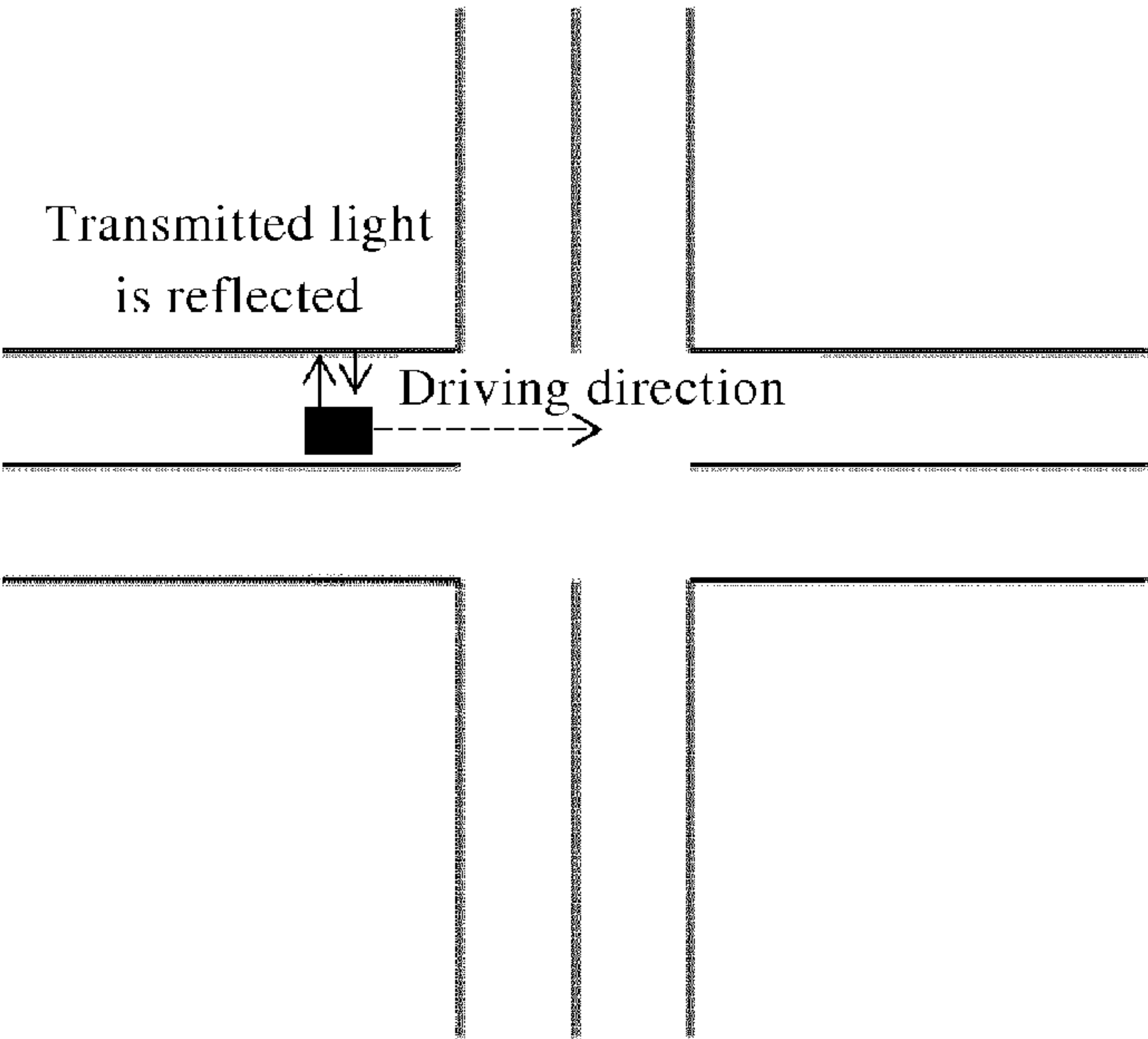




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(54) Titre : CAPTEURS DE VOIES PERMETTANT DE DETECTER LA POSITION D'UN VEHICULE PAR RAPPORT AUX VOIES  
(54) Title: TRACK SENSORS FOR DETECTING POSITION OF VEHICLE RELATIVE TO TRACKS



**Fig. 3**

(57) **Abrégé/Abstract:**  
Method and vehicle for tracking the position of a remotely operated vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding x- and y-directions on the grid, the method comprising: receiving information of the number of track crossings to pass between start and stop positions in x- and y- directions according to the set route; directing sensors attached to the vehicle at the tracks along the route of the vehicle; detecting and monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route, and transmitting a signal to a controller, controlling the drives of the wheels of the vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y- directions along the set route.

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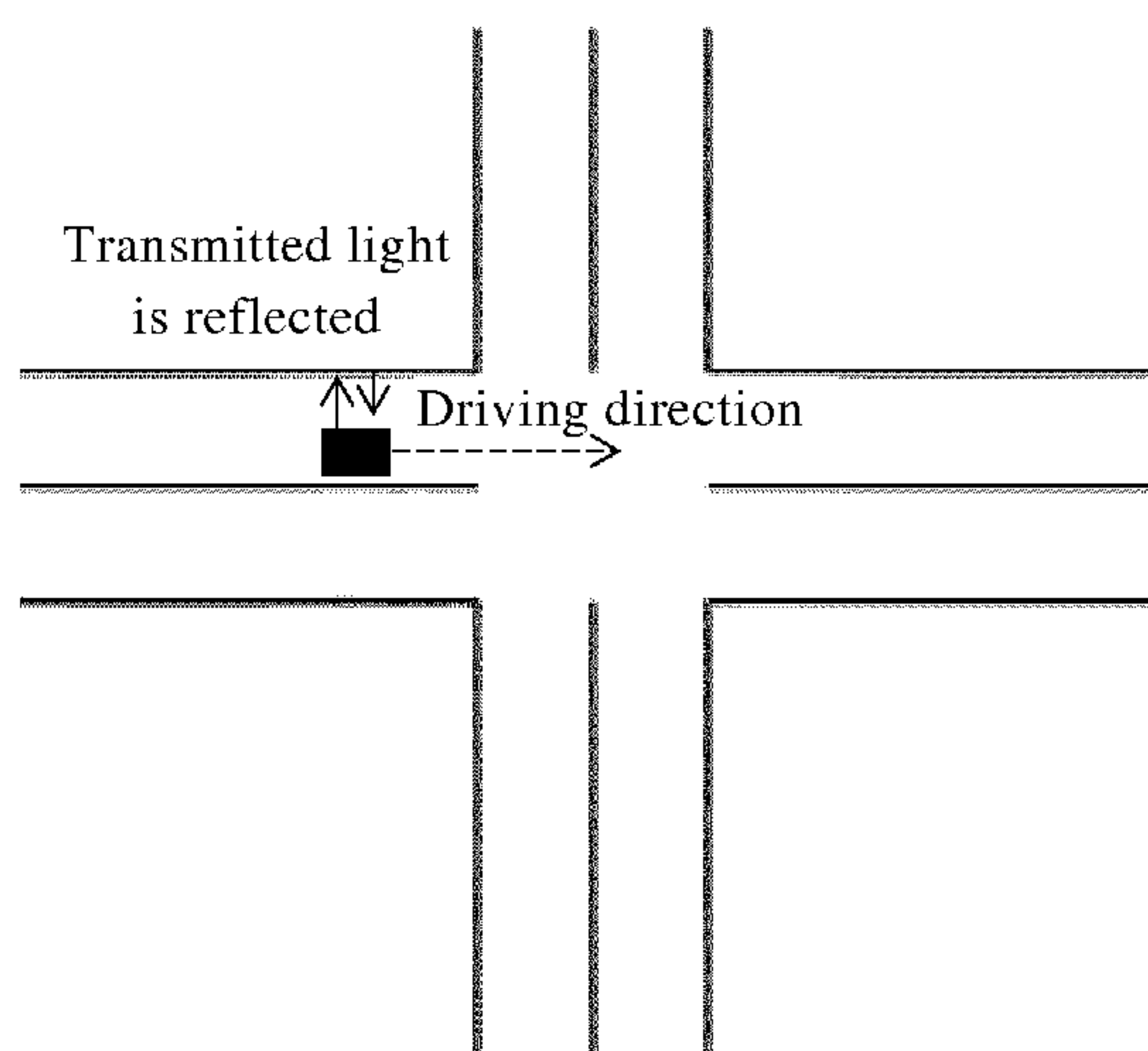


Fig. 3

(57) Abstract: Method and vehicle for tracking the position of a remotely operated vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding x- and y-directions on the grid, the method comprising: receiving information of the number of track crossings to pass between start and stop positions in x- and y- directions according to the set route; directing sensors attached to the vehicle at the tracks along the route of the vehicle; detecting and monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route, and transmitting a signal to a controller, controlling the drives of the wheels of the vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y- directions along the set route.

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## TRACK SENSORS FOR DETECTING POSITION OF VEHICLE RELATIVE TO TRACKS

### Introduction

5 The present invention relates to a method and a remotely operated vehicle for tracking the position of the vehicle following a set route relative to tracks laid out on a frame structure forming a grid.

### Background

10 A remotely operated vehicle or robot for picking up storage bins from a storage system is known. A detailed description of a relevant prior art storage system is presented in EP1037828B1, and details of a prior art vehicle being suitable for such a storage system is disclosed in detail in Norwegian patent NO317366B1 and  
15 WO2015193278A1. Such prior art storage systems comprise a three-dimensional storage grid containing storage bins that are stacked on top of each other up to a certain height. The storage grid is normally constructed as aluminium columns interconnected by top rails or tracks, onto which a plurality of remotely operated vehicles, or robots, are arranged to move laterally. Each vehicle is equipped with  
20 motors for moving the vehicle from one position to another and for driving a lift device adapted for picking up, carrying, and placing bins that are stored in the storage grid. A power supply is supplying power to the motors and drivers comprised in the vehicle, e.g. a rechargeable battery. The vehicle typically communicates with a control system via a wireless link and can be recharged at a charging station when needed.

25 Rotation of the wheels may be driven by belts connected to the wheels or by individual driving means situated at or at least partly within the wheels. The last example will provide a responsive robot with high control of acceleration and deceleration between a start and a stop position.

When a robot is moving on the tracks, it is controlled to accelerate from a start  
30 position and decelerate to a stop position. The start and stop positions will depend on the route set up for a robot prior to picking up a bin from one storage column in the storage grid, and placing it in another storage column. A set route of a robot will typically comprise several start and stop positions. A route for a specific robot will be set up by a supervisory system having control of all storage bins and their  
35 content as well as the positions of the vehicles handling the bins.

When operating and controlling a robot following a set route relative to tracks laid out on a frame structure forming a grid, it is vital to always keep track of all operating robots and their positions. The positions of a robot can be acquired in

different ways. One way is to track the position of the robot relative to the tracks on top of the frame structure. The position can be acquired by means of tracking devices located externally to the robot or by devices integrated in the robot.

By using integrated tracking devices, the robot itself will be able to keep track of its position. Integrated tracking devices are however quite complex systems and not necessarily very precise.

There is a need for a simple yet precise way of detecting the position of a robot relative to a frame structure.

According to the present invention, the position of the robot is detected by integrated tracking devices tracking the number of crossings passed in x- and y-directions relative to the tracks laid out as a grid structure.

#### Short description of the invention

The invention is defined by a method for tracking the position of a remotely operated vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding x- and y-directions on the grid, the method comprising:

- receiving information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route;
- directing sensors attached to the vehicle at the tracks along the route of the vehicle;
- detecting and monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route;
- transmitting a signal to a controller, controlling the drives of the wheels of the vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route.

Further features of the method are defined in the dependent claims.

The invention is also defined by a remotely operated vehicle for tracking the position of the vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and seconds sets of wheels connected to drives for moving the vehicle in corresponding x, y directions on the grid, said vehicle comprising:

- means for receiving information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route;



- sensors attached on the vehicle and directed at the tracks along the route of the vehicle;
- detecting and monitoring means for monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route;
- 5 - controller for controlling the drives of vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route.

Further features of the remotely operated vehicle are defined in the dependent claims.

10

#### Detailed description of invention

The invention will now be described with reference to the figures, where:

Figure 1 shows a robot equipped with sensors according to the invention;

Figure 2 illustrates how light is reflected from the grid;

15 Figure 3 illustrates the principle of using track sensors for detecting the position of a robot relative to tracks, and

Figure 4 shows light sensor signals are generated when moving a robot in x- and y-directions of a grid structure.

20 The invention comprises a remotely operated vehicle, hereafter called robot, for tracking the position of the robot following a set route relative to tracks laid out on a frame structure forming a grid.

25 Figure 1 shows an example, in perspective view, of such a robot. The robot having first and second sets of wheels connected to drives for moving the robot in corresponding different direction on the grid. The first and second set of wheels are oriented perpendicular to each other. For the sake of clarity, a Cartesian coordinate system is shown with its x- and y-axes aligned along the principal directions of the rectangular vehicle body.

30 The robot further comprises means for receiving instructions with information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route.

Sensors are attached to the robot and directed at the tracks along the route of the robot. In one embodiment of the invention, the sensors are optical sensors detecting reflection of light from the tracks.

Figure 2 illustrates the principle of using optical sensors as track sensors for detecting the position of a robot relative to tracks and grid structure. Light is reflected from tracks when a robot is moving along the tracks in x- or y-directions. When the robot is passing a track crossing, the reflected intensity of the detected  
5 light will change.

In one embodiment of the invention, at least one sensor is attached to one side, running in the x-direction of the robot, and another sensor is attached to the other side, running in the y-direction of the robot. This means that at least one sensor can be active when the robot is moving in either of the x- and y-directions.

10 In one embodiment of the invention, the sensors are connected to wheel-supports located at each side of the robot. A wheel support will typically hold two wheels, as illustrated in fig. 1. Active wheel supports enable contact between wheels and tracks. Pair of wheel supports on opposite sides of the robot are active at the same time when they are lowered from the body of the robot into the tracks.

15 In one embodiment of the invention, optical sensors are used. Other or additional sensors for detecting position of the robot relative to the tracks may also be used, e.g. acoustic sensors. A combination of different types of sensors is feasible.

The remotely operated vehicle further comprises detecting and monitoring means connected to the sensors. This will enable monitoring of track crossings passed  
20 when moving the vehicle in the x- and y-directions according to the set route.

The vehicle further comprises a controller for controlling the drives of the vehicle according to the number of track crossings passed. When this is close to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route, the controller will initiate deceleration of the  
25 robot.

The invention further comprises a method for tracking the position of a remotely operated vehicle or robot following a set route relative to tracks laid out on a frame structure forming a grid. The vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding x- and y-directions on  
30 the grid. The method comprises several steps.

The first step is receiving information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route. This information is passed to the controller of the remote operated vehicle.

35 The next step is directing sensors attached to the vehicle at the tracks along the route of the vehicle. This is described above and illustrated in fig. 2.



One embodiment comprises attaching at least one sensor to one side of the robot, i.e. in the x-direction of the robot, and attaching another sensor to the other side, i.e. in the y-direction of the robot, where x- and y-directions of the robot correspond to the x- and y-directions of the grid structure of tracks the robot is moving on.

- 5 Another embodiment of the method comprises attaching at least one sensor to a wheel support. By doing this a sensor will be lowered into the track section, and will be closer to the track it is directed at when the wheel support it is connected to is active, i.e. contact between wheels and tracks is established.

10 When a robot is moving along the tracks it will pass one or more crossings on its way from a start position to a stop position.

Figure 3 illustrates this principle where a robot equipped with a light sensor receives reflected light from the track. When the robot is moving through a track crossing, the intensity of the light reflected will drop since no light is reflected.

- 15 The next step of the invention is detecting and monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route. Detection of track crossings is based on measured intensity of reflected light. If other types of sensors are used, the detection is based on detection of change in received signal.

- 20 Figure 4 shows light sensor signals generated when moving a robot in x- and y-directions of tracks laid out as a grid structure. Based on the sensor signals, the robot is able to keep track on the number of track crossings passed.

- 25 Figure 4A shows an example of a track crossing, where there are double tracks in the x-direction, and single tracks in the y-direction. A robot running in the x-direction will have sensors directed in the y-direction, ref. fig. 3. It will thus detect the single-track configuration. When the robot is running in the y-direction it will detect the double track configuration. The letters B and C in Fig. 4A are referring to corresponding signals shown in figures 4B and 4C.

- 30 Figure 4B shows light intensity (I) versus time (t) when a robot is running in the y-direction shown in fig. 4A. As shown in the figure the light intensity will be high if the sensor receives a strong reflected signal from the track it is directed at. When the sensor is passing the track crossing, the signal will drop since a reflected signal is absent. A temporary peak of the intensity of the reflected light will occur due to the double track configuration. After passing the track crossing, the intensity, I, of the reflected signal will become high again until next track crossing.

- 35 Figure 4C shows a similar reflected signal as shown in 4B, but with only one drop in the detected signal due to the single-track configuration.

The last step of the invention is transmitting a signal to a controller, controlling the drives of the wheels of the robot when the number of track crossings passed is close



to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route.

In this way, the controller can control precise deceleration of the robot prior to the next crossing where it is to change direction.

- 5 One embodiment of the invention comprises arranging sensors placed on active wheel supports comprising the sets of wheels for detecting track crossings as described above, as well as arranging sensors on passive wheel supports for measuring distance to next track crossing. This can be used for providing an early warning signal, telling the controller that the next track crossing is approaching.
- 10 According to one embodiment of the invention, the signal transmitted to the controller can be used for performing precise control of deceleration and acceleration of the vehicle for following a set route along x- and y-directions.
- The following describes an example of how the inventive method can be implemented on the remotely operated vehicle described above.
- 15 The tracks laid out on a frame structure forming a grid can be addressed similar as the cells in a spreadsheet. If for instance a storage grid comprises 100 columns or cells for storing bins, each cell can be given a unique identity. A grid with 10 cells in the x-direction and 10 cells in the y-direction will make a 2-dimensional track configuration running on top of 100 cells.
- 20 When the movements of the robot are controlled, a controller will keep track of which cell the robot is to pick up a bin from, and which cell to place a bin in. Based on this, the controller will set up a route the robot is to follow.
- If for instance, the robot is to pick up a bin from cell C2, and place it in cell H8, and cells C8 and H2 are blocked by other robots, the following route may be set up by
- 25 the controller. First leg of the route is from C2 to C5, the next leg is from C5 to H5, and the last leg is from H5 to H8. According to said route, the robot must start and stop three times. It will first drive in the y-direction, then the x-direction, and finally in the y-direction. The robot will receive the number of track crossings to pass between each start and stop position according to said route.
- 30 The sensors attached to the robot and detecting means comprised in the robot will detect the number of track crossings passed in each direction. When the number of passed crossings is close to the total number of track crossings to pass on each leg, a signal is transmitted to the controller controlling the movements of the robot. In this way, the controller will know exactly when deceleration should start, as well as
- 35 the rate and duration of acceleration.

According to the present invention, the position of the robot is detected by integrated tracking devices for detecting the number of crossings passed in x- and y-directions relative to the tracks laid out as a grid structure is tracked.

The features of the invention can be used in addition to other distance measuring means comprised in the robot or in external means.

5 This method according to the invention will provide a simple yet precise way of detecting the position of a robot relative to a frame structure. This enables fast and efficient movements of robots moving on tracks laid out on top of the frame structure.



## CLAIMS

1. A method for tracking the position of a remotely operated vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and second sets of wheels connected to drives for moving the vehicle in corresponding x- and y-directions on the grid, the method comprising:

  - receiving information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route;
  - directing sensors attached to the vehicle at the tracks along the route of the vehicle;
  - detecting and monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route;
  - transmitting a signal to a controller, controlling the drives of the wheels of the vehicle, when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route.
2. The method according to claim 1, by attaching at least one sensor to one side, in the x-direction of the robot, and another sensor is attached to the other side, in the y-direction of the robot.
3. The method according to claim 2, by attaching the at least one sensor to a wheel support.
4. The method according to claim 3, by arranging sensors placed on active wheel supports comprising sets of wheels running on the tracks for detecting track crossings, and arranging sensors on passive wheel support for measuring distance to next track crossing.
5. The method according to any of the previous claims, using the signal transmitted to the controller for performing precise control of deceleration and acceleration of the vehicle for following a set route along x- and y-

directions.

6. The method according to any of the previous claims, by using optical sensors.

5

7. Remotely operated vehicle for tracking the position of the vehicle following a set route relative to tracks laid out on a frame structure forming a grid, the vehicle having first and seconds sets of wheels connected to drives for moving the vehicle in corresponding x, y directions on the grid, said vehicle comprising:

10

- means for receiving information of the number of track crossings to pass between start and stop positions in x- and y-directions according to the set route;
- sensors attached to the vehicle and directed at the tracks along the route of the vehicle;
- detecting and monitoring means for monitoring track crossings passed when moving the vehicle in the x- and y-directions according to the set route;
- controller for controlling the drives of vehicle when the number of track crossings passed is close to the total number of track crossings to pass between the start and stop positions in respective x- and y-directions along the set route.

15

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8. The remotely operated vehicle according to claim 7, where at least one sensor is connected to one side, in the x-direction of the robot, and another sensor is connected to the other side, in the y-direction of the robot.

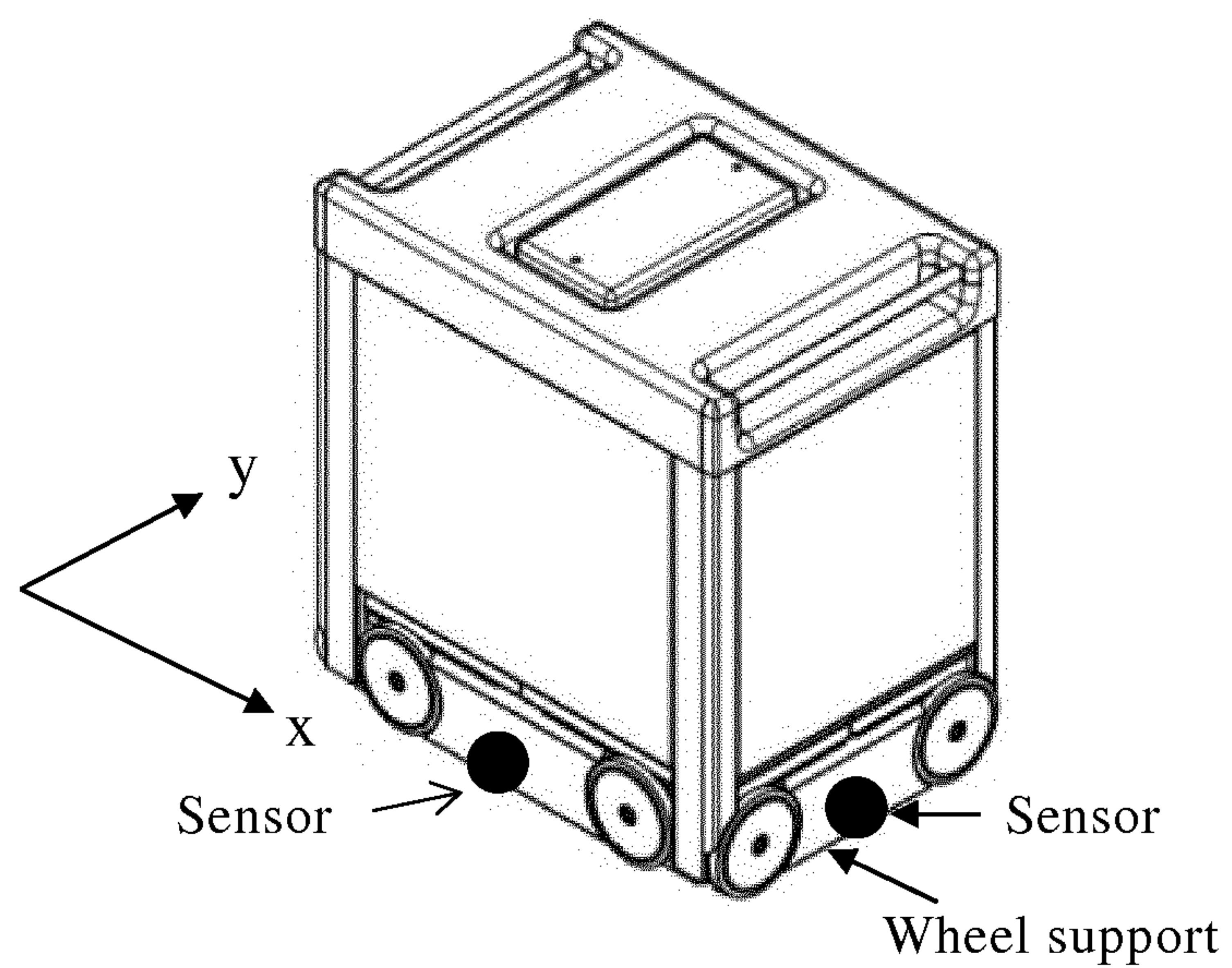
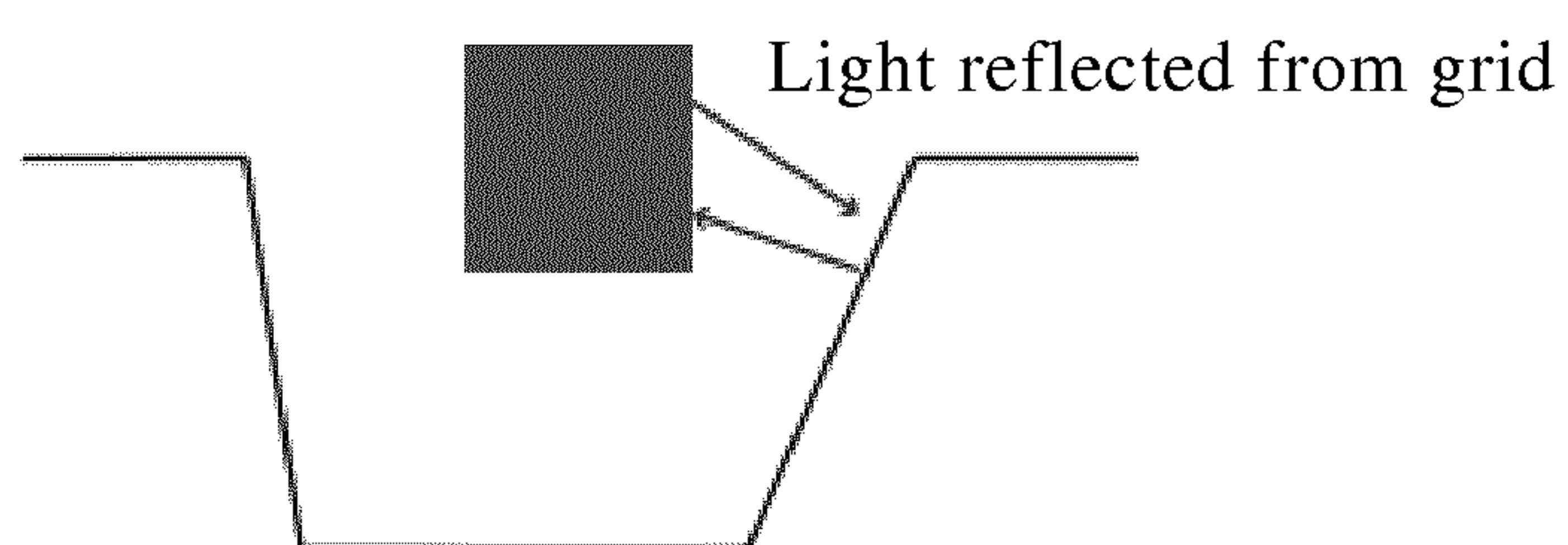
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9. The remotely operated vehicle according to claim 8, where the at least one sensor is connected to a wheel support.

30

10. The remotely operated vehicle according to any of the claims 7 to 9, where the sensors are optical sensors.



**Fig. 1****Fig. 2**

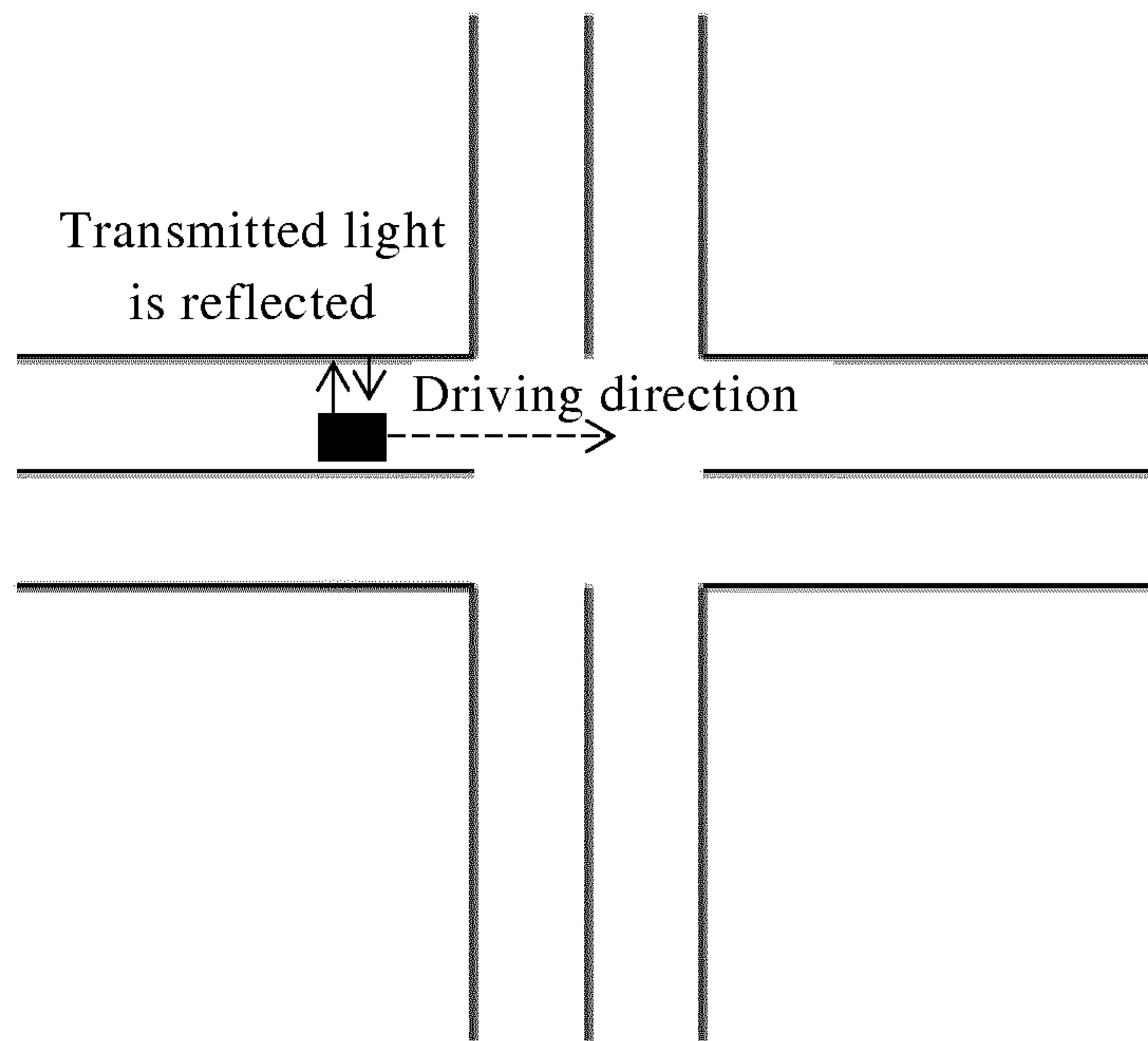


Fig. 3

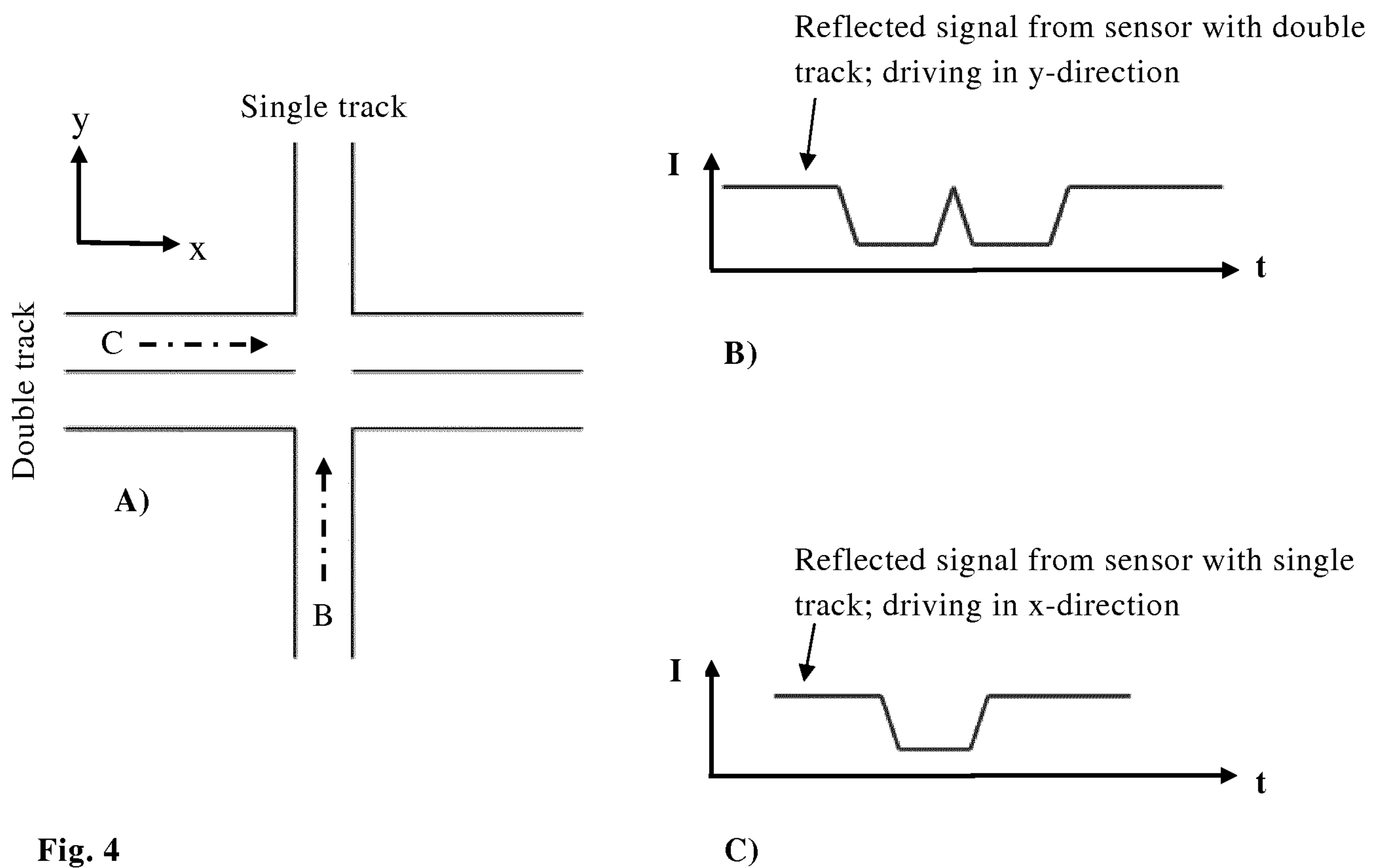
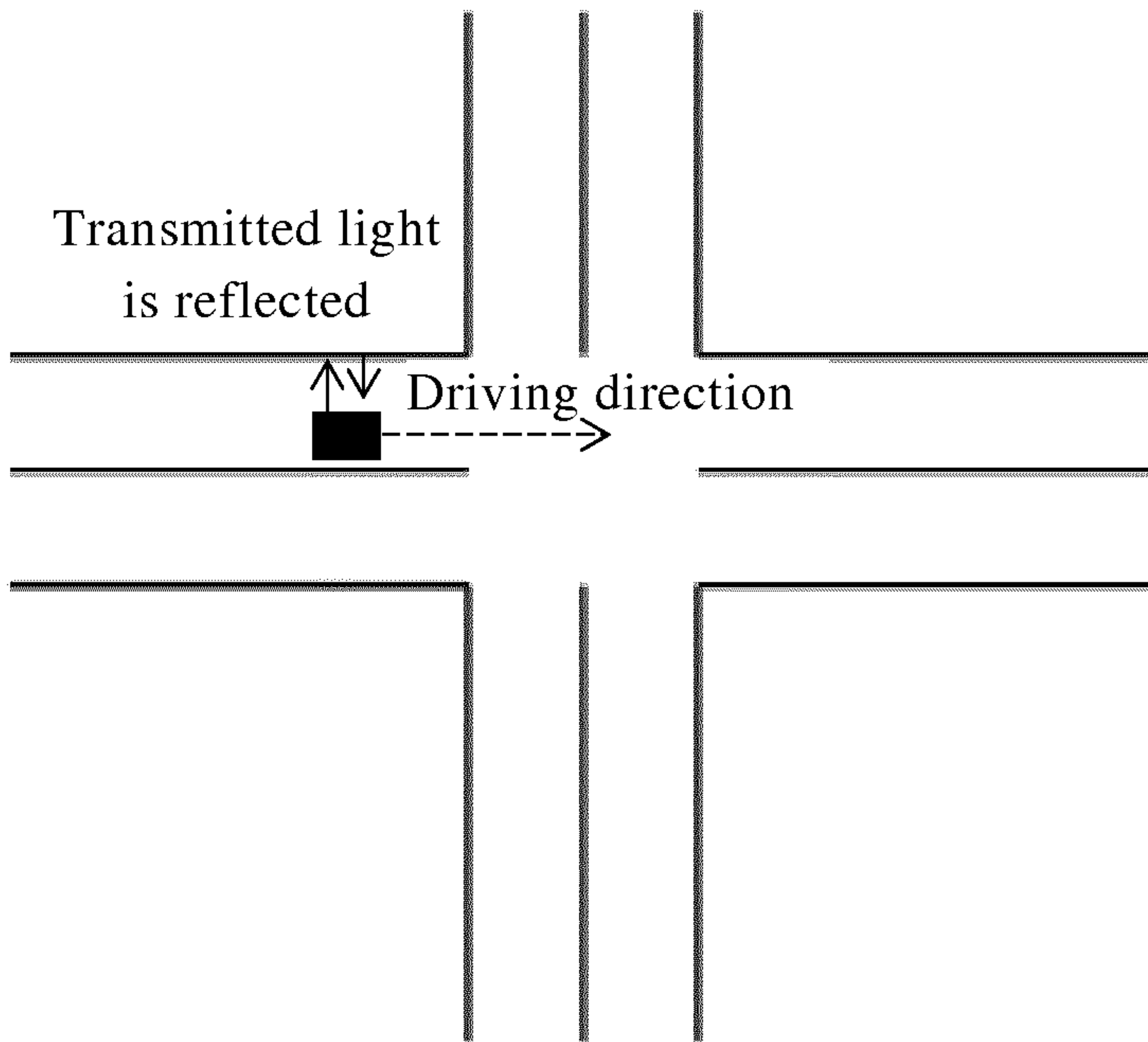


Fig. 4





**Fig. 3**