction of the movement as entering a crosswalk;
 otherwise, if the second sensor has firstly detected bending and the first sensor has secondly detected bending, then determining the direction of the movement as exiting the crosswalk.

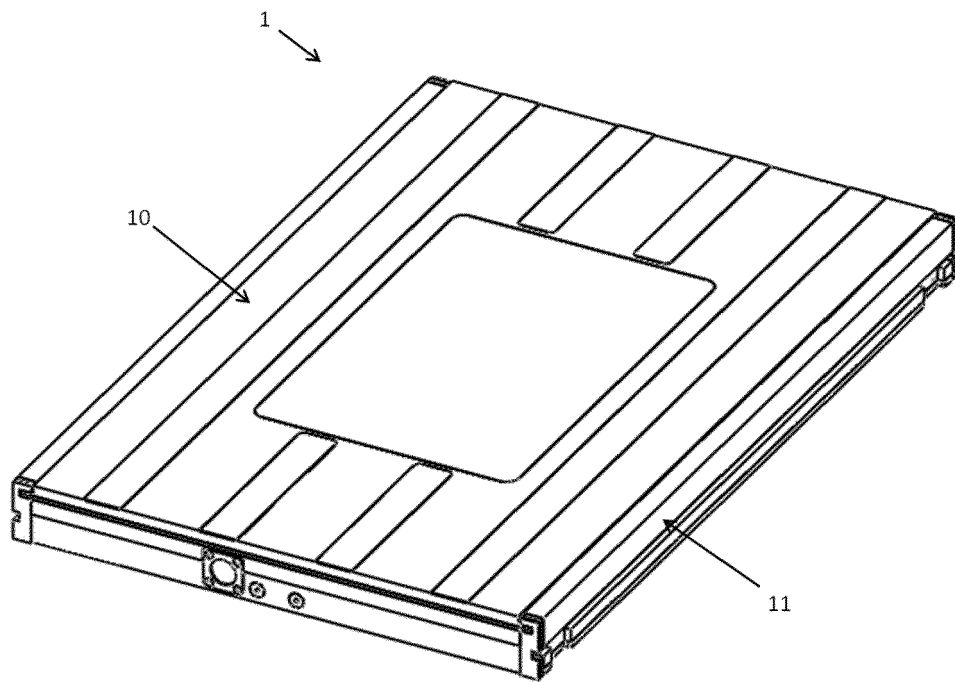


Fig. 1

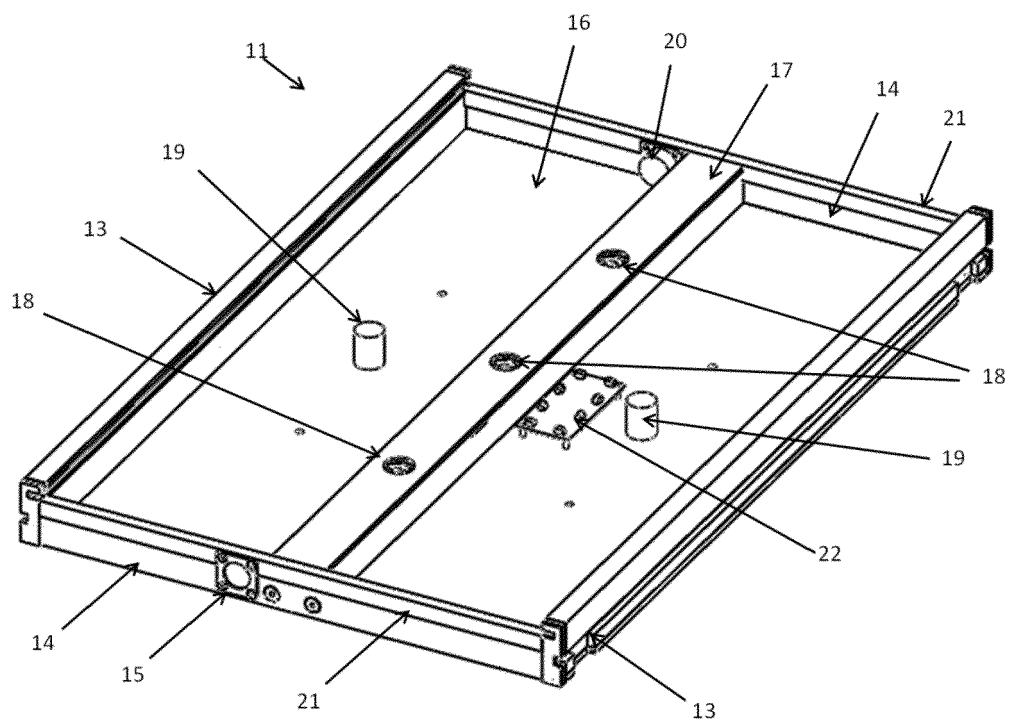


Fig. 2A

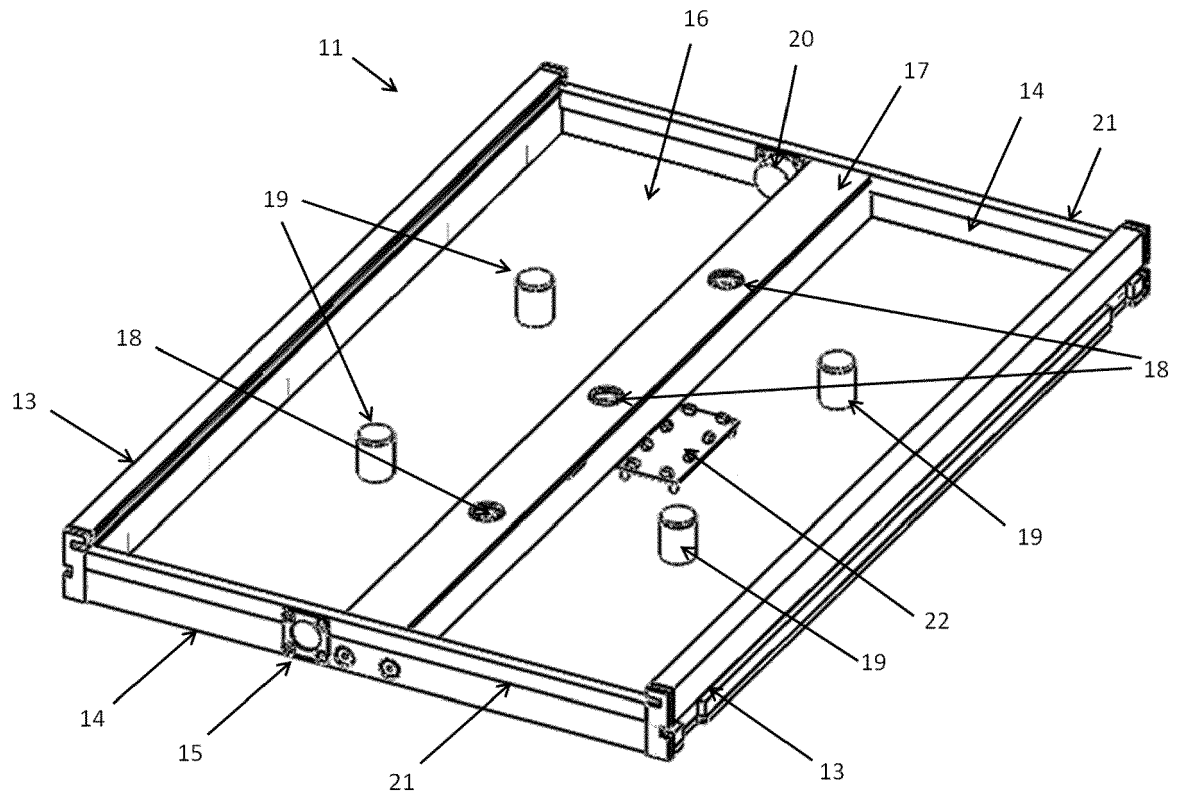


Fig. 2B

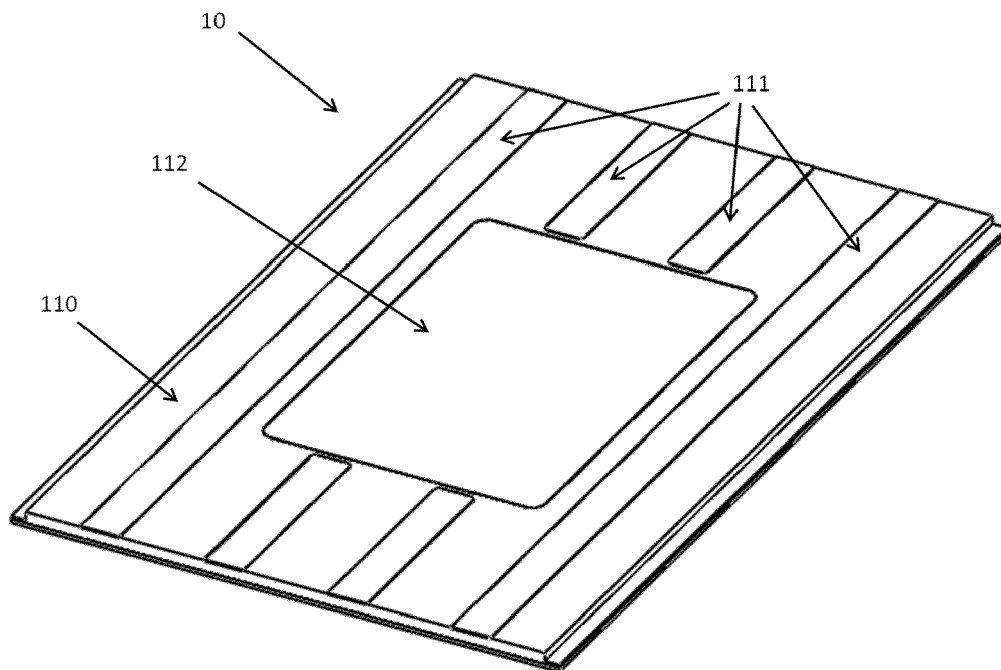


Fig. 3

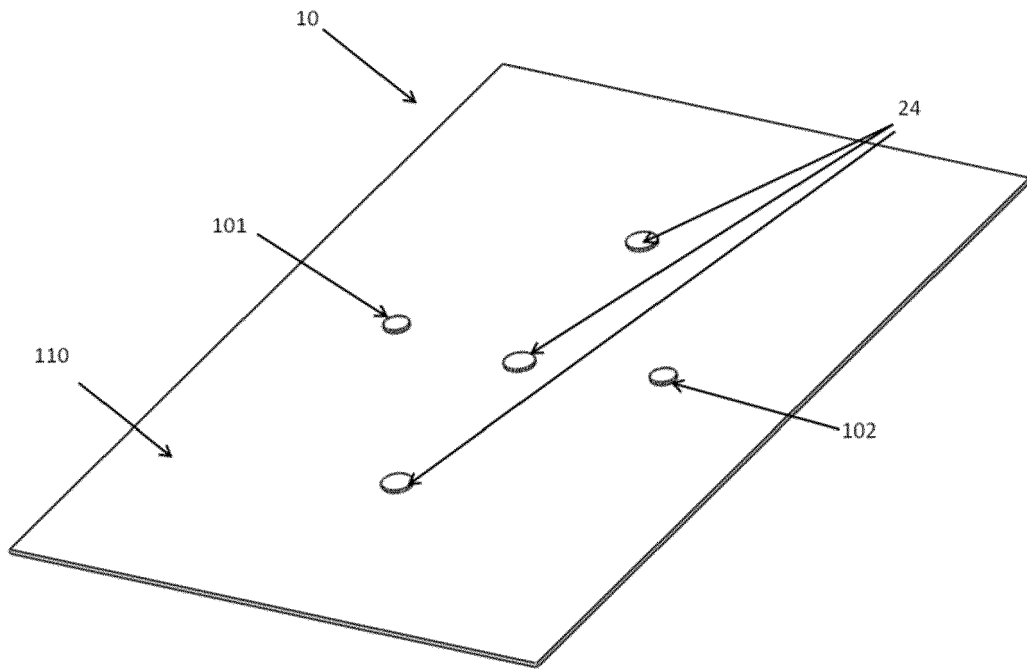


Fig. 4A

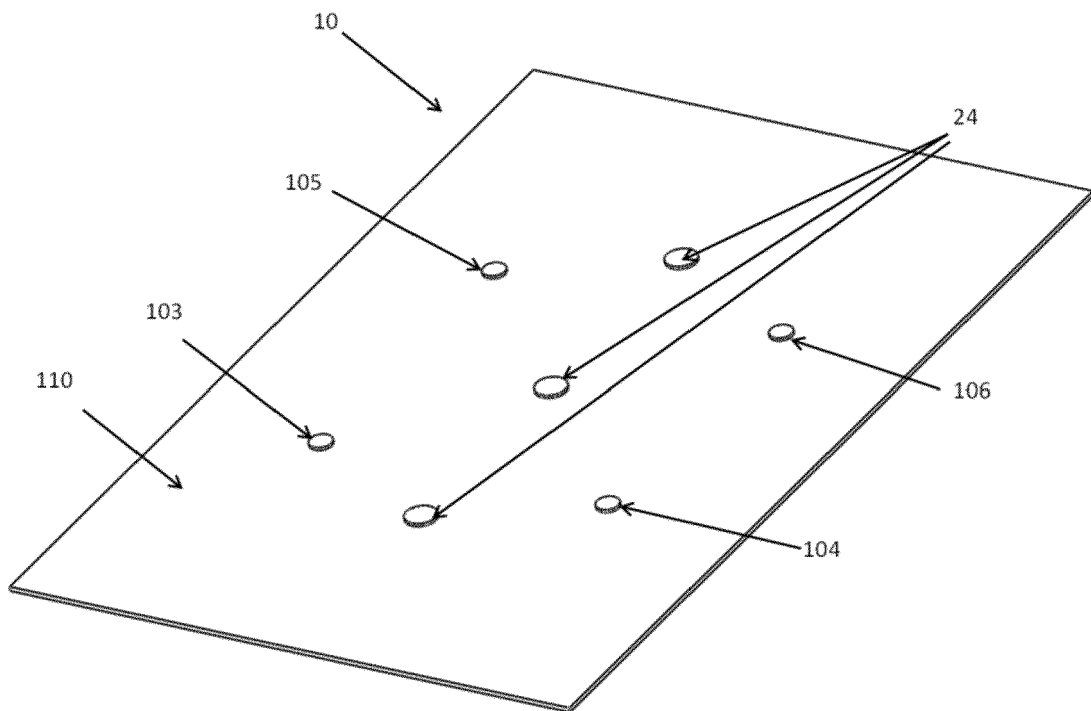


Fig. 4B

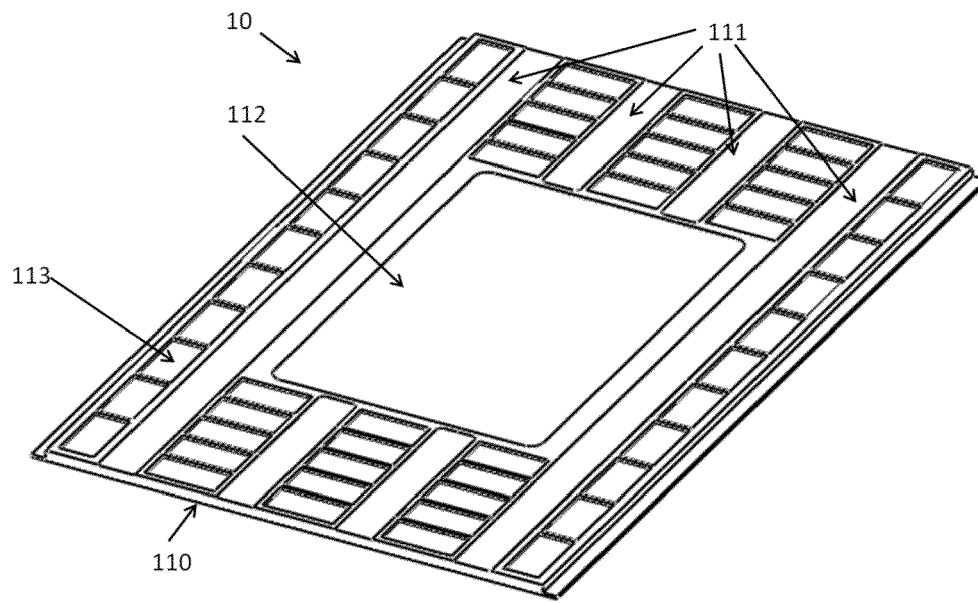


Fig. 5

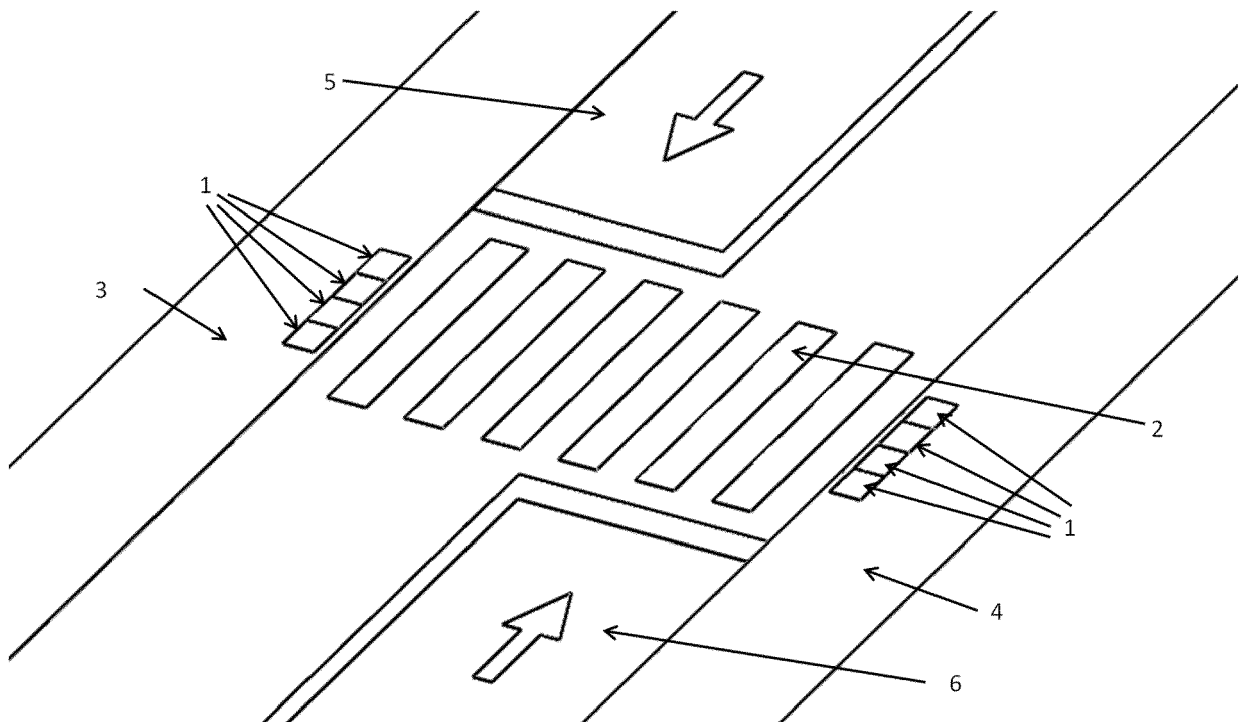


Fig. 6

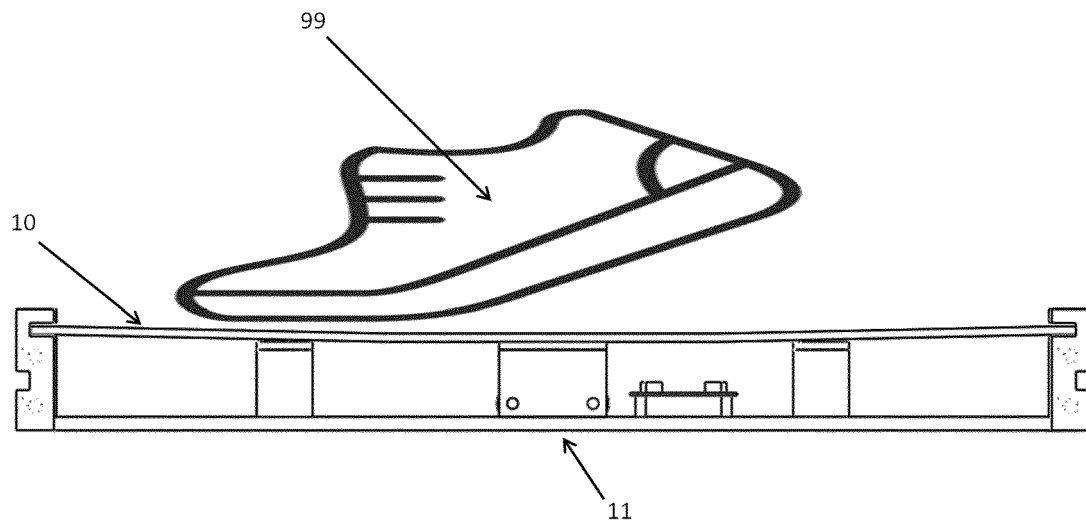


Fig. 7

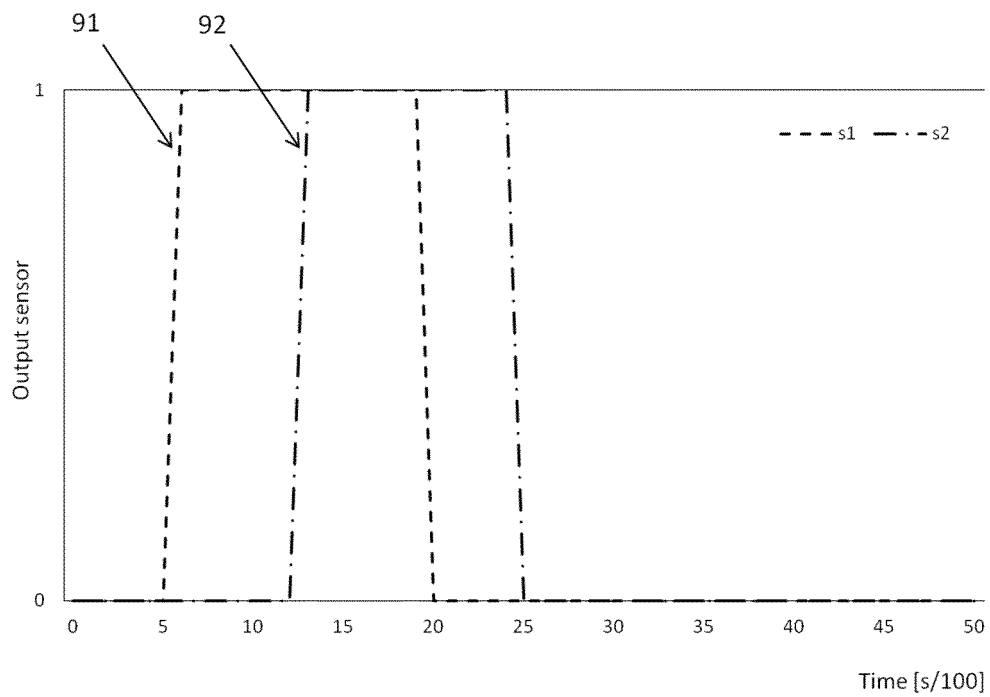


Fig.8

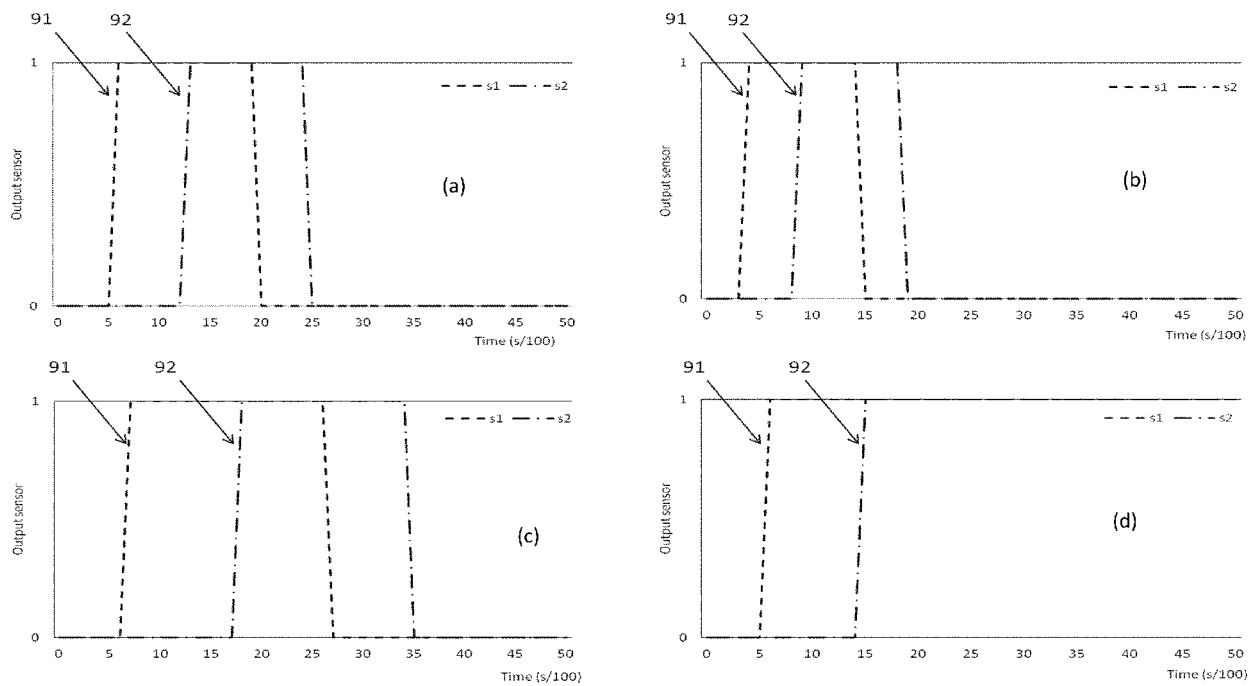


Fig.9

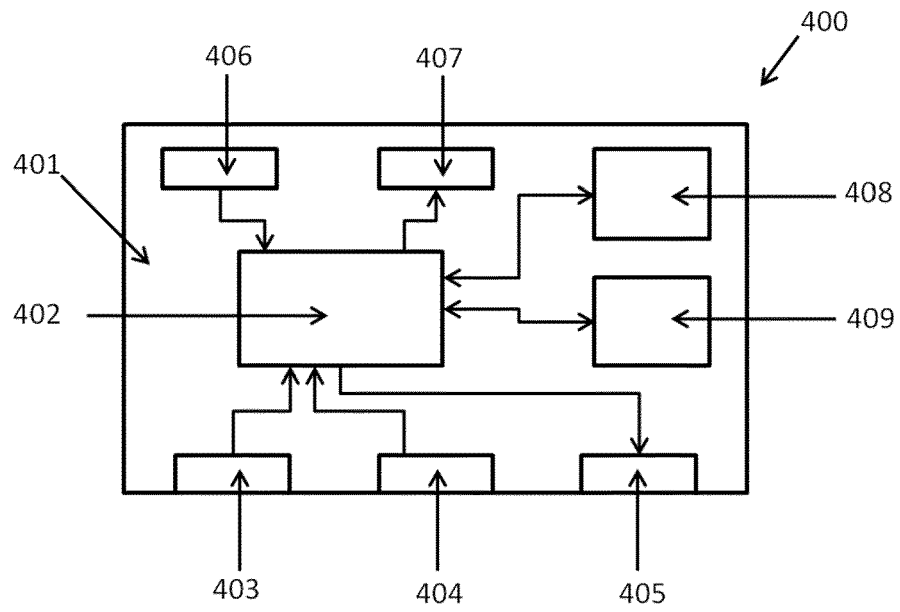


Fig.10

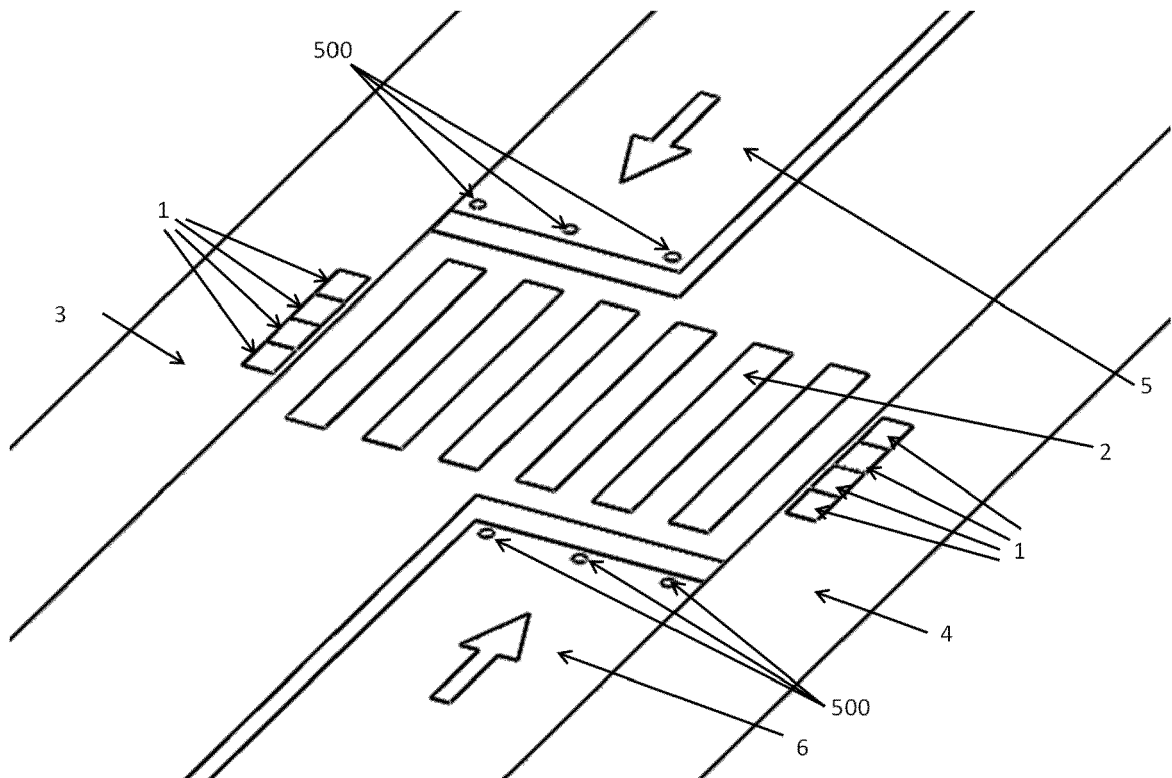


Fig.11

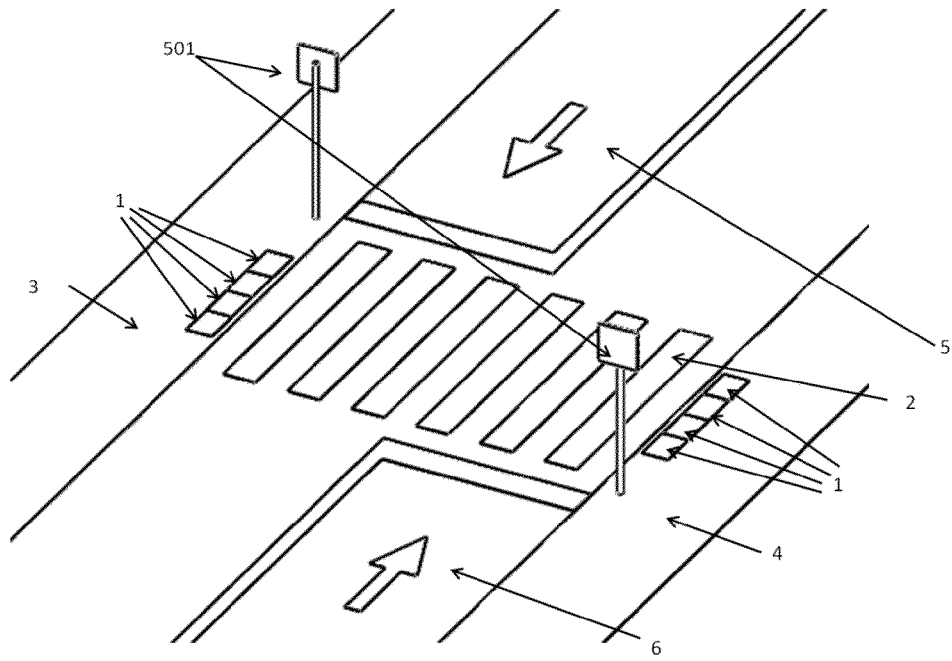


Fig.12

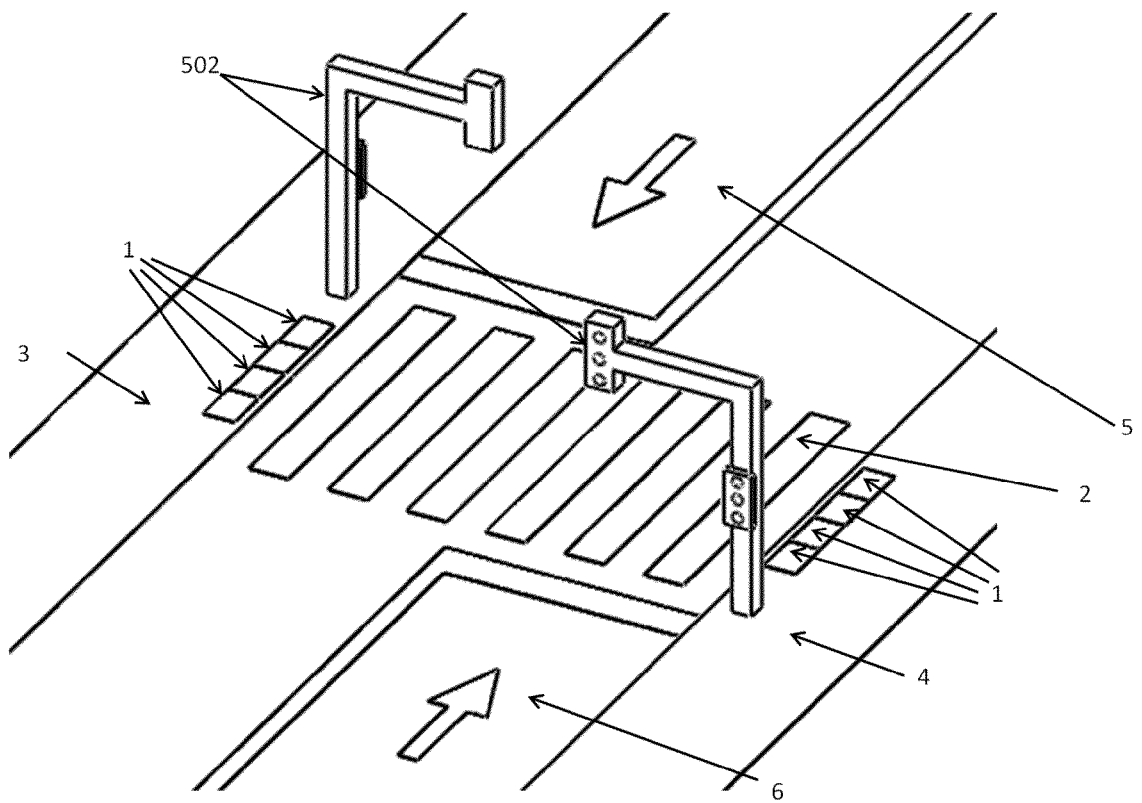


Fig.13

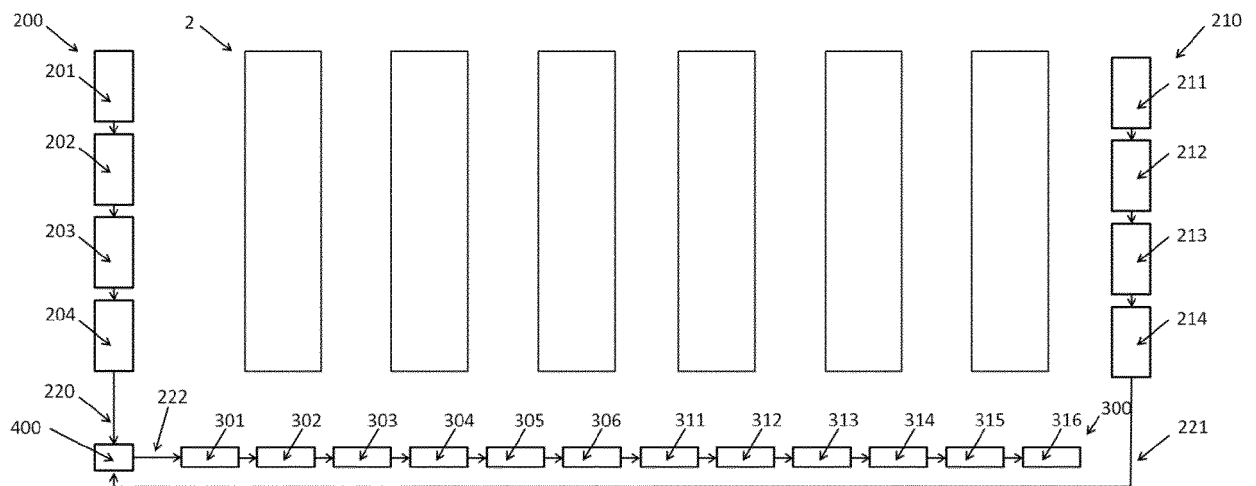


Fig.14



EUROPEAN SEARCH REPORT

Application Number

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 7 December 2021	Examiner Flores Hokkanen, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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